Capgemini

WORLD ENERGY MARKETS OBSERVATORY

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WORLD ENERGY MARKETS OBSERVATORY

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Global Editorial

01 Global Editorial

Introduction

Last year's editorial was written in the middle of the COVID-19 pandemic when many questions were on the table. Let's recall a few of them:

When and how will the world emerge from the crisis? Will different regions have the same recovery?

Will the post-pandemic world be different from the old one?

Will the lifestyle adopted during the lockdown periods, notably e-purchases, working from home and less travel, continue after the crisis?

Will companies continue to implement and use new digital processes?

Will cyberattacks grow?

Will sustainability issues be forgotten with the pandemic?

Will the consumption and emissions decrease observed in 2020 be sustained?

Will renewable energy development and green initiatives stall?

More than 18 months after the pandemic started, the world is still uncertain. However, some of these questions will be answered in this editorial and other issues will be debated.

I wish you good reading.

Pandemic-related crisis 2020 to H1 2021

A differentiated economic recovery from the pandemic crisis:

1. 2020 was an exceptional year:

The crisis linked to the pandemic in 2020 led to successive periods of lockdown and a drop in energy consumption which reached 20%[1] during the first confinement (March-May 2020).

During Q3 and Q4 2020, end of lockdowns (or less severe restrictions) in many countries allowed a global economic recovery and energy consumption grew again. Over the year, the decline was only 4.5%[2].

GHG emissions fell 20%[3] during the first lockdown but, similar to energy consumption, levels dropped only by around 6%[4] over the year.

1 https://www.iea.org/data-and-statistics/charts/year-on-year-change-in-weekly-electricity-demand-weather-corrected-in-selected-countries-january-december-2020
2 https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf
3 https://www.nature.com/articles/s41558-020-0797-x
4 https://www.nature.com/articles/d41586-021-00090-3

Commodity prices were low; the price of oil was even in negative territory in April 2020 in the United States[1] . Other commodities, such as cooper (a critical metal for electricity growth and energy transition) followed a similar path.

The average price of electricity and gas prices declined sharply in 2020 with a deep decline during the confinement period and a relative recovery after. For example, average electricity prices in European day-ahead markets fell by around 30% in 2020 compared with the previous year.

In the U.S., Henry Hub gas prices averaged $2/MBtu in 2020, the lowest price level since 1995.

2. During the first half of 2021, the global economy rebounded:

However, the recovery was uneven from region to region. Indeed, each country's economic structure, governmental decisions regarding barrier gestures and containments, economic stimuli and, above all, the effectiveness of vaccination campaigns have drawn different ways out of the crisis.

The Chinese economy started to improve by the end of 2020 and recorded around 7% growth in Q12021 compared to Q42019[2] . In Q1 2021, the U.S. GDP was only slightly below pre-crisis level while the EU GDP was 5% lower. South America is badly hit. For example, it is expected to take six years[3] for Argentina to reach pre-pandemic GDP per capita, while it should take 18 months for the U.S. and three years for the EU. The lack of vaccination in India and Africa are delaying any economic recovery.

Certain sectors such as IT, electronic platforms, telecommunications, and logistics have been boosted by the pandemic-related crisis while transport and tourism have been severely impacted by the containment, the increase in teleworking, and the drastic decline in business travel and air travel. The same is true for certain components of the tertiary sector, such as catering, retail, and others.Electric and gas utilities players were moderately impacted while Oil & Gas companies were heavily impacted by both lower consumption and lower prices (see below).

Supported by unprecedented levels of monetary and fiscal support and vaccination campaigns, the global economy should pick up speed in the second half of the year. However, the pandemic resurgence linked notably to new variants could slow down this recovery.

Energy consumption growth resumed after the crisis:

Linked to economic growth, energy demand and CO2 emissions will grow again.

In 2021 G20 countries, energy demand is expected to rebound by 4.1%[4] , pushing global energy use in 2021 0.6% above pre-COVID levels.

However, the crisis has changed behaviours in a sustained way. For example, it seems that business trips will not grow to the 2019 levels as distant meetings by Zoom, Teams, or other platforms proved to be efficient. The increase in teleworking should be sustained, as will e-purchasing and digitization of many business processes. This trend should impact the travel sector (air, railroad and, to a lesser extent, road), thereby decreasing related energy consumption.

1 WTI at -36.98 on April 20, 2020
2 https://www.pwccn.com/en/research-and-insights/china-economic-quarterly-q1-2021.html
3 Starting in Q1 2020
4 https://www.enerdata.net/publications/reports-presentations/world-energy-trends.html

1. Are energy consumption and GDP still correlated?

Will these new ways of living and working impact the correlation between energy consumption and GDP?

According to research work by J Percebois[1] , historical figures show a linear relationship between GDP and energy consumption at global level. Globally, economic growth should therefore continue to be accompanied by an increase in energy consumption, albeit at different rates depending notably on energy efficiency progress[2] and new post-pandemic consumption patterns.

At the regional level and even more at the national level, it could be different. Technical improvements and structural changes in GDP, such as those resulting from relocating manufacturing plants to lower-cost countries could result in relatively lower energy consumption.

In addition, when calculating the energy footprint related to GDP, it is necessary to count the energy spent to manufacture imported goods and services. As such, the energy saved in some countries is expended by others.

The same is true of GHG emissions. For example, the carbon footprint of France is 11 tCO2/capita, while emissions linked to national production alone are only 5 t CO_2/capita.As seen in 2021, economic growth is pushing energy consumption up, demonstrating that the correlation between GDP and energy growth is still true.

However, in the May 2021 Net Zero for 2050[3] report, the International Energy Agency (IEA) questions this correlation. In some of its scenarios, researchers suggest that our civilization can accommodate an additional 2 billion people with over twice the quantum of economic activities at present and still reduce energy consumption by 8%!

This statement is debatable as developing countries will need more energy to accommodate their increasing population and to raise their standard of living. Reversing the historical trend of per capita rising energy consumption will be very difficult. Since 1800, this consumption has risen more than four-fold from 0.43 tonnes of oil equivalent (toe) to 1.96 toe.the historical trend of per capita rising

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2. Energy efficiency improvement is difficult:

As a result of the crisis and continuing low energy prices, many investments in more efficient technologies were delayed. Meanwhile, global energy intensity improved by only 0.8% in 2020, roughly half the rate, (corrected for weather) in 2019 (1.6%) and 2018 (1.5%). This is well below the average annual energy intensity improvements of 4% needed by 2030[4], to be consistent with meeting international climate and sustainability goals.At the European level, the same difficulties are illustrated by the 2020 energy and climate change objectives achievement.

These objectives were: reducing Green House Gas Emissions GHG by 20%[5] ; increasing the share of renewables in energy consumption to 20%; and achieving a 20% improvement in energy efficiency measured by comparing energy consumption to GDP. While the GHG emission decrease and the renewables share increase, targets were met in 2020, the energy efficiency target was met thanks only to the pandemic crisis: in 2019 primary energy consumption in the EU was 3.4 % above the 2020 target.

1 https://theconversation.com/a-lechelle-mondiale-aucun-decouplage-a-attendre-entre-pib-et-consommation-denergie-158903
2 Primary energy intensity is the amount of primary energy to produce a unit of activity. Its decrease measures energy efficiency improvement.
3 https://www.iea.org/data-and-statistics/data-product/net-zero-by-2050-scenario
4 IEA 2021 report: "Net zero by 2050. A roadmap for the global energy sector"
5 Compared to 1990

3. Energy-related commodities prices are growing:

The prices of commodities soared during the first half of 2021 for different reasons:

1. Oil

In 2021, world oil demand is not expected to reach the pre-crisis level. It should expand by 5.4 Mb/d in 2021 to 96.4 Mb/d[1] , following a collapse of 8.7 Mb/d last year.[2] Oil production of US (the first producing country) and of OPEC (which represents around 40% of the world supply) are analysed below. They are often correlated. For example, during 2014-2016 period, OPEC decided to ease production quotas to "kill" shale oil production. The oil prices went down to $30/b; shale oil producers suffered and produced less, tightening the production/consumption balance. Oil prices went up and shale producers, thanks also to their efforts to lower costs, survived.

i. U.S. production: Since the shale oil basins are not profitable at the low oil prices reached in 2020 and as many shale producers were highly indebted, oil production decreased in the U.S. in 2020. Some shale producers had difficulties surviving. For example, Chesapeake Energy Corp. filed for bankruptcy protection in June 2020, due to heavy debt combined with the coronavirus outbreak consequences.

By mid-2021, the crude oil price increase helped shale producers boost their output. Therefore, U.S. crude production[3] was oscillating around 11 Mb/d, after climbing above 13 Mb/d in 2019. EIA[4] , is forecasting U.S. oil production to rise by about 7% in 2022 (to around 12 Mb/d) spurred by higher crude prices and a rebound in shale drilling. The 2020 price drop triggered consolidation in the sector. From Q4 2020 to Q2 2021, about $50 billion worth of deals have been struck. For example, in May 2021, Cimarex and Cabot Oil shale producers revealed a "merger of equals" that will create a group with an enterprise value of $17 billion.

ii. OPEC production: 2020 was a bumpy year for OPEC+[5] oil producers.

On March 8, 2020, Saudi Arabia initiated a price war that resulted in an oil price drop of around 30% (in addition to a 30% drop since the beginning of 2020). Shortly after, oil consumption dropped sharply because of pandemic-related lockdowns sending WTI oil prices into negative territory for the first time in history.

Finally, on April 12, 2020, OPEC+ members decided to adjust downwards their overall crude oil production by 9.7 Mb/d, starting on May 1, 2020 for an initial period of two months; it was further extended until the end of July.

From the end of 2020 until June 2021, these OPEC+ cuts were reduced to around 6 Mb/d, which is equivalent to more than 6% of global demand (including a 1 Mb/d voluntary cut by Saudi Arabia).

In response to increasing oil prices, and after difficult negotiations, OPEC+ members reached an agreement by mid-July 2021 to raise their oil output. They should, by the end of 2022, restore all output cut during the spring of 2020. According to this agreement, they will pump an extra 400,000 b/d each month from August 2021, reaching about 2 million b/d in total by year end.

This modest increase of output is a sign of concerns about the strength of the global recovery, given that China's growth slowed at the end of H1 2021 and the spread of new COVID variants.

iii. Oil price: The increase in oil prices, which reached $77/b for the Brent in early July 2021, is explained not only by the recovery in demand but also by better control of oil output by OPEC+, as well as stagnant production of shale oil in the United States. After the July OPEC+ agreement announcement, the Brent oil price decreased to $68/b.

1 Mb/d: million barrels per day
2 https://www.iea.org/reports/oil-market-report-may-2021
3 In 2020, about 65% of total U.S. crude oil production were produced from shale oil resources.
4 EIA (Energy Information Administration) is the US governmental Agency https://www.eia.gov/outlooks/steo/report/us_oil.php.
5 In addition to formal OPEC members, 10 additional oil exporting countries, led by Russia, form the OPEC+ cartel

2. *The electricity share in global energy consumption is growing:*

Global electricity demand declined most markedly in the first half of 2020 as lockdowns restricted commercial and industrial activity. During the first lockdown period, demand was 20-30% lower than the pre-lockdown period. For the whole 2020, demand decreased by around 1%. This decrease is lower than global energy demand and highlights the fact that electrification is continuously progressing as electricity is the best de-carbonization energy vector.

In the future, electricity demand should follow a different path than energy demand. This is illustrated in G20 countries. While 2021 energy consumption should increase by 0.2% compared to 2019, 2021 electricity consumption should surpass its 2019 level by 3.5%. The electricity share in final energy consumption, which progressed in 2020, should continue to do so in 2021, reaching 22%.

The correlation between electricity consumption and CO_2 emissions reduction is well illustrated by Germany. In May 2021, the country announced an increase in its 2030 CO_2 reduction targets from 55% to 65%; shortly after, it revised upwards its electricity needs by 15%.

On the European plate, electricity prices that fell to around € 17/MWh in April 2020 grew to €45/MWh by the end of December. Since the beginning of 2021, the prices continued to grow and surpassed €80/MWh in early July 2021.

This price increase is linked to an electricity demand increase, as well as CO_2 ETS certificate price growth.

3. *Despite increasing significantly, carbon certificates prices are still too low to guide energy policies:*

i. Present situation: In 2020, the price of the CO_2 certificate on the European ETS[1] market rose from €17/t in March 2020 to €67/t early July 2021. This increase is explained by several factors:

- The Market Stability Reserve in place since 2019 absorbs part of the extra quotas
- Regular reduction of the ceilings of allocated quotas
- The EU agreement to reduce CO_2 emissions by 55% by 2030 (compared to 1990)
- Anticipated purchases by industry players and speculation by the financial sector. The latter sees ETS certificates as an investment that is both green and lucrative as the price continues to grow. This speculation increases the liquidity of the market, making it more volatile.

Since Brexit, the prices of CO_2 emission allowances in the United Kingdom have been decoupled from the ETS and linked to a purely British auction. Several industrialists in the U.K. and Europe have called for linking the future U.K. carbon market and the EU emissions trading market.

1 ETS: Emission Trading System

In the future, the price should continue to grow as new "Fit 55" directives unveiled in July 2021 provide a more rapid tightening of the ETS allocations cap.

On one hand, this price increase will handicap the European industry until the EU Carbon Border Adjustment Mechanism (CBAM) is implemented. On the other, a higher carbon price gives the right economic signal to accelerate green investments.

ii. The European Commission's "Fit for 55" directives should enable the EU block to become the world's first mover on achieving net zero emissions by 2050.

These directives aim to ensure that the continent meets its goal of reducing greenhouse gas emissions by 55% in 2030 (as compared to 1990). Hundreds of pages of legislative proposals intend to both deepen and broaden the decarbonization of Europe's economy.

The broad package proposals include:

- A reform and extension of the ETS system, including:
- More rapid tightening of the ETS cap currently set at 2.2% per year to 4,2% per year[1] ;
- An ETS scheme extension to cover the shipping industry;
- A new EU emissions trading system for buildings and road transport; and
- A gradual phasing out of free credits that many sectors have benefitted from.
- A CBAM, which is a levy on imports based on their carbon footprint, as an attempt to prevent carbon leakage. This tool will be implemented in 2026 and initially limited to products such as such as steel, cement, aluminium, and fertilizers.
- Renewables target increase. The commission wants to raise the region's renewables target to 40% of the energy mix by 2030, as compared to the present target of 32%. This new target could be challenging to meet as nearly 66% of current renewable energies are derived from biomass and the commission will rightly introduce stricter sustainability rules for biomass (most notably, excluding biomass from primary forests).
- Energy efficiency targets for 2030 increase: A 36% reduction in the final energy consumption by 2030 (an increase compared to the previous target of 32.5%).
- A profound restructuring of energy taxation in Europe.
- Revised CO2 emissions standards for new vehicles, which will set a de facto ban on new petrol and diesel cars sales in Europe beginning in 2035. At the end of 2020, the U.K. government announced a ban on the sale of new petrol and diesel vehicles will be moved up by a decade from 2040 to 2030.

The plan will be subject to fierce negotiations among the bloc's 27 member states and could take years to complete, given that taxation policies require unanimous approvals.

4. Gas demand and prices should increase in the short term. It could be different in the long term:

i. Global gas demand is expected to increase by 3.2% year-on-year in 2021, which is more than enough to offset the 1.9% lost consumption in 2020[2] . Global gas consumption for power generation was already the most affected segment in 2020; in 2021, it is expected to see limited growth (1.2%) which is not sufficient to offset the estimated 2.1% year-on-year drop seen in 2020.

Following strong growth in Q1, European gas demand is expected to increase by 3% in 2021, returning to pre-crisis levels.

Future demand for gas in the more mature markets of northwest Europe is expected to decline by 50 bcm/year by 2040. The drivers for this drop are heating efficiency gains and electrification Growth. In addition, renewables generation growth is displacing baseload gas-for-power demand.

1 https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3542
2 IEA quarterly report April 2021

The biggest drop should be in residential demand related to measures aimed at fighting global warming. For example, in France, the new buildings energy regulation (RE2020) will impose the gradual phasing out of new gas-heated housing by setting a maximum threshold for greenhouse gas emissions from energy consumption.

ii. Blue hydrogen derived from natural gas (see below), could open new sectors to gas demand. ***Gas supply in Europe:*** In 2020, the Dutch government announced that the production cap for the Groningen field will be halved (compared to its Q4 2020 level) as of October 2021.

This decision will decrease the domestic gas supply and increase European imports.

Nord Stream 1 remained the most important supply route of Russian pipeline gas to the EU in Q4 2020, having a share of 44% in the Russian pipeline imports.

Comforted by the suspension of threats of American sanctions in May 2021, Moscow and its European partners have continued to complete the gas pipeline intended to supply Europe with Russian gas without passing through Ukraine. On July 21th 2021, the United States and Germany reached an agreement to allow the completion of this $11 billion controversial pipeline. Completion is expected by August 2021.

This US-German agreement aims also to invest more than 200 million euros in energy security in Ukraine as well as sustainable energy across Europe. depend now on the German regulator decisions.

The new Trans Adriatic Pipeline, which is part of the Southern Gas Corridor and provides access to Azeri gas sources, began shipping gas at the end of December 2020.

In Q1 2021[1] , available supply in Europe was up 19% from Q4 2020 due to increases in production, storage withdrawals, and LNG supply more than offsetting lower pipeline entries

In 2021, LNG supplies are catching up as Q1 2021 supply was up 3% compared to Q4 2020, but flat compared to Q1 2020.

Russia is set to remain the dominant gas supplier to Europe through 2040, according to the latest long-term European gas outlook from S&P Global Platts Analytics[2] .

Russia's market share in Europe is expected to remain above 30%, rising close to 40% by 2040, as domestic European gas production and supplies from Norway and Netherlands decrease.

The share of global LNG supplies in Europe's energy mix is expected to increase by 2040 however less than Russian deliveries as piped Russian gas remains competitive given its low-cost production base. Global Russian gas output is expected to grow significantly as Moscow targets also increased exports to China and focuses on building out its LNG export capacity.

iii. In Europe ***gas networks*** are facing a few challenges:

- They must increase their operational flexibility to face the more volatile gas to power demand, as the latter is now corelated with renewables variable output. Gas, contrary to electricity, is easy to store, so the latter levels need to be sufficiently well-correlated to these variable needs.

1 https://www.mckinsey.com/industries/oil-and-gas/our-insights/petroleum-blog/snapshot-of-gas-and-lng-flows-and-market-dynamics
2 https://www.spglobal.com/platts/en/market-insights/topics/hydrogen

- Investing in new import gas pipelines is questionable. In 2020, the EU approved a "Projects of Common Interest"[1] list including tens of millions of dollars' worth of investment in 32 gas projects. This funding is contrary to EU climate commitments and may be unnecessary,[2] as EU "Fit for 55" directives are setting an ambitious trajectory for reducing greenhouse emissions. Moreover, EU's natural gas import capacity is already largely above its needs, with an average pipeline utilization rate of 57% over 2019 and an average utilization rate of 51% for LNG terminals[3] . In addition, newly approved projects risk losing value before the end of their economic life, thus becoming stranded assets. To match its "Green deal" objectives, in December 2020, the European Commission proposed new rules to end EU funding for natural gas (and oil) pipelines and instead funnel cash into electricity and low-carbon energy networks to meet climate goals.

- To respond to these challenges, gas networks intend to become greener by incorporating hydrogen or biomethane. However, the acceptance of hydrogen and biomethane is still in an early stage of development, with the former mainly driven by pilot projects and biomethane being somewhat more advanced.

iv. Gas prices in Europe: At the end of Q2 2021, gas prices on wholesale markets in Europe hit a high since 2008, reaching more than €30/MWh. This price increase is the consequence of:

- A cold and long winter, which led utilities to draw on gas storages, which must now be refilled;
- Strong growth in Chinese demand;
- Strong demand in Brazil, where drought limits the operation of hydraulic dams;
- A fire that forced the Norwegian Equinor to close its LNG production plant north of the Arctic Circle; and
- Gazprom's strategy, which restricts its exportations to Europe through Ukraine to promote its Nord Stream 2 gas pipeline (see above).

5. Coal demand is increasing in developing countries as well as developed countries:

Demand for coal in G20 countries decreased by 4% in 2020 but should rebound to 5% in 2021, ending above 2019 figures.

Coal remains vital for China as the lack of energy is one the key obstacles to maintain a "moderately prosperous society" and as the country's energy security of supply relies on coal.

In 2019, 58% of the country's total energy consumption came from coal and China continues to build coal-fired power plants at a rate that outpaces all other countries combined.

In 2020, China brought 38.4 GW of new coal-fired power into operation, more than three times what was brought online elsewhere. A total of 247 GW of coal power is now in planning or development stages, nearly six times Germany's entire coal-fired capacity.

In addition, China finances more than 70% of all coal plants built today[4] . Korea and Japan finance 12% and 10% of coal plants projects, respectively, and are backing away from these projects.

By the end of Q2 2021, the high-quality cooking coal price in China has risen above $300/t for the first time since 2017, up almost 150% since October2020. This underlines the difficulties that China faces in trying to cool commodity markets which it has identified as a key risk to its economic recovery and foreign policy goals.

1 PCI: Projects of Common Interest that entitle investors to receive funding and loans from the European Investment Bank, EU institutions and private investors.
2 According to the January 2020 Arthelys report "the EU risks over-investment of €29bn in unnecessary projects".
3 http://www.carbone4.com/analysis-new-gas-infrastructure-eu/?lang=en
4 https://qz.com/1760615/china-quits-coal-at-home-but-promotes-the-fossil-fuel-in-developing-countries/

While China is relatively self-sufficient in cooking coal with domestic mining supplying about 80% of its needs, it still imports $70 million a year for its steel industry. About half of these imports used to come from Australia. In October 2020, Beijing placed an unofficial ban on coal imports from this country because of a diplomatic issue over the origins of the coronavirus. This boycott, combined with lower domestic cooking coal production and pressure from safety and environmental inspections, explains why Chinese steelmakers are paying around $100/t more than India.

6. *GHG energy related emissions growth in 2021 should reverse at least 80% of the 2020 drop:*

In 2020, G20 countries' GHG energy related emissions, which represent 80% of global emissions, decreased by 5.2%. With the 2021 economic rebound, these emissions growth should amount to 4.4% and stay below 2019 levels. This would reverse 80% of the drop in 2020, raising fears that after 2021, the increase in emissions will return to the pre-crisis rate.

4. Energy transition metals price surges could wipe out part of the renewables 2021 cost decreases:

The strong economic recovery in countries like China, the lack of mining investments during the crisis, and logistical congestions, explain the price increase in these metals. In addition, stimulus plans implemented in North America, Europe, and the United Kingdom, target investments in infrastructure (rail, road, or electrical) which will require significant amounts of these metals.

However, after highs reached in May 2021, commodity prices slipped by mid-July, as driven by the spread of COVID-19 variants and concerns over slowing growth in China, the biggest consumer of raw materials.

The implementation of the energy transition increases the needs of certain metals such as copper, lithium, cobalt, and rare metals.They are produced and refined in a limited number of countries. For example, 50% of the world's copper is produced by three countries (Chile, Peru, and China), 70% of the cobalt is produced by the Democratic Republic of Congo, 60% of the rare earths are mined in China and 90% are refined in China[1].

According to IEA scenarios[2], energy transition will result in a surge of demand for those "transition minerals," as driven by electric grid expansion, electrical vehicle production, and storage batteries growth. By 2040, total mineral demand from clean energy technologies will more than double[3] . Among the low-carbon technologies, nuclear electricity has the lowest "mineral matter intensity" per unit of installed capacity.

This increase in demand for "transition minerals" is expected to push prices sharply upward unless mitigated by early[4] investments to discover ore deposits, the opening of mines, and building of refinery facilities.

A sharp rise in the price of these minerals could wipe out the significant progress made over the past ten years in renewable electricity production costs and the cost of batteries. This slowdown in price decrease could be amplified by inflation and interest rates growth in 2021 since producing renewable electricity and hydrogen requires significant investments.

The warning has been issued for several years about the West's dependence on these rare metals. Some regions, such as the U.S. and EU, have issued strategic plans to secure supply of these critical minerals by encouraging investments in geographically diversified sources of supply, as well as development of metals recycling, most notably from used batteries.

1 IEA The Role of critical minerals in clean energy transitions (2021) p.14https://iea.blob.core.windows.net/assets/24d5dfbb-a77a-4647-abcc-667867207f74/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf
2 https://www.iea.org/news/clean-energy-demand-for-critical-minerals-set-to-soar-as-the-world-pursues-net-zero-goals
3 https://iea.blob.core.windows.net/assets/24d5dfbb-a77a-4647-abcc-667867207f74/TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf
4 It takes about 16 years between the discovery of the ore and the production

Energy system decarbonization

Electricity generation: Low carbon sources:

1. Renewables are increasing their share in the electricity mix:

a. Consumption of renewable energy increased by 3% in 2020,[1] while the consumption of energy in general decreased. This is mainly due to a 7% increase in the consumption of renewable electricity, while the consumption of biofuels has fallen

The priority of access to the network, the construction of new renewable installations, certain long-term contracts (PPA[2]), and the fall in costs have enabled this growth.

Like other industrial installations, wind or solar farm projects have slowed in 2020 due to pandemic lockdowns and social distancing rules. This will have an impact on 2021 and 2022 generation.

b. Renewables generation growth:[3]

Despite the economic slowdown, global renewable energy capacity growth in 2020 was higher than the previous years' trend. Renewable generation capacity increased by 261 GW (+10.3%) in 2020, representing more than 80% of all new electricity capacity added. While hydropower has the largest installed capacity base, solar energy continued to lead capacity expansion, with an increase of 127 GW (+22%), followed closely by wind energy with 111 GW (+18%).

These sources jointly accounted for 91% of all net renewable additions in 2020.

China and the U.S. were the two outstanding growth markets : China, already the world's largest market for renewables, added 136 GW last year, while the U.S. installed 29 GW, nearly 80% more than in 2019.

Renewables' rising share of total electricity installed capacity is also attributable to net decommissioning of fossil fuel power generation in Europe, North America and, for the first time, across Eurasia. Total fossil fuel additions fell to 60 GW in 2020 from 64 GW the previous year, highlighting a downward trend of fossil fuel-fired plants expansion.

Consequently, the percentage of renewables in electricity production increased by 29% in 2020 as compared to 27% in 2019.

c. Sustainability of energy sources is key in the fight against climate change:

When evaluating the sustainable character of an energy source, one must analyse its impact on atmospheric pollution, rare mineral resources, water utilization, and land occupation.

Hydro, solar, or wind are natural resources and do not generate GHG emissions. However, the construction of dams, solar, or wind farms will generate emissions.

When comparing the total emissions over the lifecycle of the different sources of electricity used to produce a kWh[4], it appears that the median value for nuclear energy is 29g CO_2 eq/kWh, which is similar to wind generation (26) and hydro-electricity (26 g CO2 eq/kWh Photovoltaic solar farms is 85, which is still a very low value as compared to gas (499) and coal (888).

Rare metals are needed in solar panels, windmills, and electrical batteries, highlighting the importance of recycling so as not to deplete those resources.

It must also be acknowledged that unlike fossil fuel plants or nuclear reactors, wind and solar farms use little water resources.

1 https://www.iea.org/reports/global-energy-review-2021/electricity#electricity-demand
2 PPA: Price Purchase Agreement
3 https://www.irena.org/publications/2021/March/Renewable-Capacity-Statistics-2021
https://www.irena.org/newsroom/pressreleases/2021/Apr/World-Adds-Record-New-Renewable-Energy-Capacity-in-2020
4 http://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Working_Group_Reports/comparison_of_lifecycle.pdf

Concentrated energies, such as nuclear energy, occupy much less land surface than diffuse energies such as wind and solar energy The occupied land surface (for a given electric power) for solar electricity is 500 times larger than that for nuclear electricity and 2500 times larger for wind electricity than for nuclear electricity.[1]

With a share of around 66%[2] of the renewables' energy consumption, biomass constitutes the main renewable energy source within the EU. Expanding its utilization is the key to reaching the 2030 goal of 40% renewable energy in the total consumption. To answer to questions on the sustainability of certain biomass products, the EU "Fit for 55" package strengthens its "suitability criteria" on certain forms of biomass, which involve combustion of wood pellets. Indeed, burning wood contributes both to carbon emissions and to a reduction in the absorption of CO2 by forests. Moreover, if those pellets must be supplied from far-flung locations, their transportation creates additional pollution.

d. Technology improvements are either specific to each renewable source or common to all:

i. Solar[3] technology progress aims at:

- Increasing solar cell conversion efficiency: For example, by layering perovskite crystals over silicon to increase the conversion of sunlight into energy, it is possible to reach a conversion rate of 27%, as compared to 22% at present. Using hexagonal lenses in the protective glass that coats solar panels concentrates light and produces more energy; this technology has reached an efficiency rate of 30%.
- Generating higher volumes of electricity at a lower cost, as compared to land-based solar farms, thanks to large installations of floating photovoltaic panels.
- Building-integrated photovoltaics within building materials themselves, as opposed to only rooftop-mounted solar panels. Solar glass is of particular interest in hot climates where it reduces the amount of heat penetrating the windows, in turn reducing energy consumption from air conditioning.

1 https://mcusercontent.com/1c10cc56874327bd9a8c7fa54/files/c6222552-0b1e-e8b1-ec47-1326b62478d0/Artificialisation_sols.pdf
2 https://etipbioenergy.eu/images/ETIP_B_Factsheet_Bioenergy%20in%20Europe_rev_feb2020.pdf
3 https://ratedpower.com/blog/solar-power-technology/

ii. Wind new technologies aim at:[1]

- Increasing blade size and tower height: Ten years ago, the length of the rotor blade, from vertex to tip, measured 30–40 meters long. Today, blades are double that length, thereby increasing the wind capture. Wind turbines and their towers are getting larger and taller. Ten years ago, most wind turbines averaged about 80 meters in height. At 248 meters tall, the new towers (GE Haliade X) will far exceed the height of today's tallest wind turbines.Bigger blade size and taller turbines make for stronger production capacity. For example, the average turbine of one decade ago had the capacity to produce 1.5 MW of electricity. The average nameplate of newly installed land-based wind turbines in the U.S. in 2019 was 2.55 MW.

- On-site assembly: Huge blades can cause road transportation issues. Companies are exploring how to make the blades easier to ship by creating them as segmented pieces, which can later be fit together. Some equipment providers are experimenting with new composites like carbon fibre that could make on-site assembly easier.

- Turbine recycling: With huge blade waste forecasted to reach 43 million tons by 2050, more wind-turbine makers are looking for ways to recycle their products when they are no longer viable. For example, in December 2020, GE Renewable and Veolia signed an agreement to recycle blades removed from U.S. onshore wind.

- Floating turbines: Putting turbines on floating platforms in the water, rather than fixed foundations allows for the installation of offshore wind farms in larger seawater depth. In 2017, Equinor opened the first full-scale floating offshore 30 MW wind farm. The facility had the highest capacity factor in the U.K. for the third year in a row as of 2020.

- Repowering: Up to 76 GW of the EU's onshore and offshore wind energy capacity will come to the end of their operational life between 2020 and 2030[2] . Repowering these wind farms by replacing aging assets with fewer, modern ones offers many advantages:

  - It enables to harness a higher amount of power;

  - Long-term wind resource data are already available, which facilitates the tailoring of turbine size to local wind conditions to optimize power output; and

  - Local communities are accustomed to the presence of wind farms, which means that repowered projects could be more easily accepted.

iii. CO2 sequestration:

Thanks to prototypes return of experience, there is progress in Carbon Capture and Storage (CCS) technology, which has led to price decreases.

In addition, new research is aimed at finding ways to remove carbon dioxide directly from the atmosphere. To accelerate discoveries, in 2021, Elon Musk and the Musk Foundation[3] launched a $100 million, four-year competition that invites innovators to create and demonstrate solutions that can pull CO2 directly from the atmosphere or oceans and sequester it durably and sustainably.

iv. Digital enabled progress:

Intelligent sensors and better granular weather forecasting allow improved renewables operations and maintenance.

Gathering wind or solar farm fleets data into one platform via advanced energy software products enables significant savings in operation and maintenance costs thanks to:

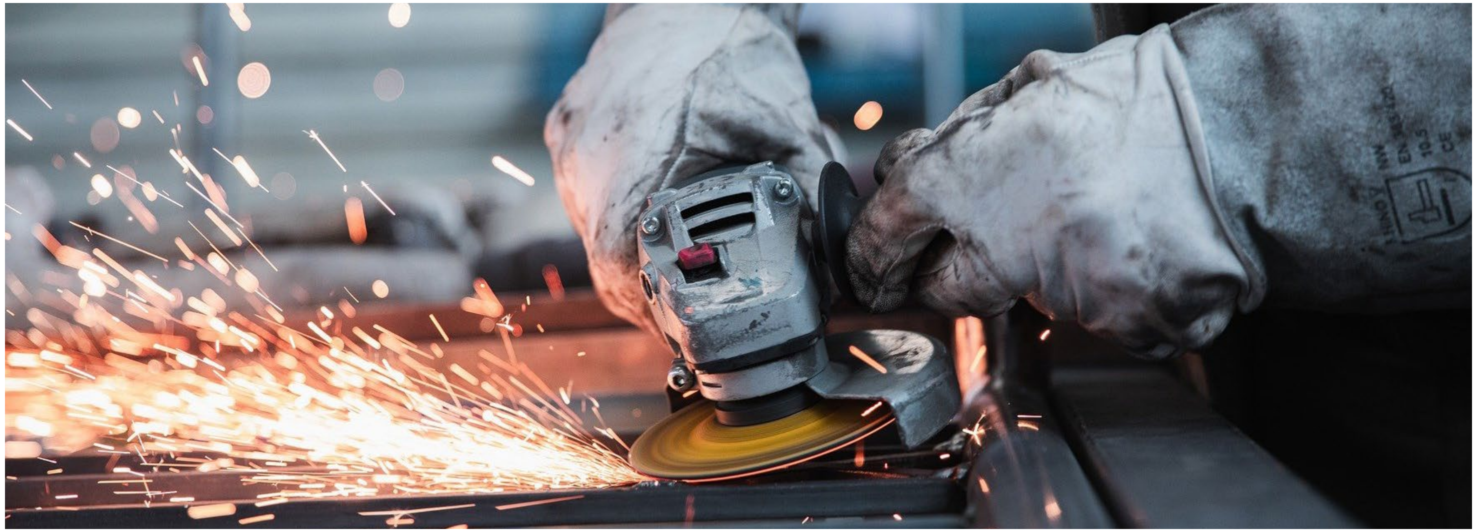
- Reduced time spent in standard inspections and repairs; and

- Improved predictive maintenance based on data analysis and machine learning technologies.

1 https://www.asme.org/topics-resources/content/6-advances-in-wind-energy
2 https://windeurope.org/wp-content/uploads/files/policy/position-papers/WindEurope-Framing-Note-on-Repowering.pdf
3 https://www.xprize.org/prizes/elonmusk

e. Renewable energy costs have continued to decrease. Will there be a pause?

In recent years, renewable energies' costs have dramatically decreased, making electricity generation technologies competitive, in LCOE[1] terms, with dispatchable fossil fuel-based electricity generation in many countries. While the cost of electricity from new nuclear power plants is high, electricity from existing long-term nuclear power plants constitutes the least cost option for low-carbon generation.



i. 2020-2021 achievements:

According to the latest Irena report, in 2020, renewable power generation costs continued to fall significantly year-on-year[2] . The global weighted-average LCOE of utility-scale solar PV fell by 7%, year-on-year, from $61/MWh to $57/MWh, while that of onshore wind fell by 13%, year-on-year, from $45/MWh to $39/MWh and that of offshore wind decreased by 9%, from $93/MWh to $84/MWh. By the end June 2021, the New Jersey Board of Public Utilities awarded the Atlantic Shores Offshore Wind[3] a contract to develop an 1,510 MW offshore wind energy project located off the coast of New Jersey at a price of $86/MWh .

Over the last ten years (2010-2020) the renewables cost decrease was spectacular. The global weighted-average cost of electricity from newly commissioned onshore wind projects fell by 56%, while that of utility-scale solar fell by 85%, offshore wind declined by 48%, and Concentrated Solar Power (CSP) fell by 68from $340/MWh to $ 108/MWh.

ii. Will there be a pause in the drop in renewable energy costs?

The prices of Chinese solar panels are increasing[4]. This is partly related to the increase in the price of steel[5] (nearly three-fold from November 2020 to May 2021but also to the dominant position of China in this market. For example, the price of containers for transporting floating solar floatsfarms has increased dramatically. With rising inflation, the cost of capital will increase, thus increasing the cost of energy produced.

In countries like France there is a strong opposition to onshore wind. The legal suits and the project changes to accommodate local neighborhoods increase the length of the construction and thus the cost. All of these factors could slow down the renewables cost decrease.

1 LCOE: Levelized Costs Of Electricity
2 https://www.irena.org/newsroom/pressreleases/2021/Jun/Majority-of-New-Renewables-Undercut-Cheapest-Fossil-Fuel-on-Cost
3 Atlantic Shores is a 50-50 joint venture between EDF Renewables North America and Shell New Energies US
4 https://www.livemint.com/news/india/hike-in-solar-panel-prices-by-chinese-cos-to-hit-projects-11617213860784.html
5 Renewables energy (solar and wind) that have a low energy density use more steel and concrete per kWh generated than centralized generation. https://fortune.com/2021/07/08/steel-prices-2021-going-up-bubble/

iii. LCOE costs comparison limitations:

The LCOE method is used to compare electricity costs of different energy sources. This method allows analysts to compare very different means of producing electricity with different life spans, capital investments, operating costs, and availability factors.

However, it does not reflect all external factors, such as electricity storage cost for renewables, cost of reinforcement of networks, or end-of-life costs; nor does it measure the impact of intermittency on power grid balancing. It is also a static indicator that does not consider the impact of renewable generation on the market and the value of these variable sources of electricity.

For example, on a very sunny day with high PV solar penetration, the grid can be overloaded with this electricity generation. As a result, the excess supply could be curtailed to balance the system. In this case, the value provided by this excess PV solar electricity is zero.

However, unlike PV solar farms, CSP, with thermal energy storage, has the flexibility to target output in high-cost periods of the electricity market, irrespective of whether the sun is shining.

The LCOE also fails to consider other potential sources of revenue. For example, hydropower generators can earn revenue from providing ancillary grid services. This is not the case for variable renewable generation.

However, hybrid power plants that aggregate variable renewables with batteries and, in the future, hydrogen production and fuel-cells, are more grid friendly.

LCOE measurement is no longer sufficient and new metrics need to be introduced to measure the renewables value provided to the electric system. Therefore, IEA introduced the value adjusted LCOE (VALCOE).[1]

iv. Clean energy companies:

In 2021, a speculative bubble is growing as renewable energy companies attract financing, thanks to decreasing costs and increased governmental support. In 2021, many renewable companies have gone public[2] with promises of significant increases in their installed capacity. They need to win tenders and therefore are proposing low prices and counting on cost decreases by the time the project is completed. If the renewable costs stop decreasing, their profitability (as well as that of the sector) will be negatively impacted.

Orsted, a former Oil & Gas company majority-owned by the Danish state, has successfully developed in offshore wind power and was ranked third among European energy companies by market capitalization. A slight change in its strategy in renewable energies with a higher weight of solar and onshore wind power[3] was interpreted as the warning signal of the continued erosion of the profitability[4] of capital invested in offshore wind. Following this announcement, Orsted's share price dropped by 35% between January and June 2021.

Similarly, Neoen[5] stock decreased from €64 at the beginning of the year to €38 at the end of H12021.

The S&P global clean energy index[6] has decreased significantly since January 2021. After increasing steadily from around 500 points in 2016 to 900 in January 2020, it decreased sharply due to the COVID-19 crisis to 600and then grew continuously to more than 2000 in January 2021. In June 21 it had decreased to 1400.

1 https://www.iea.org/reports/projected-costs-of-generating-electricity-2020
2 https://renewablesnow.com/news/?topic=ipos
3 Offshore wind should still be 60% of Oersted's power capacity 2030
4 This profitability declined in a few years from more than 15% to a range of 5% to 10%.
5 A French renewable energy company that develops, finances, builds and operates solar power plants, wind farms and energy storage facilities
6 https://www.spglobal.com/spdji/en/indices/esg/sp-global-clean-energy-index/#overview

2. Nuclear electricity is indispensable to reach the climate related goals:

Nuclear electricity remains the single largest source of low-carbon generation in advanced economies.

After being set aside for years, climate change issues are bringing this very low carbon electricity source back to the forefront. It is recognized by many institutions as an essential component to achieving carbon neutrality.

- **The existing reactors have operated in 2020 and H1 2021 without significant incidents** and have provided about 10% of the world's electricity, making nuclear the world's second largest source of low-carbon power. Globally, nuclear electricity provided 2553 TWh of electricity, down from 2657 TWh in 2019. The availability rate was reduced due to the inability to perform heavy maintenance work during the containment periods.

Prior to 2020, electricity generation from nuclear energy had increased for seven consecutive years. China was the second largest producer of nuclear electricity after the United States, overtaking France, which moved to third place.

In 2020, five new reactors (out of a total of 442) became operational and five reactors were shut down (in the U.S., France, and Russia). Some shutdowns, such as the two French reactors at Fessenheim, were completed for political reasons.

In April 2020, during the first confinement, EDF forecasted a nuclear production of 330 TWh compared to 2019's production, which was slightly above 379 TWh. Thanks to EDF's efforts to optimize the annual reactor's shutdowns maintenance works , the production for the year was 335 TWh and there was no electricity supply problem during the winter of 2020-2021. However, French reactors' availability will stay below 2019's level for two or three years and the winters 2021-2022 and 2022-2023 could remain tense in France and Europe.

In February 2021, the French Nuclear Safety Authority (ASN) agreed to extend, subject to conditions, the lifespan of 32 French 900 MW reactors to 50 years. This is a welcomed decision and will help ensure the security of electricity supply at a competitive cost.

Many European energy transition plans call for the premature shutdown of nuclear plants.

In Germany, the Energiewende has ordered all nuclear reactors to be shut down by 2023. With the acceleration of the shutdown of coal plants decided in 2021, controllable production is decreasing, which can increase the risk of blackouts.

To achieve the goal set by French Energy Transition law of reducing the share of nuclear power to 50% of the electricity mix by 2035, the 2020 Multiannual Energy Program PPE[1] has set a path to shut down 14 of its oldest reactors by 2035. This plan forecasts anticipated closures (before their 50-year lifetime) of two reactors by 2025-2026 and two others by 2027 and 2028, as well the decommissioning of all coal-fired power stations by 2022. However, the operator of the electricity transmission network, RTE,[2] estimated that by 2026 the safety margins of the electricity system will be very low or even insufficient and therefore recommends not closing reactors in 2025 and 2026.

1 Programmation Pluriannuelle de l'Enerrgie
2 In its provisional assessment of the electricity system for 2021-2030, presented on March 2021

Belgium plans to phase out its nuclear reactors between 2022 and 2025 making the country a major importer of electricity if enough electricity is available on the European electric plate.

The climate change emergency and the difficulty of balancing networks with a high proportion of renewables give us hope that these policies will be reviewed.

- **New large reactor construction in the West is challenging:**

In 2020, China, UAE, and Belarus added nuclear units. China is taking the lead in new construction with 18 reactors under construction. In 2020, Fuqing 5, the first of two Hualong One reactors'(HPR 1000; China's third-generation 1000 MW pressurized water reactor), was connected to the grid.

In Pakistan, the HPR 1000 Karachi 1 reactor sold by China was connected to the grid in 2021.

The Barakah facility is the first nuclear power plant in the Arab world. When its four APR-1400 reactors become fully operational, they should deliver about 25% of the UAE's electricity.

However, other projects, including most notably the Flamanville (in France) and Olkiluoto (in Finland) EPR reactors, have encountered significant construction difficulties with construction costs exceeding than 3 times the original budget and construction durations of at least 3.5 times the original timeline.

Nuclear power capacity continues to grow worldwide, as larger reactors[1] are added to the grid and smaller units are retired. Furthermore, uprates to some existing reactors have also added to the world's nuclear power capacity. The World Nuclear Association reports the total net installed capacity is about 400 GW as of early 2021.[2]

Nuclear power should rebound and increase by 2% in 2021[3], reversing only half of the decline in output that took place in 2020.

- **Small Modular Reactors are promising for certain usages:**

These are reactors with a power per module between 50 and 200 MWe[4] . Several technologies can be used including pressurized water reactors, as well as HTR[5] reactors as in China.

These modules are connected to obtain powers of up to 600 MW.

At the end of 2020, the IAEA counted 72 projects in development or under construction across 18 countries. They are developed by many players, ranging from public companies, including those in China and Russia, to North American start-ups[6] .

In 2021 no small modular reactors were in operation except the Russian barge of Rosatom, whose level of safety should be assessed. The most advanced projects are:

1. In North America, the NuScale Power: after the NRC[7] design approval in 2020, their first 720MW plant should be connected to the grid in 2029.

2. In North America, GE-Hitachi BWRX-300: a boiling water 300 MW reactor is at the stage of pre-application review.

3. In China: the ACP 100 (designed by CNNC) construction has started in July 2021 in Changjiang (Isle of Hainan).

4. South Korean's SMART 100 MW reactor is at the preliminary review stage.

1 50 reactors are under construction in 16 countries notably China, India, Russia and the United Arab Emirates. 7 new reactors came online in the second half of 2020 and Q1 2021 and up to ten more new reactors could be connected to the grid worldwide by the end of 2021, including four in China.
2 https://www.world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx
3 https://www.iea.org/reports/global-energy-review-2021/nuclear
4 For example, Nuward, the French SMR project, is designed with modules of 170 MWe each
5 HTR: High Temperature gas cooled Reactors
6 These start-ups are often supported by the US Department Of Energy
7 NRC: Nuclear Regulatory Commission

In the United Kingdom, Rolls-Royce unveiled in mid-May 2021 its reactor design and plans a commercial operation by the early 2030s. The French Nuward project, developed by EDF, Technicatome, Naval Group, and the CEA, is currently in the industrial design phase.

Thanks to their small size and simplified designs with passive safety features, SMR construction should be easier than that of large reactors. They are designed to use factory-built modules assembled on site. This modular construction was also the design of the APR 1000 from Westinghouse. However, this large reactor construction encountered significant setbacks, as factory production of the modules was prematurely started without all safety clearances which required many to be remanufactured.

The SMR's modular design is expected to significantly reduce construction times as compared to large nuclear reactors. The target time is around 4 years (compared to around 10 years for Hinkley Point C[1] EPR and more than 15 years in the case of Olkiluoto and Flamanville 3 EPR reactors). As such, a reduction in construction expenses should significantly reduce the cost of electricity generated[2]. The modular and standardized approach will also reduce manufacturing costs. However, the cost of safety studies and regulatory approvals for these reactors are similar to those for large reactors, while the electrical generation output is around half (or less) of that of large reactors. This will lead to a cost per kWh increase factor.

According to Nuscale, the capitalized construction cost per kW for their plant should be well below a 4-loop PWR ($2,850/kW versus $5,587/kW). Operating and maintenance costs for a NuScale plant should also be lower than those of the top 25% of U.S. large nuclear power plants[3] .

SMRs are better adapted to small grids than large reactors, with large electricity injections from the latter posing balancing issues. This would enable SMRs to replace coal plants, particularly those in the developing world, provided that the nuclear non-proliferation issues are solved and that spent fuel and wastes are managed in a sound way.

1 https://world-nuclear-news.org/Articles/Hinkley-Point-C-delayed-until-at-least-2026
2 Investment costs represents 80% of the cost of the final kWh
3 https://www.nuscalepower.com/benefits/cost-competitive

- **Large reactor financing is complex:**

A nuclear power plant project is characterized by high upfront capital costs and long construction periods, low and stable operational costs, and lengthy payback periods.

This investment profile, combined with the risks associated with construction, mean that the cost of financing is a key determinant of the cost of electricity generated.

Most nuclear power plants in operation were financed in regulated energy markets where returns on investment were generally secure. Market deregulation has worsened the risk profile related to investing in these new capacities because electricity prices are less predictable.

Several models have been used in recent years to facilitate large nuclear plant investments:

i. In the Western world, most models combine a long-term power purchase contract to reduce revenue risk, as well as a means of capping investor exposure. For example, this may be done through loan guarantees.

In the United Kingdom, the Hinkley Point project benefited from the sale price defined bythe "cost for difference" system. This mechanism has helped EDF and CGN finance the investment from their own funds together with loans benefiting from a British state guarantee.

Funding for Sizewell B could be different from Hinkey Point C in that it may have greater U.K. state involvement. This financing scheme is still under discussion.

In France, a higher price for the ARENH[1][2] mandatory 100 TWh/year sales from EDF to its competitors could improve the EDF balance sheet and allow it to finance the construction of new EPR reactors (EPR2). EDF has summitted in May 2021 its plan for the construction of three pairs of EPR2s.

The discussion on ARENH and related issues are lengthy and complex. They are linked to an EDF activities reorganisation (see below the "Hercule-Grand EDF" project description). However, long-term governmental commitment to the French new nuclear power program is indispensable.

The inclusion of nuclear energy in the green taxonomy in the EU would help attract potential investors wanting to fund green projects. The first EU act published in April 2021 did not include nuclear energy. It should be the subject of a separate decision, probably by end 2021.

ii. National companies such those as in China (CGN, CNNC) or Russia (Rosatom) are financing reactors in their territory and providing financing for reactor exportation. This is one of the reasons why Rosatom is successful in exporting its reactors. However, as Rosatom has both military and civil nuclear activities, the financing source of its civil activities is unclear.

iii. Financing SMRs should be less of a problem because they are smaller, easier to build, and lower investments are needed. One could even imagine financing them through a PPA[3] model.

- **Sector consolidation:**

Faced with the delay in the decision of the French State to launch new EPRs, Framatome continues to consolidate the nuclear sector. At the end of May 2021, it formalized the takeover of Valinox, which specializes in the manufacturing of seamless tubes. Earlier in the year, Framatome bought the Civil Nuclear activities of Rolls-Royce and acquired FoxGuar Solutions, the American specialist in industrial cybersecurity, in addition to overtaking the Schneider nuclear control command activities. These acquisitions aim to strengthen its skills, expand its offer, and gain a foothold in new markets.

1 For example increasing it from €42 to €48/MWh
2 ARENH Accès régulé à l'électricité nucléaire historique)
3 PPA: Power Purchase Agreement

3. Electrical batteries manufacturing has accelerated, driven by electrical cars development:

Electric batteries have experienced significant development in recent years, as driven by the need to decarbonize the transportation sector by increasing the electrical vehicles (EVs) sales. Stationary batteries (used for grid balancing) are benefiting from progress in EV batteries even if their characteristics, such as weight or charging time, are different.

These batteries will be more and more needed with the development of variable renewable energies. The latter reached up to 46% of electricity produced annually in Germany in 2020[1] and 47% in U.K. in Q1 2020. Much larger renewables shares in the electricity mix, can be reached on certain days. For example, in California, for a few hours in a row, the renewables percentage of electricity generation reached 90%[2] , with variable renewables (solar and wind farms) being the main contributors. In these cases, blackouts are possible as evidenced by one that occurred in California in August 2020.

More dramatic situations can be experienced. For example, fatal renewable generation, due to PV solar rooftop development, exceeded demand midday on October 11, 2020 in South Australia. In the absence of the possibility of balancing the network, the operator, if permitted, will curtail renewables. Curtailment was as much as 8.5% for solar PV in certain parts of Australia, 3% in China[3] , and a few percentage points in California.

- **Electric vehicles sales are growing fast:**

EVs, as well as hydrogen vehicles powered by low-carbon electricity, should contribute significantly to decarbonization of the transportation sector, which is responsible for more than 16% of global GHG emissions[4] . Of course, this makes sense only if the electricity used to power the batteries is predominantly carbon free.

In 2020, EV development was boosted both by battery cost decrease and by public policies[5]. The U.S. federal government is presently subsidizing electric cars with a $7,500 consumer tax break for the first 200,000 vehicles an automaker sells. President Biden has promised $400 billion in public investment in clean energy, including battery technologies for EVs. It will notably support 500,000 new EV charging outlets by the end of 2030[6] . In Europe, 2020 was the first year of CO2 emission targets for new passenger cars and light-commercial vehicles in the EU[7] . As part of the stimulus plans, EV purchase incentives increased, most notably in Germany and France.

In July 2021, the EU Commission revealed its “Fit for 55” plan that establishes a ban on internal combustion vehicles by 2035. In 2020, global sales increased by 39% year on year to 3.1 million units. This compares with a sales decline of 14% of the total passenger car market during the same year. In 2020, the global electric car stock hit the 10 million mark, a 43% increase over 2019, representing a 1% stock share. China, with 4.5 million electric cars on the road, has the largest fleet. That said, in 2020, Europe had the largest annual increase, reaching 3.2 million vehicles.

Studies[8] forecast that the number of EVs sold will rise to 30 million in 2028 and that EVs will represent nearly half of all passenger cars sold globally by 2030.

1 https://ieefa.org/renewable-energy-will-supply-46-3-of-germanys-electricity-this-year-utility-group/
2 Most of Saturday April 24 2021 afternoon
3 https://www.statista.com/statistics/973698/china-pv-power-curtailment-rate/
4 https://ourworldindata.org/ghg-emissions-by-sector
5 https://www.iea.org/reports/global-ev-outlook-2021/trends-and-developments-in-electric-vehicle-markets
6 The U.S. currently has less than 29,000 public EV chargers, according to the U.S. Department of Energy
7 The passenger car standards are 95 g/km of CO2, phasing in for 95% of vehicles in 2020 with 100% compliance in 2021. The light-commercial vehicle standards are 147 g/km of CO2
8 https://canalys.com/newsroom/canalys-global-electric-vehicle-sales-2020#:~:text=New%20research%20from%20Canalys%20shows,passenger%20car%

Electric vehicles are both a problem and a solution for the electricity grid. On one hand, they are a problem as simultaneous EV charging could saturate the distribution networks (even if this threat is lowered by Battery Management Systems development). On the other, as EV batteries are only used a few hours a day, they could help balance the grid. This point must be assessed by solving the following two issues:

i. Conflict between car owner and grid managers to use the EV or its battery

ii. Batteries manufacturers' guarantee for grid usages

- **To be economically viable, stationary batteries must be multipurpose:** They can be used in any of the following ways:

i. Standalone to offer ancillary services to the networks, notably through frequency regulation, primary regulation services, and secondary reserve services. For example:

- Large Neoen-Telsa battery installed in South Australia (Hornsdale Power reserve 150MW/200 MW) is collocated with Hornsdale wind farm and helps to stabilize the grid[1] .
- The U.K.'s first directly connected grid-scale AI controlled battery system of 50MW has started operation in June 2021 near Oxford.

1 100MW/129MWh with 50MW/64.5MWh expansion under construction https://hornsdalepowerreserve.com.au/

ii. Participation in capacity markets together with demand response. For example, in France RTE retained 250MW battery storage in early 2020 and was able to release it in half a second as power back to the grid when needed.

iii. Participation in grid bottlenecks solutions by avoiding heavy network investments: For example, the concept of a "virtual battery line" implemented by the French RTE in the Ringo experiment with 30-40 MWh battery storage to help solve congestion problems. In July 2021, the first batteries were installed on site. This project, initiated by RTE and its partner Nidec ASI, is intended to test the storage of occasional surpluses of variable renewables production and their destocking. By balancing storage and electricity release at all times, RTE does not modify the balance between production and consumption; therefore, RTE remains a neutral operator within the regulatory framework. The grid's regulation should evolve to allow more virtual lines to relieve congested power lines.

iv. Coupled with renewables to improve the regularity of their output and avoid curtailment: PV, onshore wind generation, and energy storage combined in hybrid farms are becoming a least-cost combination in advanced markets to avoid curtailment. A significant proportion of new renewables projects launched by large investors are hybrid projects, including storage batteries.

v. The global battery energy storage market is expected to reach $11 billion in 2025, with the market increasing by close to $5 billion between 2020 and 2025[1] . Asia Pacific will continue to lead the market, accounting for 54% of the global market value.

- **Technical improvements related to the battery's electrode composition, safety, and digitization:**

Presently Li-based batteries are dominating both EV and stationary batteries markets. Lithium-ion batteries come in a range of types[2] and have a variety of characteristics, including energy density, power density, safety, performance, and lifespan. That means that some are better suited for key applications than others.

In the late 2020s, Li-ion technologies could see increasing competition from other battery technologies, though Li-ion cells are expected to maintain their dominant position. The transition to solid-state battery technologies provides a clear 'next-step' for the industry, improving the flammability issues. Those safety issues will also be improved with diagnostics on the state of the battery, mostly by introducing intelligence through the injection of sensors, the role of which will be to detect the evolution of key parameters governing parasitic reactions.

- **Manufacturing boost:**

Li-ion battery global demand should increase more than ten-fold by 2029, reaching more than 1,800 GWh capacity. The pipeline capacity of battery giga-factories exceeds 2,000 GWh at over 145 facilities globally[3] .

i. China plays a dominant role in battery plants investments: In 2020, battery producers were mainly Chinese; the rest were Korean or Japanese. Planed mega-factories are predominantly in Asia (mainly China).

Chinese players are striking significant partnership deals with European automakers (CATL with Daimler and Volvo and BYD JV with Daimler.) CATL and SVOLT (from China) are building plants in Europe.

The Chinese company Envision, which acquired AECS, the Japanese battery manufacturer from Nissan, is also investing in Europe. At the end of May 2021, the company announced the construction of a battery plant in France in partnership with Renault (the French car manufacturer). In the U.K., in partnership with Nissan, the company should build a giga-factory able to support production of 200,000 battery's car a year.

1 https://www.power-technology.com/comment/global-battery-energy-storage-market/
2 LCO: Li-cobalt battery, LMO: Li-manganese battery, NMC: Lithium Nickel Manganese Cobalt Oxide ,LFP: Lithium Iron Phosphate ,NCA: Nickel Cobalt Aluminum Oxide
3 https://roskill.com/market-report/lithium-ion-batteries/

ii. China has also established a predominant place in upstream battery manufacturing by:

- Acquiring cobalt, lithium, and nickel mining projects in Chili, Australia, and Canada.
- Developing refining capacities: half of the lithium, cobalt and graphite refining capacities is located in China.

iii. Europe is reacting to its loss of sovereignty and in 2019-2021, 14 mega-factories have been launched, many of which are located in Germany. France and Germany have launched a strategic project called "batteries Airbus" to locate batteries manufacturing in their countries. In France, two mega-factory construction projects have been announced in 2020: the first being led by Automotive Cell Company, a joint venture formed by Saft (Total) and the PSA Group, and the second named Verkor, supported by EIT InnoEnergy, Schneider Electric, Capgemini, and the IDEC Group. The market for batteries in Europe is expected to grow at a CAGR of approximately 15.52% during the period between 2020-2025[1] to cover all the industrial needs of European car manufacturers. By 2030, 900 GWh batteries manufacturing capacity should be installed, covering the needs of 12 million EVs per year[2] .

- **Dramatic cost decrease:**

Li-ion battery pack prices have fallen by nearly 90% over the last decade[3] reaching $137/kWh in 2020; fully installed stationary batteries system costs dropped to $299/kWh in 2020 and should decrease to $167/kWh by the end of the century[4] . Standalone stationary batteries are usually not economical as in most regions, ancillary services remuneration is not sufficient. Securing multiple revenue streams is the key to providing the business case for battery storage.

- **Environmental and supply considerations are important:**

i. Environmental issues: According to recent studies[5] ,, the battery manufacturing process equates to approximately 40-45% of total CO2 emissions for a typical plug-in EV, which is by far the largest component. As a result, greater importance is now being placed on the sustainability of Li-ion battery supply chains, including second life and recycling of spent/faulty Li-ion cells. Second-life EV batteries could be used for stationary usages. However, their value to the grid is unclear. They need to be thoroughly tested and the cost of their end life should be clearly allocated between their first and second life span.

ii. Recycling: Batteries are using strategic metals, such as nickel and cobalt, the latter of which is supplied predominantly from the Democratic Republic of Congo and extracted in conditions that do not comply with humanitarian rights. Thus, many battery manufacturers are decreasing the use of cobalt in their products.

With the forecasted batteries expansion, there is a risk to totally deplete these already not abundant resources. It is thus imperative to recycle used batteries.

The battery recycling industry is presently concentrated in China and South Korea, where most of the batteries are made. Chinese players have already started to integrate their activities with recyclers. For example, CATL with Brunp.

Elsewhere,[6] many start-ups or conglomerates are emerging, such as: Li-Cycle in North America; Northvolt, BASF, Umicore in Europe; the newly-formed consortia Renault Veolia and Solvay in France; and Neometals and SMS Group in Germany.

These organizations aim to reduce recycling costs by automating and streamlining clean up

2 https://www.mordorintelligence.com/industry-reports/europe-battery-market-industry
2 Le Figaro May 28, 2021
3 Bloomberg NEF The Role of Storage in the Path to Net Zero Accenture RAEL in collaboration with the University of California - Berkeley
4 https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2020/
5 https://www.transportenvironment.org/what-we-do/electric-cars/how-clean-are-electric-cars
6 https://spectrum.ieee.org/energy/batteries-storage/lithiumion-battery-recycling-finally-takes-off-in-north-america-and-europe

In Europe, the cost of recycling batteries was estimated at $62/kWh in 2020, while in China, it is around $32/kWh[1] . Revenue generated from the sale of recycled material was estimated at $42/kWh in Europe and China.

By 2025, thanks to automation and scaling up, costs of recycling batteries should fall to around $40/kWh in Europe.

1 https://www.argusmedia.com/en/news/2178338-eu-battery-recycling-could-be-profitable-by-2025

4. Hydrogen

a. What is new?

Today, the role of hydrogen in the world energy system is still modest, making up just 2% of global primary energy demand. Production of pure hydrogen reached 70 Mt and total hydrogen, including syngas, reached 120 Mt in 2020. Most was used in oil refineries and chemical production.

Political support for hydrogen development acquired more momentum at the 2019 G20 summit in Japan. It is now at the forefront of Chinese, Japanese,[1] and European climate policies.

A few factors explain this shift:

i. The decreased cost of renewable electricity generation.

ii. The electrical grid balancing issues, which includes a large share of variable renewables. Hydrogen production would help balance the grid, as it allows for storage of large volumes of electricity, as compared to batteries, which can store only a few hours[2] . The same equipment that generates hydrogen by electrolyzing water (electrolyser) can release electricity when functioning as fuel cells.

iii. Hydrogen usage could decarbonize around 15% of our economy (including steel, refinery, and chemical), which cannot be done by using low-carbon electricity.

iv. Finally, hydrogen can be used in heavy transportation, such as trucks, trains, and boats, where battery volume would be too large and too heavy.

b. What are the challenges?

At present, 98% of hydrogen is produced from coal and methane (natural gas). Both processes generate significant CO2 emissions, which is why it is called “Grey Hydrogen.” A very small portion (0.3%) is produced from electrolysis of water, as powered by renewables.

Two main routes are available for low emissions hydrogen production:

i. “Blue hydrogen,” which is produced by the reforming of natural gas or by gasification of coal or coke with CCS. With a large existing fleet of gas and coal-based hydrogen plants, the move to large-scale, low-emissions hydrogen will require significant deployment of CCS plants.

Today there are a few industrial-scale reforming gas or coal gasification hydrogen facilities with CCS worldwide, producing a total of 1.4 Mt per year, representing slightly more than 1% of global production[3]. However, in August 2021, scientists from Stanford and Cornell universities published a study on the lifecycle greenhouse gas emissions of blue hydrogen accounting for emissions of both carbon dioxide and unburned fugitive methane. They conclude that far from being low carbon, greenhouse gas emissions from the production of blue hydrogen are quite high.

ii. “Green hydrogen,” which is produced by electrolysis of water using carbon-free electricity is a low carbon energy source.

- It is however expensive. According to the European Commission’s July 2020 hydrogen strategy report[4] , green hydrogen produced with renewable resources costs between $3/kg and $6.5/kg, whereas grey hydrogen costs about $1.80/kg and blue hydrogen costs about $2.40/kg. Further renewable generation costs decrease is a key factor for green hydrogen to reach parity with grey hydrogen in 2030. In addition, electrolysis cost (including installation) should decrease by 40% in 2030[5] thanks to:
    - Electrolyser cost reduction by technology improvements e.g., PEM(Proton Exchange Membrane) technology fitted for an intermittent electricity generation feed is not yet mature and improvements are expected. Other concepts are

1 https://www.mfat.govt.nz/en/trade/mfat-market-reports/market-reports-asia/japan-strategic-hydrogen-roadmap-30-october-2020/#:~:text=Japan’s%20Hydrogen%20Roadmap%20has%20an,fuel%20cell%20buses%20by%202030
2 Pumped hydro can do also but in Europe for example nearly all sites are equipped
3 https://www.globalccsinstitute.com/wp-content/uploads/2021/03/Global-Status-of-CCS-Report-English.pdf
4 pglobal.com/marketintelligence/en/news-insights/latest-news-headlines/experts-explain-why-green-hydrogen-costs-have-fallen-and-will-keep-falling-63037203#:~:text=Green%20hydrogen%20produced%20with%20renewable,Commission’s%20July%202020%20hydrogen%20strategy.
5 https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Dec/IRENA_Green_hydrogen_cost_2020.pdf

experimented as high temperature electrolysers developed by the CEA that promise higher production yields of hydrogen, thus driving a cost decrease

- Return of experience on prototypes

- Scale effect: the Norwegian electrolyser producer Nel unveiled early 2021its plans to cut the cost of its electrolysers by about 75% in a new 2GW factory — set to be the world's largest — which would reduce the price of green hydrogen to $1.50/kg by 2025.

- Electricity feeding optimization: either electrolysers operate during periods when there is an excess renewables production, or they are fed by dedicated renewables installations with collocation of wind/solar farms with the electrolysers. The latter option is probably more competitive as it saves balance of plan and other installation costs.

- Green electricity availability is a challenge : Europe's ambition is to develop at least 40 GW of electrolysers by 2030, imply a huge green electricity generation increase. If provided only by intermittent renewables, this would pose grid balancing problems. To mitigate this challenge:
  - Existing safe nuclear reactors should not be prematurely closed, present nuclear projects should be finished, and new builds launched.
  - Hydrogen could be imported from low-cost renewables generation countries (such as Morocco). It would be easier to transport hydrogen as ammonia than as liquid hydrogen that needs to be compressed at 700 bars[1] and cooled at -253°[2]

- Impact on electricity grids will depend on the electricity feed system:
  - Small electrolyzers collocated with renewables will require the storage of hydrogen (bottles, cavities) followed by transportation via pipelines. Investment in dedicated pipelines will be necessary.
  - If electrolyzers are located near their usages (such as steel plants or refineries), green electricity provided by the grid will be used to feed them, particularly when renewable generation exceeds consumption. In this case, electricity grid investments will be needed.

c. Hydrogen logistics and security questions are challenging:

It is possible to mix hydrogen in natural gas pipelines. Presently 6% is authorized in France and 10% in Germany. However, hydrogen, which is the smallest molecule, can escape through the steel interstices of certain steel grades, posing security problems since hydrogen combined with air explodes. Some existing pipelines could be converted to hydrogen, but there is the need to build dedicated ones. In Europe, 12 gas TSOs are planning to create 22,900 km pipelines for hydrogen.

Moreover, as hydrogen energy density is low, it must be compressed in dedicated vehicle fueling stations at 700 bars.

d. Many regions have launched subsidized hydrogen development programs

i. Europe:

Europe, the home of hydrogen industrial champions such as Air Liquide and Linde, wants to keep sovereignty on hydrogen technology and production. In 2020, Europe committed €180-470 billion to very large green hydrogen projects between 2020 and 2050.Member states like France and Germany have also committed to significant plans by 2030, pledging €7 billion and €9 billion, respectively.

1 1 bar is the atmospheric pressure, 700 bar is thus 700 times the atmospheric pressure. It is a lot
2 Hydrogen energy transported is only 25% per unit volume compared to gas

The European plan is to build 6GW of electrolysis by 2024 and a minimum of 40GW by 2030. By 2050, its quite ambitious objective is a 560 Mt/year CO2 abatement with green hydrogen providing 24% of the European energy needs.[1]

Many players are positioning themselves to contribute to the economy's further decarbonization, as well as benefit from the huge amount of funds allocated. Present champions include:

- Air Liquide and Linde;
- Utilities, including EDF, which has has created a dedicated subsidiary Hynamics, and invested in electrolyzers manufacturer, McPhy;
- Oil & Gas companies such as BP, which has entered a dedicated JV with Oersted (that will provide wind offshore electricity);
- Electrolyser's manufacturers (such as Nel, McPhy) or new players (like membrane specialist GTT acquiring Areva H2);
- Gas TSOs, such as "GRT gaz," which is sponsoring the Jupiter1000 power to gas prototype[2] , or Terega with "Lacq Hydrogen"; and
- Investment funds, which intend to acquire smaller players, many of which have a skyrocketing market valuation.

ii. China, the biggest contributor of greenhouse gases, has incorporated the hydrogen industry in its 14th Five-Year Plan (2021-2025) as one of China's six industries of the future.

The China Hydrogen Alliance[3] predicts that by 2030, China's demand for hydrogen will reach 35 million tons, accounting for at least 5% of China's energy end usage. The country announced in May 2021 that the fuel could account for 20% of the nation's energy mix by 2060, the deadline that President Xi has set for China to become a carbon-neutral country.

Chinese state-controlled oil giant Sinopec[4], the country's largest grey hydrogen producer, said it expects to launch its first green hydrogen project, fed by renewable electricity in the Inner Mongolia region in 2022. Located in Ordos, the green hydrogen plant is designed to have annual production capacity of 20,000 tons, with a total investment of ¥2.6 billion ($405.58 million). The city of Beijing has an ambitious plan to develop low-carbon fuels and aims to have more than 10,000 fuel cell vehicles on the road and build 74 hydrogen filling stations by 2025.

1 https://www.fch.europa.eu/sites/default/files/20190206_Hydrogen%20Roadmap%20Europe_Keynote_Final.pd
2 Jupiter 1000 is a Power-to-Gas industrial demonstrator project aiming at transforming renewable electricity into gas to be able to store it. The surplus electricity will be converted into hydrogen but also into synthetic methane
3 https://www.globaltimes.cn/page/202104/1220923.shtml
4 https://www.reuters.com/business/sustainable-business/sinopec-launch-first-green-hydrogen-project-2022-2021-05-25/

Electricity grids are at the heart of the energy system:

1. Large investments are needed for various reasons:

a. Grid enhancement: Massive investments in electric grids are necessary. The single biggest investment driver is infrastructure modernization and enhancement.

i. In Europe, approximately one-third of the grid is more than 40 years old.This share is likely to surpass 50% by 2030. The European "Ten-Year Network Development Plan 2020" forecasts a total CAPEX of €123 billion until 2030 for transmission and storage projects. In addition, European distribution grids will need investments of €375-425 billion until 2030.

The EU policy objectives[1] regarding energy network funding are changing with the "Green Deal" and the "Fit for 55" package. New rules are being proposed to stop EU funding for natural gas infrastructure and instead funnel cash into electricity and low-carbon energy networks to meet climate goals. According to EU energy commissioner Kadri Simson, "From now to 2030, we estimate that investments in electricity grids will have to double, compared to the last decade, reaching more than €50 billion per year."

ii. The U.S. grid is older than the Europe's grid: the average age of the U.S. installed base is 40 years old, with more than a quarter of the grid being at least 50 years old.

The Department of Energy announced in early June 2021, the availability of up to $8.25 billion in loans for efforts to expand and improve the nation's transmission grid. This will support the Biden Administration's commitment to modernize the nation's power grid.

The North American Power & Energy industry will be under pressure[2] as electricity demand is expected to grow at a rate of about 2% per year with strong renewables development and limited schedulable power capacity. The industry faces billions of dollars in maintenance and upgrades, which have been deferred for many years.It is also urgent to upgrade the grid's robustness for exceptional climate events that could become more frequent or more extreme given the current climate change trends.

For example, in February 2021 Texas experienced extreme cold weather which had never been observed in the past. Wind turbines froze and could not generate electricity while electricity consumption soared. The result was massive power cuts lasting several days.

In addition to equipment robustness to manage extreme weather conditions, investments are needed all over the world to accommodate a higher share of variable renewables in the electricity mix as well as new consumption behaviours. Hydrogen development will also require grid reinforcements.

b. Developing interconnections that help improve security of supply. For example, if the Texas grid would have been interconnected with neighbouring grids, restoration of the grid may have been quicker during the 2021 outages.

There are many submarine interconnections under construction or in project in Europe. These projects aim to improve security of electric supply and allow for better use of renewable electricity by matching customer needs on a larger geographical area.

For example, NordLink, inaugurated in May 2021, will allow Norway to export excess hydroelectricity to Germany, and Germany to sell excess wind power to Norway. This record-breaking 634-kilometer HVDC[3] cable has capacity of 1,400 MW with a voltage of ± 525 kV.

2. Digitization will improve grids stability: The grid—and distribution grids in particular—must become more and more digital with improved data collection via IoT equipment, such as: transformersuse of Artificial Intelligence for predictive asset management and self-healing; digital twin development; improved grid management IT systems; and more granular weather forecast data.

1 https://www.euractiv.com/section/energy/news/eu-shifts-energy-infrastructure-funding-away-from-gas-into-electricity-grids/
2 https://www.mordorintelligence.com/industry-reports/north-america-power-markets https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2020.pdf
3 HVDC : High Voltage Direct Current

This increasing digitization is also driven by decentralized generation, microgrids, self-consumption, and EV charging growth. Consequently, data volume is increasing quickly and data storage is getting more decentralized.

In the EU, the global data volume generated by grids is growing very significantly with increasing decentralized storage increasing cyberattack risks.

3. Cybersecurity is a growing concern both in Europe and the U.S.: Data volume growth and theshift to a decentralized storage model are increasing the risk of cyberattacks.

Cyber risk has more than quadrupled since 2002 and more than tripled since 2013.

In April 2021, following a high-profile, through ultimately unsuccessful, cyberattack in Florida that sought to compromise a water treatment plant, the Biden administration kicked off a 100-day effort to enhance cybersecurity of the nation's power grid, calling for industry leaders to install technologies that could thwart attacks on the electricity supply.

On May 7, 2021 the Colonial Pipeline, an American pipeline system that originates from Houston and transports fuel oil primarily to the South-Eastern part of the U.S., suffered a ransomware cyberattack, which forced the computerized equipment operating the pipeline to shut down. The attack interrupted all pipeline operations and disrupted supplies for several days, causing fuel shortages in states such as Georgia, North Carolina, and South Carolina. U.S. President Joe Biden declared a state of emergency on May 9. It was the largest cyberattack on oil infrastructure in U.S. history.

Cyberattacks are a significant concern for President Biden. On June 16, 2021 at a U.S.-Russia presidential meeting, President Biden warned his Russian counterpart that 16 specific entities defined as critical infrastructure under U.S. policy, including energy and water, were "off limits to cyberattack."

4. Energy transition is transforming grid management: Another significant part of the electrical grids' investment need is driven by the ongoing energy transition.

a. These include expansions and replacements related to ***integration of variable renewables*** such as solar and wind.

The German Energiewende[1] with the closure of the country's nuclear plants (an in the future the coal plants) has triggered a grid overhaul. The North-South German Interconnection's[2] four corridors project now under construction will wheel electricity from offshore wind farms in the North Sea to the southern, industrial part of Germany. These North-South underground lines constructions are challenging projects, especially on the technical side involving 700 kilometers HVDC cables (±525 KV) using XLPE[3] insulation.

b. In addition to new lines construction, ***new flexibilities*** are needed to face intermittent decentralized generation growth. As mentioned in the 2020 WEMO edition, these flexibilities can be provided by better using the available data improving ancillary services remuneration to allow new player involvement and by enabling new technologic solutions. For example, this may include physical assets, such as using storage batteries or idle EV batteries or virtual components, such as a battery-enabled virtual power lines[4] .

Smart grids at scale with higher digitization are progressively being deployed at the distribution grid level to enable managing increasing shares of renewables, stationary batteries (see above)and new consumption patterns as collective and individual self-consumption and energy communities. Growth of EVs represents a potential source of storage and demand-side flexibility, but also poses challenges to the grid balancing.

1 German Energy Transition
2 https://ec.europa.eu/energy/sites/default/files/documents/pci_factsheet_de_ns_interconnection_2017_0.pdf
3 XLPE Cross-linked polyethylene
4 Ringo RTE project

c. As pointed out in the WEMO 2020, ***the regulatory framework should be adapted***. To finance these large investments, remuneration of capital, as included in transmission tariffs, is a main pillar.

However, most European regulatory framework tariffs do not cover non-capital-related activities, including those aimed at system management, digital solution deployment, and other innovations.

These investments are essential to increasing the grid management flexibilities needed to accommodate significant variable renewables share. Thus, grid tariff calculating rules should evolve to remunerate these "softer" investments.

5. Security of supply is a growing concern: In IEA's[1] New Policies Scenario, 21% of global electricity production is projected to come from variable renewables by 2040, up from 7% in 2018. This is supported by about $5.3 trillion in investments. The EU share is even higher at around 39%.

This expansion of variable renewables is leading to challenges to power systems management as illustrated by the near blackouts in Europe[2] during the confinement period in April 2020.

1 https://www.iea.org/commentaries/more-of-a-good-thing-is-surplus-renewable-electricity-an-opportunity-for-early-decarbonisation
2 See WEMO 2020

The August 2020 California rolling blackouts were, unfortunately, another illustration of the difficulty to balance grids with high renewable shares. Those blackouts were triggered by an exceptional heat wave and a consequence of heavy reliance on solar power. The regulator and the network operator have recognized a need for more generation redundancy, electricity storage, and demand-response solutions implementation. Consequently, in August 2021, California authorities gave their green light to the construction of five gas plants (30MW each)in order to avoid new blackouts.

However, fears of electricity supply shortage during the 2020-2021 winter in Europe were not justified. Those fears were linked to the lower nuclear plant availability due to the lack of or slow-down of maintenance operations during confinement months. Even with the two Fessenheim reactors closed for political reasons, EDF succeeded in putting enough nuclear reactor power stations back into service to provide needed electricity generation during tense winter days. However, as mentioned above, they are worries about security of electricity supply in Europe during the winter 2021-2022and the following one.

6. Electricity markets rules must be adapted: As more countries move to higher variable renewables shares, it appears that curtailment will be more widely used to balance the grid, leading to waste a portion of the billions invested in renewables.

In China, for example, the national average for wind curtailment was around 7% in 2018, with much higher levels in certain provinces[1].

In 2019, the Canadian province of Ontario has curtailed 6.5 TWh of clean electricity– an amount sufficient to power 720,000 average-sized homes for one year[2]

To avoid these curtailments:

a. Renewables generation should become more schedulable thanks to:

i. The development of hybrid farms associating storage batteries and/or green hydrogen production to wind or solar generation; or

ii. The use of more accurate and granular weather forecast algorithms.

b. Demand side management must be boosted. Market players as

aggregators have already developed technologies enabling even small customers to take advantage of grid managers remuneration for removal of their consumption during tense periods.

In addition, dynamic pricing, when implemented, can enable end customers (including domestic customers or small- and medium-sized businesses) to take advantage of cheap electricity when there is abundant renewables production.

The June 2019 European Directive requires suppliers with more than 200,000 customers to offer dynamic pricing contracts from 2021 onwards.

These are electricity supply contracts that reflect price variations in the spot electricity markets. In its 2018 report on dynamic electricity prices[3] , Ecofys demonstrates that dynamic power prices can lead to cost savings at the system and consumer level and that the results are generally positive in European countries that have already adopted this pricing system.

However, this system could be difficult to understand by individual customers and could lead to erratic electricity bills. In France, the Energy Regulatory Commission (CRE) has noted that the absence of relevant supplier information poses a risk for domestic consumers and wants to strictly regulate those offerings through clear communication and easy-to-understand criteria or definitions.

1 https://www.rechargenews.com/wind/-china-wind-capacity-to-double-by-2028-as-curtailment-drops-/2-1-659479
2 https://www.businesswire.com/news/home/20200903005165/en/Ontario-Wasted-Enough-Clean-Electricity-to-Power-720000-Homes-in-2019-OSPE-Data
3 https://asset-ec.eu/wp-content/uploads/2018/10/Dynamic-electricity-prices.pdf

Energy players:

1. Oil & Gas companies are under a lot of pressure:

The Oil & Gas industry is in the eye of a new storm, with:

a. Increased volume and price volatility: In 2020, Oil & Gas companies had to absorb a double shock: the oil price decrease linked to the OPEC-Russia divergences (the barrel prices crashed by more than 60% in just four months) and the consumption decrease linked to the pandemic. The 2020 results of the industry's five major players have shown cumulative losses of more than €60 billion as compared to 2019 when they had reported cumulative gains exceeding €40 billion. Many of them have sharply reduced their exploration spending, halting the implementation of new projects, and prompting re-evaluation of their asset portfolios to concentrate in already known areas and thereby limit risk. In 2020, their investments in upstream activities dropped to around $300 billion, the lowest since 2005.

The economic recovery in 2021 has led to an increase in oil demand and prices. Price levels will depend on the global economic recovery pace, shale oil production growth, and the OPEC+ member's discipline.

b. Stakeholder's pressure: Oil & Gas majors are subjected to strong pressures from climate change-related influencers and shareholder activism.

i. In May 2020, the IEA published its Net Zero by 2050 report. This report sets out 400 milestones to achieve net zero and provides analysis on what it considers to be the most technically feasible, cost-effective, and socially acceptable pathways to bringing global energy-related carbon dioxide emissions to net-zero by 2050. It outlines a route to net zero emissions by 2050 in which coal demand falls by 90%, gas demand is down 55% and oil demand falls 75%. Most importantly, it states that all oil companies must curb all exploration by 2022 to reach the net zero goal by 2050.

ii. This report is strengthening major oil companies' shareholders pressure to establish a carbon neutral strategy by reducing their scope 1 and 2 emissions, as well as scope 3 emissions, which is much more challenging. This movement, which started in the late 2010s in European majors' shareholders meetings, is now spreading to American companies.

In mid-May 2021, Royal Dutch Shell lost a Dutch legal case brought by environmental activists. The court ruled that the company had to reduce its greenhouse gas emissions more aggressively than planned. Meanwhile, shareholder protesters shook both ExxonMobil and Chevron when climate-change activists took two seats on Exxon's board and Chevron was forced to commit to tougher emissions-reduction targets.

On the other hand, TotalEnergies' strategic climate plan was approved by more than 90% of shareholders. The Company is committed to investing €60 billion in renewables and electricity and reducing its sales of petroleum products by a third (compared to 2015) over the next ten years.

This combined pressure from reputable institutions such as IEA and oil major's shareholders could force Oil & Gas majors to stop exploration campaigns and not launch new projects, which could in turn lead to a significant decrease in their reserves and push oil prices up.

Consequently, majors are targeting more than $30 billion[1] in disposals in the coming years. Private companies and National Oil Companies (NOCs) that are not under the same environmental related pressure are natural buyers.

1 Financial Times 7 July 2021 https://www.ft.com/content/4dee7080-3a1b-479f-a50c-c3641c82c142

Let's recall that major Oil & Gas companies account for only 12% of oil and gas reserves, 15% of production, and 10% of the emissions from the sector's operations.

These asset's transfer would be negative for the sovereignty of Western countries and for the climate. In addition, the resulting price shock would make access to energy more expensive, especially for developing countries which are large oil consumers.

c. European Oil & Gas companies are aiming to become renewables champions:

Unlike Americans majors who are betting on CCS, European oil companies have started to invest in renewables several years ago. Capitalizing on their expertise in running giant offshore structures and managing the production, storage, transport, and distribution of gas, oil operators would have the ability to generate value in offshore wind power projects or the large-scale use of "green" hydrogen as an energy source.

For example, Repsol is participating in the development of the first semi-submersible wind farm off the coast of Portugal with Engie and EDP. Shell has signed a deal with Amazon for the distribution of renewable electricity from an offshore wind farm in the Netherlands. BP, for its part, is stepping up its expansion in wind power generation with the purchase of a 50% stake in two offshore wind projects in the U.S. from Equinor for $1.1 billion; more recently, the company formed a new partnership with EnBW for setting up and operating a 3 GW wind farm in the North Sea.

Orsted, the former Danish national oil company, plans to grow its 10 GW installed capacity in 2020 to 30 GW by 2030.

Total has made a dramatic move by positioning itself across all segments of carbon-neutral energy and has adopted a new name, TotalEnergies. The French group, which is investing heavily in wind and solar electricity generation with the ambition to reach 100 GW installed capacity by 2030, is also developing its battery subsidiary, Saft. Together with the PSA group, Saft intends to build gigafactories in northern France and Germany.

2. Utilities weathered the 2020 storm better than Oil & Gas majors:

a. European utilities are increasing their renewables portfolios:

i. Financial results were lowered by the crisis: In 2020, utilities' financial results were impacted by consumption and spot prices decreases.

Electricity consumption decreased by 4% and spot prices by 32%; gas demand and spot prices decrease was similar to that of electricity[1]. European utilities financial situation was diversely impacted with in general moderate revenue decreases and more significant net margins drops deteriorating their leverage ratio[2] . In certain cases, important divestments, such as Engie's sale of its Suez shares to Veolia, led to an improvement in this ratio.

The pandemic-related lockdown and social distancing measures prevented EDF from executing its nuclear reactor's annual maintenance and fuel loading program. These programs are difficult to reshuffle, since they are the result of a complex optimization between regulatory constraints, specialized workers' availability, and spent fuel replacement by fresh one (see above).

These players weathered the crisis much better than the oil companies for several reasons:

- While conventional electricity generation (including nuclear) was significantly reduced, renewables generation increased with generally good margins.
- Thanks to electricity generation hedging policies, their turnover was not too severely impacted by the drop in spot prices.
- They benefited from the resiliency of their network operations.
- As oil companies, they implemented cost-cutting programs and delayed investments when possible.

1 https://ec.europa.eu/energy/sites/default/files/quarterly_report_on_european_gas_markets_q4_2020_final.pdf
2 Leverage ratio: net debt/EBITDA

Some utilities' 2021 results could still be impacted by the pandemic crisis through 2020 forward electricity sales at low prices. In France, nuclear reactors' availability will not be restored to pre-pandemic levels before mid-2022, leading to lower nuclear electricity generation for EDF.

New plant construction suffered pandemic-related delays. For example, Hinkley Point C and Flamanville 3 have increasing construction costs.

However, the electricity and gas consumption rebound in 2021 and significant price increases will contribute to the restoration of utilities' financial situation.

ii. Large utilities reform plans are in progress: While European utilities are focusing their investments on renewables, batteries, and electrical mobility, they are lowering their ambition in services. The latter was a strategic development component over the past several years that proved difficult and insufficiently profitable. They have been partly cannibalized by the development of digital. For example, thanks to the development of smartphones, which allow for remote control, residential utilities customers can directly adjust their heating and air conditioning and provide remote monitoring of their home security. This makes many home utilities services unnecessary.

- ***Engie:*** After a net loss of €1.5 billion in 2020, and under the leadership of its Chairman and new CEO, the Engie group has begun its overhaul to refocus on renewable energies (biomethane, wind power, photovoltaic, etc.) and the supply of natural gas (transport, distribution, and storage).

At the start of 2020, the company sold 29.9% of Suez (water management services) to Véolia for €3.4 billion. The company should complete the sale of its service activities by end 2021. They are grouped in the "Equans" entity, whose activities include electrical engineering, HVAC &refrigeration mechanical and robotic engineering, digital and ICT and facility management. These activities represent around €13 billion in turnover and are valued between €4 and €6 billion

- ***EDF:*** Hercules project

In 2011, France set up a system called ARENH[1] , which aimed to encourage the development of competition in its electricity market. This regulation, which will be extinguished in 2025, requires EDF to sell 25% of its total nuclear production (around 100 TWh) to its competitors at a regulated price of € 42/MWh.

This system has several drawbacks for EDF:

- It is asymmetrical: EDF has a commitment to keep this electricity (for example not to sell it on the forward markets) for its competitors while the latter have no commitment to buy it[2]

- The regulated price of € 42/MWh has not been revised since 2012; it is very clearly below the marketas in the first half of 2021, average spot price was around € 58/MWh.

- Finally, with the evolution of the electricity market, EDF's competitors are no longer young start-ups but large groups (TotalEnergies, Engie) or subsidiaries of large European energy companies (Alpiq, ENI, Iberdrola, Vattenfall) that do not need to be supported in their diversification policies.

This system is a handicap for EDF which has a heavy debt[3] on its balance sheet and which must finance extending the lifetime of its current reactors, the construction of new reactors[4] in order to replace those reaching the end of their lifetime, as well as development of renewable energies and storage. Negotiations have started with the European Commission to repeal this regulation from 2022 and increase the regulated price of nuclear-regulated electricity to around €48/MWh[5] .

In exchange, EDF should reorganize by setting up three entities:

1 https://www.optima-energie.fr/actualite/l-arenh-en-2021-un-fonctionnement-en-perte-de-vitesse/
2 They buy this electricity only if the market price is above 42 € / MWh
3 EDF's debt amounted to € 43bn at the end of 2020
4 It would be necessary to decide at the end of 2022 to launch the construction of 3 pairs of EPR2 reactors, the first of which would start electricity generation in 2035-2037
5 This price would apply to all of EDF's French nuclear electricity production with the current fleet and the Flamanville 3 EPR, and no longer only to the present 100TWh

- The “EDF Bleu” entity, which is 100% owned by the State[1], to house nuclear activities

- A regulated entity, EDF Azur, which would be a subsidiary of EDF Bleu, to house the hydraulics, making it possible to avoid competition between hydraulic concessions.

- Finally, the creation of EDF Vert, where the commercial department, energy-related services, renewables, and Enedis electricity distribution activities would be housed. The capital of EDF Vert would be open on the stock market[2] to finance development in renewable energies and investments in the distribution network.

This project, called ”great EDF” formerly known as “Hercules” , encountered strong opposition from EDF trade unions. In addition, negotiations with the EU commission on the rules of governance and circulation of financial flows between the entities making up the new EDF turned out to be very complex.

Given the French electoral deadline[3] and the need to pass a law to change the structure of EDF, it is very unlikely that this project will materialize in 2021.

iii. Renewables development: Like Oil & Gas companies, utilities are racing to increase their renewables and storage capacity portfolios.

The renewable champions are: Enel (46 GW); Iberdrola (34 GW); EDF (33 GW); Engie (31 GW); and, in the U.S. Nextera (25 GW).

The most ambitious companies, Iberdrola and Enel, are planning to triple their capacity by 2030.

EDF, limited by indebtedness, plans to “only” double its capacity. Engie also has an ambitious plan to reach 80 GW by 2030.

Utilities are also embracing new technologies development as hydrogen.

b. U.S. utilities trends are like those in Europe[4] :

i. Sustainability is a growing commitment:

Like their European counterparts, U.S. utilities, are committed to getting the energy they provide as clean as possible without compromising on reliability or affordability. In 2020, 40% of the U.S. electricity came from carbon-free sources, including nuclear energy, hydropower, wind, and solar energy. Carbon emissions from the U.S. power sector were at their lowest level in more than 40 years—and will continue to fall.

Replacement of coal by gas in electricity generation has enabled significant emissions decreases.

ii. U.S. utilities are more profitable than their European counterparts: In 2020, U.S. Q2 electric output fell by 4.7% year-to-year with a full-year decline of 2.9%. However, that weakness was focused on commercial and industrial load, which fell more than 10% year-to-year from Q2 onwards. Residential demand actually jumped by 7.5% in Q2, from roughly 3% to 4% in 2020’s second half as people remained at home. The rise in higher margin residential demand helped soften the pandemic’s impact on utility earnings.

As a result, total EEI[5] utilities revenue declined by 3.8%, from the prior year. Thanks to lower energy operating expenses, net income rose by 4.2%.

The utilities Index[6] fell by 6% percent in 2020, a deviation from the classical pattern as utilities are usually seen as safe havens in times of market stress.

This performance was far better than the oil industry, where the index fell by more than 33%.

1 At the beginning of June 2021, the State held 83.7% of the capital of EDF
2 At 30% maximum
3 In May 2022
4 https://www.eei.org/issuesandpolicy/Finance%20and%20Tax/Financial_Review/FinancialReview_2020.pdf
5 The Edison Electric Institute (EEI) is the association that represents all U.S. investor-owned electric companies. Its. members provide electricity for 220 million Americans and operate in all 50 states and the District of Columbia.
6 It measures Utility’s shares Total Shareholder Return,

iii. Utilities investments are mainly in renewables: The electric utility industry brought around 35 GW of new capacity online in 2020; this was a 38% increase over 2019.

Similar to Europe, wind and solar new capacity accounted for a 75% share of 2020's added capacity. Projected capacity is overwhelmingly renewable with solar representing 48% of the total and wind 30%. Natural gas generation accounts for 18% and nuclear 3%.

Since 2015, total installed energy storage capacity in the U.S. has increased about 13%, from nearly 23 GW to about 26 GW. Pumped hydro accounts for the majority, at roughly 84% of the total. Yet battery storage is, by far, the fastest-growing storage technology, increasing six-fold from 540 MW in 2015 to more than 3 GW in 2020. By 2025, energy storage is expected to continue its rapid growth, with approximately 31 GW of new battery and pumped hydro energy storage projected to come online, increasing total capacity by 120%.

The conditions for a successful energy transition

Populations in developed countries, and young people in particular, are very concerned by climate change questions. The COVID-19 pandemic has not changed this attitude; in fact, it has in some ways reinforced it. Their wish is for the world post-coronavirus to be "greener" than before.

By contrast, populations in developing countries, notably the poorest countries, (the populations of which represent a large majority of the world population) want, above all, to get out of poverty and achieve an acceptable standard of living; thus, climate issues do not come first.

All GHGs impact climate change:

According to the scientific studies analysed and reported by IPCC[1] , anthropogenic greenhouse gases are extremely likely to have been the dominant cause of the observed warming since the mid-20th century.

Continued emission of greenhouse gases will cause further warming, increasing the likelihood of severe and irreversible impacts for people and ecosystems.

In December 2015, nearly all countries signed the Paris Climate agreement and committed to substantially reduce their GHG emissions to limit global warming to below 2°C and better than 1.5°C, relative to pre-industrial levels, by 2100.

Different GHGs exist, including carbon dioxide (CO2), methane (or natural gas), nitrous oxide, and ozone. These GHGs have different lifespans in the atmosphere and different Global Warming Power (GWP) scores compared to CO2. Methane is a potent GHG[2] responsible for about 40% of planetary warming.

Methane levels in the atmosphere surged during 2020, driving the biggest increase since records began in 1983. A May 2021 United Nations backed study[3] urged reductions of methane emissions by 40% during the coming decade.

Agriculture is a major source of methane and accounts for about 40% of human-related emissions; fossil fuels account for 35% of those emissions, while landfill and wastewater accounts for 20%.

The measures to cut methane recommended by the report include faster gas leak detection, landfill covering, and eating less meat.

As primary energy demand dropped nearly 4% in 2020, global energy-related CO2 emissions fell by around 6%[4], the largest annual percentage decline since World War II. In absolute terms, the decline in emissions of almost 2 billion tonnes of CO2 is the equivalent of removing all of the European Union's emissions from the atmosphere.

However, due to the global economic recovery, energy-related carbon dioxide emissions are on course to surge by 1.5 billion tonnes in 2021, reversing most of last year's decline[5] .

Unless a new global crisis happens, GHG emissions would increase even more in 2022.

The world temperature increase is not on the right trajectory to meet the goals set in the Paris Agreement. According to the Nationally Determined Contributions (NDCs) that were summitted, temperatures are set to increase by 2.7°C by 2100. In its June 2021 report, the IPCC estimates [6] that exceeding +1.5°C could lead "gradually to serious consequences, for centuries, and sometimes irreversible." Moreover, the World Meteorological Organization suggests that there is a 40% probability that this threshold of +1.5°C will be exceeded as early as 2025.

1 https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_SPM.pdf
2 A tonne of methane has a GWP of 84 on a 20-year scale,
3 https://news.un.org/en/story/2021/05/1091402
4 https://www.iea.org/articles/global-energy-review-co2-emissions-in-2020
5 https://www.iea.org/news/global-carbon-dioxide-emissions-are-set-for-their-second-biggest-increase-in-history
6 According to June 2021 new report extracts

In addition to energy conservation, the substitution of fossil fuels by carbon-free energies (that we analysed in preceding sections) should be accelerated. In 2020, fossil fuels (that are GHG emitters) represented more than 80% of global energy consumption and up to 84% in China[1] . However, those primary sources of energy are essential to ensuring an affordable energy supply needed to sustain economic growth in certain developing countries and in China.

Thus, the question that arises is: ***How can we ensure the energy supply of populations under acceptable economic conditions without depleting the planet's resources (energy, aquifers and minerals) and without temperature increases exceeding 1.5°C by 2100*** (compared to the pre-industrial era)?

We will analyse the involvement of governments, the financial sector, and businesses in answering this crucial and complex question and try to define the conditions of success for this difficult transition.

Government mobilization is key: Politicians enlightened by scientists should adopt realistic plans with the means to achieve them.

1. In 2021 country leaders increased their commitments to fight against climate change:

a. China[2] : At its address to the 75th session of the UN General Assembly in February 2021, President Xi Jinping declared that China would aim to have CO2 emissions peak before 2030 and achieve carbon neutrality by 2060.

China also announced that it would enhance its nationally determined contributions under the Paris Agreement for 2030 and issued rules for its emissions trading scheme for the power sector. Carbon trading is expected to begin in late 2021.

If achieved, China's carbon neutrality would lower the projected rise in average global temperature by an estimated 0.2 to 0.3°C. This commitment alone would represent 25% of the climate effort needed to keep the average global temperature rise within the 1.5°C Paris Agreement target (assuming all other factors remain constant).

China[3] sits at a crossroads. On one hand, China is well positioned to reap a large share of the economic opportunities and geopolitical advantages of a low-carbon transition. China has positioned itself as a leading manufacturer of green technologies, from EVs and electric batteries to solar panels and wind turbines. The country is therefore poised to meet growing global demand for cleaner technologies and become one of the big winners in a global low-carbon transition.

On the other hand, coal is critical for the country to provide the energy needed to pursue its economic growth and increase the living standards for 1.44 billion citizens. Therefore, China has accelerated the construction of coal fired plants (see above), threatening China's decarbonization plans and hampering worldwide efforts to tackle climate change.

b. Japan: At the Climate Summit hosted by U.S. President Biden in April 2021, Japan's prime minister committed to nearly doubling the country's 2030 target for cutting carbon emissions, raising the target to 46%[4] (from 26%).

In July 2021, the industry minister unveiled a draft of Japan's 2030 revised energy policy. According to this plan:

i. The renewable energy share in the country's electricity mix would grow to 36-38% (double the level of 18% in 2020)[5];

ii. Nuclear electricity should contribute to 22% of the electricity generation even though the country has struggled to reopen nuclear reactors after the 2011 Fukushima accident; and

iii. The use of coal in the energy mix will be reduced to 19% (from 26%) and that of gas will decrease to 41% (from 56%).

1 https://theconversation.com/china-finances-most-coal-plants-built-today-its-a-climate-problem-and-why-us-china-talks-are-essential-161332
2 https://odi.org/en/insights/five-expert-views-on-chinas-pledge-to-become-carbon-neutral-by-2060/
3 https://theconversation.com/china-finances-most-coal-plants-built-today-its-a-climate-problem-and-why-us-china-talks-are-essential-161332
4 Compared to 2013
5 The earlier target was for renewables to contribute 22-24% of electricity in 2030.

c. U.S.: On June 1, 2017, then-U.S. President Donald Trump announced that the U.S. would cease all participation in the 2015 Paris Agreement on climate change mitigation. The withdrawal took effect on November 4, 2020, one day after the presidential elections. In January 20, 2021, on his first day in office, President Biden signed an agreement to bring the United States back into the Paris Agreement.

In his "American Jobs Plan," President Joe Biden aims to achieve unprecedented investment in action to address climate change.

The administration's $ 2 trillion infrastructure plan included $174 billion in spending to boost the electric vehicle market and shift away from gas-powered cars.

The plan also proposed $100 billion in funding to update the country's electric grid and make it more resilient to climate disasters, such as the recent winter storm that disrupted Texas's power grid and California's July 2021 outages related to the big Dixie Fire. Following Pacific Gas and Electric acknowledgment that its equipment might have sparked the Dixie Fire[1] , the company committed to moving 10,000 miles of its power lines underground.

Biden's plan should also retrofit millions of homes to increase energy efficiency, with efforts focused on the low-income and minority communities most vulnerable to climate change.

The plan provides for the creation of an agency, ARPA-C (C for climate) "to develop new methods of reducing emissions and strengthening climate resilience." An estimated $15 billion could l be directed towards the storage of large-scale energy, carbon capture and storage, hydrogen, advanced nuclear, tidal turbines, biofuels, quantum computing, and electric vehicles.

Passing this plan through Congress and Senate is difficult. However, early August 2021, the Senate passed a $1 trillion bipartisan infrastructure plan, half the amount of the initial plan but still an historic piece of legislation that should reshape American infrastructures.

d. Europe: The €750 billion European COVID-19 recovery plan, adopted in June 2020, dedicates 30% of funds to climate change issues. Unfortunately, it took around one year to free the related funds, thus slowing down the related actions.

In December 2020, the EU member states have agreed, after difficult negotiations, to lower by 2030 the region's emissions targets by 55% as compared to 1990. On July 14, 2021 the EU commission announced its bold "Fit for 55" package that will take years to implement (see above).

e. Global COVID-related recovery plans: A comprehensive analysis[2] of COVID-19-related fiscal rescue and recovery efforts has shown that in the largest 50 economies $368 billion of the $14.6 trillion in 2020 spending was green.

It is estimated that 18% of the future spending, or $341 billion, can be considered green. This includes:

- $66.1 billion invested in low carbon energy, thanks in part to Chinese and Korean support for renewable energy projects, as well as French and German hydrogen investments;
- $86.1 billion announced for green transport, notably through electric vehicle transfers and subsidies;

1 https://www.sacbee.com/news/california/fires/article252927498.html
2 Evidence from 2020 and Pathways for Inclusive Green Recovery Spending https://wedocs.unep.org/bitstream/handle/20.500.11822/35281/AWBBB.pdf

- $35.2 billion dedicated to green building upgrades to increase energy efficiency, mostly through retrofits, notably in France and the U.K.;
- $56.3 billion announced for Nature Based Solutions ecosystem regeneration initiatives and reforestation;
- $28.9 billion was announced in green R&D, including renewable energy technologies and technologies for decarbonising sectors such as aviation, plastics, and agriculture, and carbon sequestration.

The report estimates that without progress notably in green R&D, meeting the Paris Agreement targets would require even greater pricing and lifestyle changes.

HOME

2. All facets of the problem must be considered when changing: This includes public opinion, international relationships, employment, security, and cost of energy supply.

Here we share a few examples:

a. Excessive recommendations are damageable: According to the IEA May 2021 "Net Zero by 2050" report (see above), energy groups must stop all new oil and gas exploration projects by the end of 2021 if global warming targets are to be kept[1]. The agency admits the contraction of oil and natural gas production will have "far-reaching implications" for producing countries and companies. These implications have been discussed above.

However, a sudden halt to new oil and gas exploration projects appears improbable.

The agency recommendation is at odds with a deal the U.K. government reached in March 2021 to continue allowing North Sea offshore oil licensing in exchange for pledges to cut emissions. Consequently, the U.K. will not commit to stopping new oil exploration in the North Sea, owing to the fact that a halt would threaten jobs in Britain's large oil and gas industry.

Norway appears to be taking a dual approach to energy transition. In its June 2021[2] energy white paper, the Norwegian government says it is committed to producing renewable energy and bolstering its power grid. However, the country is unwilling to halt development of its oil and gas resources.

The prospect of no new exploration drew a frosty response from U.S. industry groups[3] .

For example, the National Offshore Industries Association (NOIA), which supports the Paris climate treaty's goals, said the IEA's roadmap places efforts to reduce global warming ahead of all other concerns. "Climate and emissions solutions need to balance the environmental, social, economic and energy needs for society. Progress in one cannot come at the expense of another need," said NOIA president Erik Milito.

b. Energy transition plans are generally not realistic:

i. According to the latest estimates and despite an acceleration expected in 2021, France will not achieve its objectives of the Pluriannual Energy Programming (PPE) which included installing 44.2 GW of onshore wind and solar capacity by 2023. This is duenotably, to many oppositions at the local level[4]

ii. In January 2020, the German government agreed on a €40 billion deal with coal-producing regions to phase out coal power plants by 2038.

Less than 18 months later, a climate law adopted by Merkel's cabinet will require Germany to close these plants much earlier than 2038. Germany now plans to become carbon neutral by 2045 (rather than 2050) and reduce greenhouse emissions by 65% (rather than 55%) by 2030.

This change was in response to a constitutional court ruling that the previous law placed too much responsibility on the young generation for cutting emissions. Under the new plan, Germany must raise the share of wind and solar within the electricity mix from 43% to 65% by 2030. This could be very challenging as approval for wind farms may take much longer than it used to, given that local resistance has increased. This new plan, which accelerates the closure of coal plants and coal mines, is threatening the jobs of tens of thousands of workers, either in opencast mines or coal-fired power stations. It is also threatening the electricity security of supply in Europe (see above).

Moreover, Germany's accelerated Energy Transition plan is costly. The country has one of the highest electricity prices in the world; other countries, such as the U.K. and U.S., have done better at reducing CO_2 at lower cost for their populations.

1 https://www.iea.org/reports/net-zero-by-2050
2 https://www.regjeringen.no/en/aktuelt/regjeringen-legger-frem-stortingsmelding-om-verdiskaping-fra-norske-energiressurser/id2860271/
3 https://www.upstreamonline.com/energy-transition/bombshell-iea-report-fuels-row-on-oil-and-gas-industrys-climate-goals/2-1-1012771
4 https://www.montelnews.com/fr/news/1197920/la-france-ratera-ses-objectifs-enr-pour-2023--ser

c. Carbon prices or carbon taxes have negative impacts on local industries competitiveness: It is generally recognized that high enough carbon prices, usually estimated at a level of €100/t, are needed to give the right economic signals for low carbon investments.

There are many carbon emissions markets or carbon taxes at the national or local levels.

The European ETS system is one of the best because of its coverage of the region's total remissions and the level of price reached. The price has increased in 2020 and 2021 to a level of €55/t in June 2021 thanks to sound reforms implemented by the EU commission as MSR and annual cap reduction. In addition to pursuing these reforms, the EU "Fit for 55" package includes an ETS extension to cover the maritime traffic and construction sectors (see above).

Very early on, relatively high prices gave rise to fears in industries that emit a large amount of CO2, which were at a disadvantage compared to their non-European competitors, which did not have the same constraints. Concerns about the relocation of these industries out of Europe (carbon leakage) have arisen.

To protect its heavy industry, and avoid carbon leakage, the European Commission has distributed CO2 emission certificates free of charge to so-called carbon intensive companies, such as those related to cement, steel, chemical, and petrochemicals.

Those free allocations have resulted in significant windfall profits for corporations[1] .

Energy-intensive companies made over €50 billion selling those EU ETS during 2008-2019. Moreover, European taxpayers are picking up the bill as governments lost the revenues raised from auctioning these pollution permits. During the 2008-2014 period, governments had given out 11 billion free pollution permits and have thereby missed out on at least €137 billion in auctioning revenues.

Without an urgent change of these rules, emission reductions of industry will stall, since giving away free emission allowances reduces the incentive of companies to produce more efficiently or to invest in breakthrough technologies that reduce CO_2. When the Carbon Border Adjustment Mechanism (CBAM) will be implemented, there will be less "carbon leakage" risks and these free allocations will be progressively phased out.

d. Compliance with international treaties must be considered: In July 2021, the European Commission has put forward its proposal for the CBAM. Under this regulation, EU carbon pricing would apply to imported goods in the same way as goods produced in the EU. The aim is to tackle carbon leakage (estimated in the range of 5 to 30%) more effectively than existing instruments (like free allowances) within a framework compatible with World Trade Organization rules.

The EU CBAM must address several legal, technical, economic, and political challenges. For example, South Africa, India, and China, have criticised the plan as "discriminatory" and unfair to developing nations.

The U.S. is also raising concerns. John Kerry, the U.S. climate leader declared that an EU carbon border tax should be a "last resort".

e. Economic and social impacts must be assessed: The EU "Fit for 55" package plan could trigger social unrest across Europe from poorer people and less developed member states, who may argue that the changes and increased regulations will be a financial burden for them. In addition, some political and industry leaders have expressed concerns.

To cushion this blow, the package includes a "Social Climate Fund" of €72 billion (financed by 25% of the new ETS revenues), which is aimed at supporting building renovations and pledges to subsidize clean cars to vulnerable families and small businesses . It remains to be seen how fairly and efficiently the funds will be allocated.

These few examples demonstrate how decision-making related to climate measures is complex as it must consider all implementation facets, while also allowing for time for adjustment.

1 https://carbonmarketwatch.org/wp-content/uploads/2016/03/Policy-brief_Industry-windfall-profits-from-Europe%E2%80%99s_web_final-1.pdf

3. Governments should demonstrate a sustained will.

They should avoid "stop and go" efforts in subsidy policies. This is detrimental for investor and operator confidence; it also discourages the sustained development of new technologies.

For example, after strong growth in its renewable production capacity, China will end government subsidies for new solar power plants and wind projects in August 2021.

The electricity produced by the new projects will be sold at a market price or the benchmark price of coal.

Electricity produced by projects already approved in 2021 will be sold at prices set by the provincial governments where they are located. This measure will allow the Chinese government to avoid increasing its backlog in the payment of subsidies, which amounts to ¥400 billion (€51 billion).

The French government is also going back on its commitment by revising the feed-in tariffs for solar electricity granted between 2006 and 2010 at a price of €300-600/MWh (as compared to the European electricity market price of €55/MWh). The reason for this backward movement is the same as in China: the need to decrease related government debt.

4. Sound regulations must be implemented

a. Buildings' regulations

In the EU, the buildings sector represents 36% of global GHG emissions.

Around 35% of buildings in the EU are over 50 years old and almost 75% of the building stock is energy inefficient. Renovation of existing buildings can lead to significant energy savings and play a key role in the transition to clean energy, in that it could reduce total EU energy consumption by 5-6% and CO2 emissions by about 5%. However, only 0.4-1.2% (depending on the country) of the building stock is renovated each year. Many transition plans outline efforts to accelerate this renovation and allocate subsidies to do so. However, as of now, the pace of deep housing renovations is still slow.

Recently, the French government decided to act on emissions from new buildings in the residential and tertiary sector, which represent 25% of national greenhouse gas emissions.

The country will implement a new regulation (RE2020) that is among the most ambitious in Europe, along with regulations in the Netherlands and Sweden. The aim of RE2020 is to reduce the carbon footprint of buildings and improve their thermal performance.

Thus, individual dwellings must not exceed a CO2 emissions ceiling for energy consumption of 4 kilos of CO2/m²/year. This implies the end of gas heating for new dwellings in favour of heat pumps and electric heating using low carbon French electricity[1].

CO2 emissions linked to the construction phase of the building will also need to be limited by the use of using materials such as wood. The total energy consumption should be less than 100 kWh/m², which is half that of current regulations.

These new rules will require a strong adaptation of building professionals and gas vendors and could result in a housing price increase, which will be a handicap for low-income populations. Therefore, enforcement of this regulation has been postponed until 2022 and gas will be authorized until the end of 2023.

1 In 2020, French electricity was carbon-free at 92%.

b. *Transport regulations*

Transportation share of GHGs varies between 30% in high income economies to less than 3% in low-income countries[1]. Numerous regulations exist to limit consumption and emissions of gasoline or diesel vehicles. In Europe, these regulations were considerably tightened when the member states agreed in 2014 that car manufacturers should limit CO2 emissions to 95 g/km, across the entire model range within seven years. The figure for 2015 was around 130 g/km on average.

If the target is not met, groups must pay fines of €95/g over the limit, multiplied by the number of cars they sell. Therefore, manufacturers who fail to meet these targets risk significant penalties totalling several billion euros.

This directive has prompted European car manufacturers to bring more electric cars models to the market. They are, however, very late compared to Asian manufacturers, and in particular Chinese ones. Therefore, these manufacturers could take advantage of the “Fit for 55” ban on sales of internal combustion cars from 2035 onwards.

Other transportation sectors are also aiming at reducing their emissions: the International Maritime Organization, which regulates shipping, is trying to reach an agreement to reduce the fleet’s carbon intensity by 40% by 2030 (compared with 2008 levels). Its members should take swift action in this direction since the maritime sector will be included in the European ETS scheme.

On the aviation side, GE and Safran are exploring plans to cut engine fuel consumption and emissions by 30% by 2035.

5. Long term future must be prepared now: There is a need to accelerate research in fundamental science.

For example, superconductors materials conduct electricity with zero resistance, thus avoiding energy losses in electricity transmission and distribution[2] and in electronic devices. Eliminating these losses would save billions of dollars and have a significant climate impact.

In 1911, Dutch physicist Heike Kamerlingh Onnes found that mercury becomes a superconductor when cooled to a few degrees above the absolute zero (-273 °C). He soon observed the phenomenon in other metals.

For many decades afterwards, superconductivity was created only at extremely low temperatures. Then, in late 1986 and early 1987, a group of researchers at IBM’s Zurich laboratory found that certain ceramic oxides can be superconductors at temperatures as high as 92°K[3]. (Crucially, this is above the boiling temperature of liquid nitrogen, which is 77°K). This transformed the study of superconductivity, as well as its applications in areas like hospital MRIs[4], since liquid nitrogen is cheap and easy to handle. This huge leap in the 1980s led to feverish speculation that room-temperature superconductivity might be possible.

Room-temperature superconductors avoiding cooling have been discovered in laboratories. However, they operate at extremely high pressures (roughly 2.5 million times greater than the atmospheric pressure). Scientific progress in those room temperature superconductors could enable their industrialization. This technology would not only save energy, but enable magnetically levitated trains, generate magnetic fields for MRI machines (in better conditions than today), and accelerate quantum computing. Investing more in this fundamental research field should be considered.

Beyond public spending on energy developments, it is interesting to note private initiatives by American billionaires. Since 2008, Bill Gates and Warren Buffet have financed Terrapower, which recruited high level scientists and top engineers to develop a novel nuclear reactor concept: *the Traveling Wave Reactor.*

General Fusion, a Canadian start-up backed by Jeff Bezos (Amazon founder) and Shopify founder Tobias Lütke, will build a $400 million fusion demonstration reactor in the U.K. The construction of the plant, which will be 70% of

1 https://www.eea.europa.eu/highlights/new-cars2019-co2-emissions-well
2 5 to 10% of the electricity generated is lost in transmission and distribution
3 0°K is -273°C, 92°K is -181°C
4 MRI: Magnetic Resonance Imaging

the size of a true fusion reactor will begin in 2022 and is expected to be completed in 2025. This plant, like the international large ITER project, is using magnetic fields to confine the matter. It would be able to heat its hydrogen plasma fuel to 150 million°C. Its cost will be a fraction of the cost of ITER, an international nuclear fusion megaproject being built in the south of France that is estimated between €22 billion and €65 billion.

This start-up approach is unusual in the nuclear sector. Until recently, nuclear activity was relegated to large companies.

New entrants should enable progress in the use of this promising energy source.

Inertial fusion using confinement by lasers is another way than magnetic confinement, to reach fusion. On August 8, 2021, researchers at the National Ignition Facility (NIF) at the Lawrence Livermore National have approached the threshold of ignition, the moment when one recovers as much thermonuclear energy as what the laser energy provided. The yield was 0.7, very close to 1, the ignition threshold, a result never obtained before. The NIF researchers thus obtained a proof of concept of the ability to reach ignition by inertial fusion.

Financial institutions have a crucial role to play in climate change

1. Increased commitment of financial players on climate change-related objectives. Many central banks, private banks, investment funds, and insurers have committed to reducing emissions from their asset managed portfolios. In April 2021, the Glasgow Financial Alliance for Net Zero (GFANZ), UN Race to Zero Campaign, and COP26 presidency launched the Net Zero financial alliance with world's biggest banks, asset owners, asset managers, and insurers[1]. It unites more than 160 firms (together responsible for assets in excess of $70 trillion) to accelerate the transition to net zero emissions by 2050 at the latest.

All GFANZ member alliances must use science-based guidelines to reach net zero emissions and cover all three emission scopes (see below). They must also include 2030 interim target setting and commit to transparent reporting and accounting.

At the same time, 43 banks from 23 countries (with assets totalling $28.5 trillion) have launched the Net-Zero Banking Alliance (NZBA), which joins GFANZ. NZBA members have committed to align operational and attributable emissions from their portfolios with pathways to net zero by 2050 or sooner.

At the same time, an activist group, RAN[2] claimed that global banks provided $750 billion in financing to coal, oil and gas companies in 2020, which highlights the difficulties of instantaneous change.

To achieve these commitments, the financial sector has defined different metrics to measure the "temperature" of its asset portfolio (see following paragraph). The sector has also launched special instruments, such as green bonds, to encourage companies to invest in sustained activities. It also uses taxonomy to identify and select the sectors for investment. For example, coal-related activities have been marked as a sector to avoid. Accordingly, during their May 2021 meeting, the G7 countries committed to no longer financing coal fired-plants.

1 https://www.unepfi.org/wordpress/wp-content/uploads/2021/04/GFANZ-Launch-press-release.pdf
2 https://www.ran.org/bankingonclimatechaos2021/

2. ESG[1] oriented loans:

The amounts raised by companies through financing with an ESG dimension have constantly increased the last years. During the first half of 2021 they represented nearly a quarter of bond issues denominated in euros[2] . Among those instruments, green bonds that enable capital-raising for investment in projects with environmental benefits are growing quickly. Even in the difficult 2020 year, green bond issuance reached a record-breaking $269.5 billion, just above that of 2019. This figure should continue to grow in 2021.

This green finance market experienced an Average Annual Growth of 60% since 2015 with a cumulative $1 trillion milestone reached.

3. Taxonomy, used to select investments, should be based on scientific facts:

To direct investments towards sustainable activities and enable climate and energy targets for 2030 to be met, the EU commission created a “green” classification system (EU taxonomy) covering 13 sectors representing 80% of the EU GHG emissions.

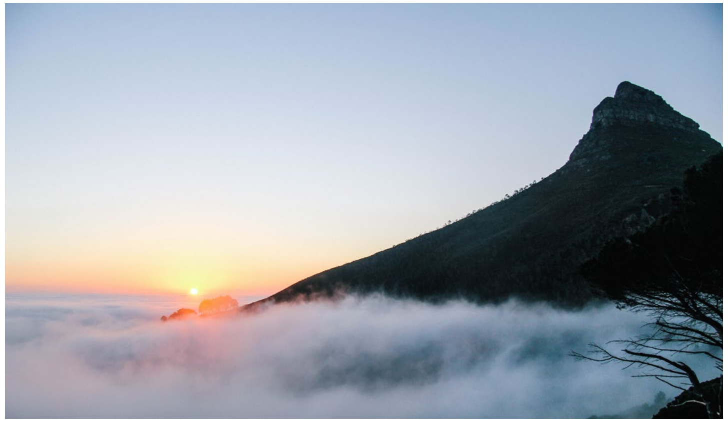
This taxonomy recognises economic activities that make a substantial contribution to at least one of the EU’s climate and environmental objectives as green, or ‘environmentally sustainable’[3] .

Another condition is that these activities ‘do not significantly harm’ any of the other environmental objectives.

Surprisingly, the commission did not include in this green taxonomy nuclear electricity, which emits less CO2/kWh than solar photovoltaic farms (see above).

Other countries, such as China, Japan, and the U.S., have included nuclear energy in their plans to reach the Paris Accord objectives.

Moreover, in March 2021, the European Commission research body the Joint Research Centre (JRC)[4] concluded in its technical assessment related to the ‘do not significantly harm” criteria that “there is no science-based evidence that nuclear energy does more harm than other electricity production technologies already included in the EU taxonomy as activities supporting climate change mitigation. “



Despite these positions in April 2021, the European Commission unveiled a first batch of implementing rules effectively postponing the decision on nuclear (and gas).

Businesses are mobilizing for the fight against climate change.

Many companies have made commitments to reduce their GHG emissions and have established net zero emission targets[5]. Among the 2000 largest companies in the world (according to the Forbes Global 2000), a large majority have made such announcements. More than 20% of them have even pledged to achieve net zero emissions by 2050[6].

1 ESG: Environment, Social and Governance relates to the three main factors that make it possible to assess the sustainability of an investment.
2 https://www.bondvigilantes.com/insights/2021/070/esg-themed-corporate-bond-issuance
3 They are: climate change mitigation, climate change adaptation, sustainable use and protection of water and maritime resources, transition to a circular economy, pollution prevention and control and protection and restoration of biodiversity and ecosystems.
4 https://snetp.eu/2021/04/07/jrc-concludes-nuclear-does-not-cause-significant-harm/
5 Nature vol 592, 18 March 2021
6 https://www.reuters.com/article/us-global-climate-carbon-business-trfn-idUSKBN2BF2ZX

We can also cite RE100, which is a global initiative bringing together the most influential companies in the world who are committed to a 100% renewable electricity supply. As of March 2021, RE100 had more than 300 members, which represents an annual electricity consumption volume of more than 330 TWh/year, which is the equivalent of Australia's total consumption.

However, their plans often lack clarity; definitions are loose, and they are hard to compare.

Three fundamental aspects must be specified:

1. Net zero targets are more credible if they ***have milestones and sound implementation plans.***

The latter should be based on the following actions:

a. Avoiding emissions by migrating to more efficient or less emitting technologies. For example, converting a vehicle fleet to electrical vehicles using carbon-free electricity.

b. Reducing emissions through energy efficiency measures or by questioning the reality of the need (such as replacing international travel with videoconference) or by implementing new technologies. For example, Colas, the world road construction leader, has developed a cold asphalt product that avoids the heating step and thus saves energy.

c. Compensating for the portion of remaining emissions that are difficult to reduce by acquiring off-setting certificates.

2. Their commitments scope must be clearly defined. It is recommended to follow the coded definitions:

a. "Scope 1" which corresponds to the direct GHG emissions generated by the company's activities

b. "Scope 2" which corresponds to the emissions associated with the consumption of electricity and heat

c. "Scope 3" which corresponds to indirect GHG emissions, for example those produced by the company's customers

Participants should also specify what GHG emissions they are targeting (e.g., only CO2 or all GHG including methane).

3. Clear and universally understood measures must be implemented:

Government institutions, notation agencies, investors, and proxies are defining their own criteria and measures, which has introduced a lot of confusion.

a. There are several methods for "measuring" a business portfolio with are each leading to different results.

Among the numerous initiatives, let's cite the "Science Based Targets" initiative, which advocates a scientific assessment method for carbon neutrality targets to verify whether they are achieved. This provides a solid basis for evaluating companies' climate change strategies. As of April 2020, more than 800 companies have established their goals using this SBT method and more than 500 companies have committed to doing so soon.

The International Financial Accounting Standards (IFRS) Foundation announced in March 2021 that it is working on a proposal to set up international sustainability standards. They are initially focusing on climate-related reporting.

These initiatives come as asset managers are already dealing with the EU SFRD and other regulations, such as Ucits, adding to many other sustainability disclosures including TCFD, SASB, GRI, and CDSB.

These numerous measurements create a lot of extra work for companies and don't allow analysts to benchmark progress.

b. The lack of accurate data is an important obstacle to achieving sustainable investments. According to a 2020 BlackRock survey of 425 investors across the world, which together represent $25 trillion in assets under management, poor quality or unavailable ESG data and analysis represent the biggest obstacle to sustainable investment. Without reliable data, companies face the proverbial "garbage in, garbage out" scenario.

c. ***Research*** can support improvements in all aspects. For example, studies should better characterize the future reliability of nature-based carbon sinks, as well as their potential change under climate change.

Engineering solutions, such as using chemical filters to suck CO2 from the air to be buried underground, are still nascent (see above).

Progress has been made in Carbon Capture and Storage technologies. Plant size is increasing, while costs are decreasing. If carbon prices continue to increase, they could become competitive.

Research and development efforts should be boosted. Better communication and greater social acceptance are also important factors. For example, some communities are against CO2 storage in their vicinity.

As more and more companies engage in green investments, clear targets, meaningful science-based data, and comparable reporting aggregates are indispensable to progress towards a cleaner world.

Conclusion

2020 has been an exceptional year in recent human history.

Because of the health crisis and the successive confinements, global energy consumption has fallen by 3.5%, which reduced GHG emissions by 6%. We would need a similar drop in these emissions every year for 30 years to meet the goals of the Paris Agreement.

The consumption of renewable energies has increased sharply, though there has not been a significant reduction in the consumption of coal.

Despite all the health issues related to the pandemic, governments have strengthened their position vis-à-vis a green economy and, under the leadership of its new president, the United States has returned to the Paris agreement.

In addition to government commitments and declarations, the mobilization of businesses and the financial sector in the fight against climate change has increased.

However, in 2021, energy consumption and GHG emissions started to rise again. It is likely that this growth will offset the reductions seen in 2020.

In the absence of major crisis in 2022 and onwards, the energy and emissions growth path could be like pre-pandemic figures.

Climatologists warn that we are not on the right trajectory to reach the objectives of the Paris agreement and that we must increase our efforts.

However, it is necessary to consider the adaptation time of societies, their industries', and the lifestyles of their populations. These transitions are more complex because our societies are dependent on each other; change is also more difficult in democratic societies.

This is one of the reasons for delays in realizing energy transition plans.

Setting ambitious but realistic goals is necessary. At the same time, it is also necessary to know how to measure the effect of actions taken.

The methods of measuring and comparing energies have been deeply impacted by the growth of renewable energies. In addition, there is a great deal of confusion in the definition and application of ESG indicators used by companies. Financial institutions should define standardized extra-financial indicators (at least within the same sector), thus enabling comparisons between efforts undertaken by companies.

The digitization progress associated with improved data management and growing use of AI has improved energy players' knowledge and management of their assets. However, cyber crime is getting worse, as more devices are connected to networks and geopolitics relations become less stable.

Faced with the delay in climate objectives, “adaptation” solutions should be considered, at both the country and company level. The latter have started to include the risks associated with climate change in their risk maps.

It is time for public institutions and businesses to take the necessary actions to guard against these risks, including floods, extreme heat, and cold episodes as well as more frequent and violent natural events.

Rich countries should also help poorer nations. Investment needs linked to the fight against climate change have been assessed[1] at $5,000 billion per year by 2030, a significant part of which concerns developing countries.

Finally, countries and regions must provide more funding for research that is likely to accelerate the fight against climate change.

Finally, over the period under review, China increased its position in the energy markets on low-carbon electricity production technologies (renewables, batteries, rare earths, and rare metals) and green hydrogen. As part of its “Silk Road” project, it is also positioning itself on the technology of direct current cables to transport electricity over long distances.

At the same time, it also remains the largest emitter of GHGs and the leading financier of coal power plants in the world.

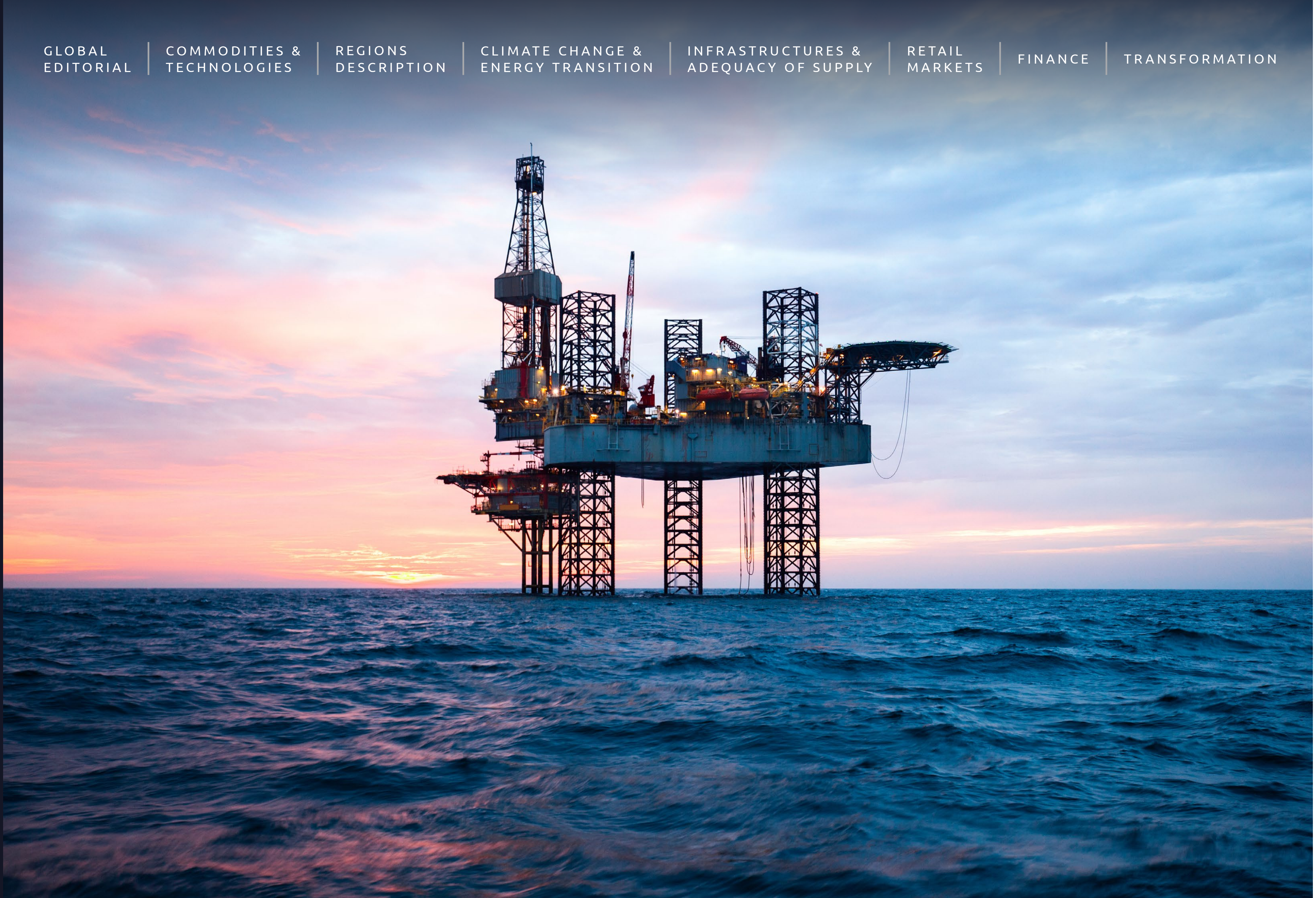
1 by the International Energy Agency

With the pandemic and the rapid rebound of its economy, China has also strengthened its position as a rival to the United States and geostrategic tensions have increased in 2020-2021.

I wish you a good reading of this new and very rich WEMO edition.

Colette Lewiner
Paris, August 29, 2021

02 Commodities & Technologies



02

02 Commoditities & Technologies

02 Commoditities & Technologies

Oil, Gas and Electricity Markets

Colette Lewiner
Alexandra Bonanni
Augustin Danneaux

Oil, gas and electricity markets

Oil markets

2019:

- Demand growth was lower than expected due to better efficiency in new vehicles.
- U.S. had driven up supply growth with shale.
- Upstream investment kept growing

2020:

- The COVID crisis had a drastic effect on oil demand, resulting in negative crude prices during the first wave.
- This historic shock caused severe cuts in upstream spending.
- U.S. shale was particularly impacted by the crisis.

2021:

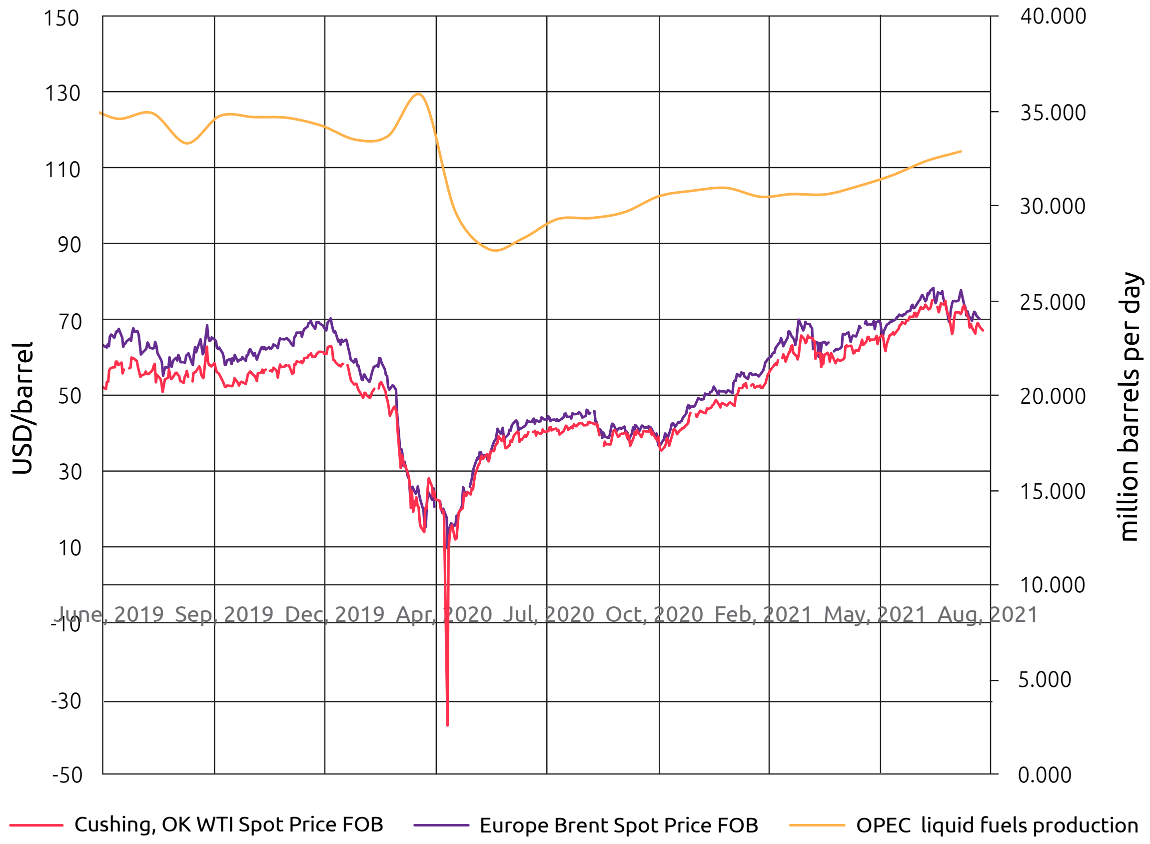
- As economies recover post-COVID, demand for oil is expected to bounce back. The speed of recovery will depend largely on regional sanitation and economic perspective. Demand growth is also expected to be much slower in certain sectors, such as aviation fuel.
- Demand growth during the first half of 2021 has resulted in an increase in crude prices.
- In the Middle East, OPEC+ controls the market.
- Tensions between Saudi Arabia and the UAE resulted in the cancellation of OPEC+ in a meeting in early July. A compromise to increase production by 0.4mb/d per month was finally reached in mid-July 2021.
- The growth of production is limited due to spending cuts during the pandemic.

The pandemic has shifted the balance of power in oil production from the U.S. back to the OPEC+ countries, amidst tension between Saudi Arabia and the UAE. As economies recover, demand in oil will be slower in certain sectors.

1 IEA

FIGURE 1

Crude oil spot prices



Source: EIA (2021)

Gas markets

2019:

- The growth of LNG created competition with piped gas in Europe, resulting in a decrease in gas prices.

2020:

- There was a historic drop in demand.
- U.S. power plants moved from coal to gas, allowing gas to remain more resilient than other commodities.
- During COVID lockdowns, prices decreased and regional prices converged.

2021:

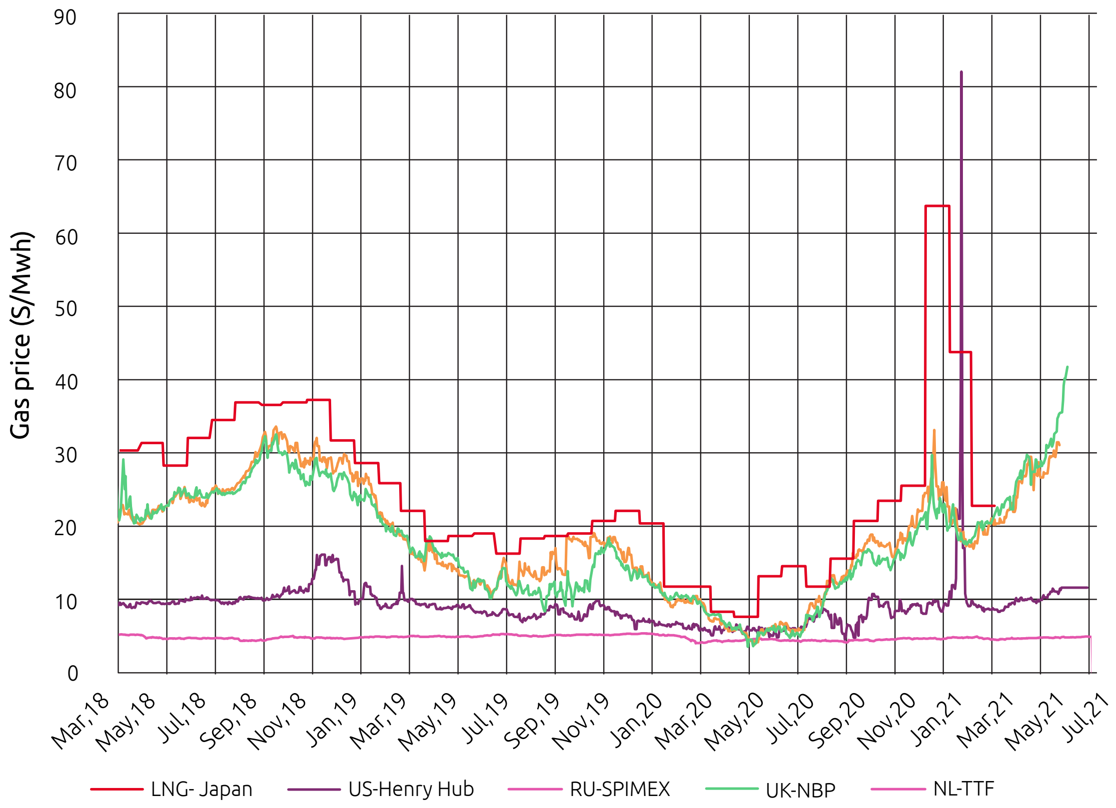
- An overall consumption growth of 3.2% is expected to make up for 2020 losses, as driven by recovery in Asia.
- Extremely high prices were observed in January due to exceptionally low winter temperatures, increasing gas demand particularly in East Asia and North America.
- Post-COVID lockdowns caused prices to diverge once more, as economies took different recovery paths.
- Russian gas remains a cheaper option as compared to LNG.
- Gas production decreases in Europe, with reduced output from the North Sea (like the Groningen gas field), are reinforcing Russian gas exports to Europe.
- As the new U.S. administration lifts sanctions imposed by the previous administration, Nordstream 2 is finally getting closer to operation.

**In 2020 there was a drop in demand for natural gas, induced by the pandemic.
A cold winter in 2021 increased demand in Asia and Europe, resulting in high prices.**

1 IEA

FIGURE 2

Gas spot prices*



*SPIMEX are day ahead TTF are OTC day off

Source: Refinitiv 2021, Spimex 2021

Coal markets

2019:

- Demand grew for non-steam coal.
- Coal lost its place to gas as the cheapest fuel for power generation.

2020:

- Coal was hit harder by the pandemic than other commodities, as lower carbon fuels were prioritised.
- Coal consumption fell in most countries, excluding China and Malaysia.

2021:

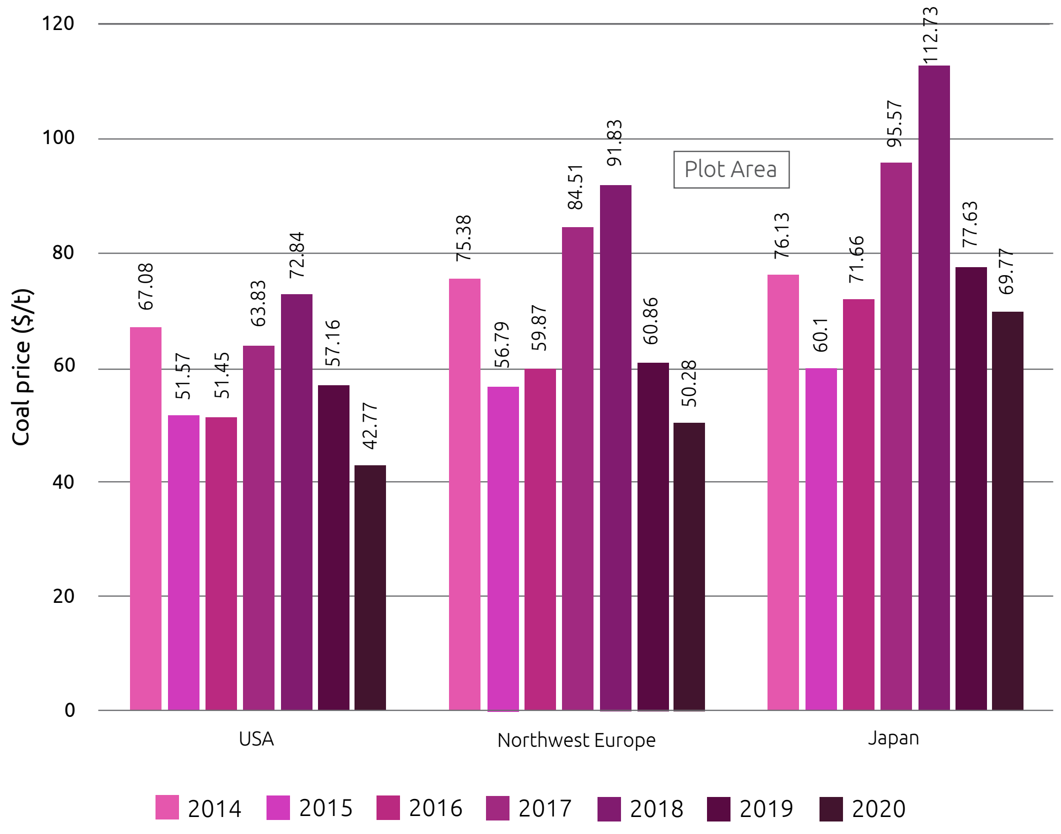
- After a demand decrease due to the pandemic, many countries should return to higher coal consumption.
- China's unofficial ban on Australian coal imports has shifted the balance between Asia-Pacific trade relationships.
- China has set up a target of net zero emissions by 2060. However, the country's fourteenth five year plan is vague about the use of coal, resulting in China's five major coal utilities not setting up plans to decommission their plants.
- The decrease of coal consumption in Europe is structural, with planned closures of coal power plants in many countries (at least half of them by 2030).[3]

Despite the expected rebound in demand around the world in 2021, the decline of coal is structural in many advanced economies. It remains an essential source of energy in China and many other developing countries.

1 IEA
2 https://www.reuters.com/business/energy/asia-coal-prices-surge-china-australia-dispute-means-rally-is-uneven-russell-2021-06-08/
3 https://ember-climate.org/commentary/2021/03/23/half-way-there/

FIGURE 3

2014-2020 coal prices evolution



Source: BP statistical review 2021

Electricity markets

2020:

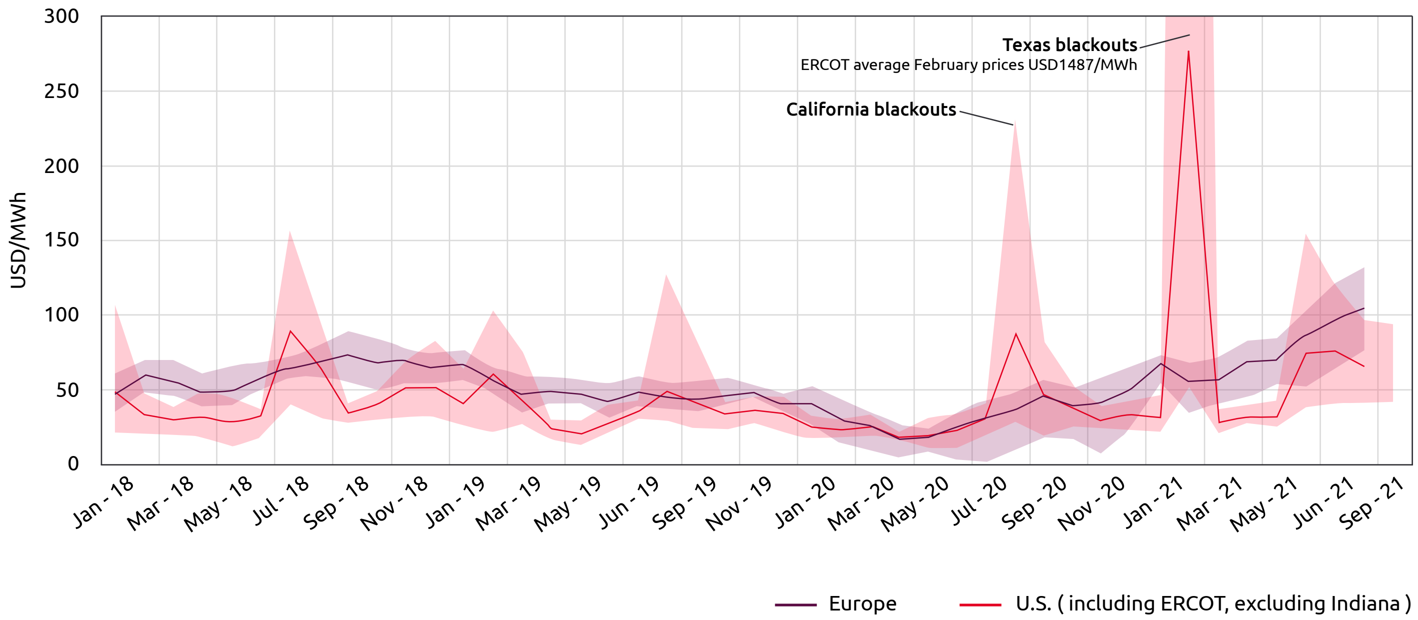
- Electricity prices dropped with demand in 2020H1 as economies entered lockdowns.
- In Europe, prices dipped below €5/MWh in April 2020 and sometimes reached negative levels.
- Prices began rising as soon as economies reopened.
- Extreme summer weather had drastic effects on wholesale electricity prices in the U.S. as California experienced blackouts.

2021:

- Wholesale electricity prices continued their hike in 2020H1.
- Peaks above €190/MWh were experienced in Europe in September 2021 due to demand growth, rising CO2 and natural gas prices, as well as poor wind conditions in the North Sea.
- Prices reached historic highs in the U.S. in February 2021 as the country experienced low winter temperatures. Due to lack of resilience of power generating infrastructure and low levels of interconnections, supply could not catch up to demand in the state of Texas, leading to blackouts.

FIGURE 4

Evolution of electricity day-ahead prices in Europe and the U.S.



Source: EIA, Power Exchange websites, Macrotrends, Capgemini Analysis

02

02 Commodities & Technologies

02 Commodities & Technologies

Nuclear Energy Needed to Fight Climate Change

David Steiger
Colette Lewiner

Nuclear Energy Needed to Fight Climate Change

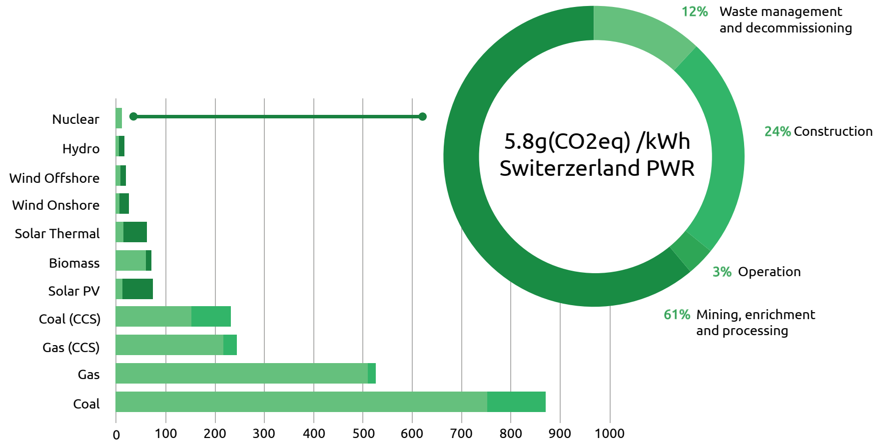
The climate change

Electricity generation is responsible for 42% of global CO2 emissions.

With the global population and economic growth, the electrification of transportation and other sectors, global electricity demand could double by 2050. At the same time, carbon neutrality has to be reached.

FIGURE 1

Lifecycle greenhouse gas emissions per kilowatt-hour (g co2 – equivalent /kw-h)



Source: IAEA
World Energy Markets Observatory 2021

To tackle the climate emergency by 2040, over 80% of electricity should be low carbon, which is more than double current levels.

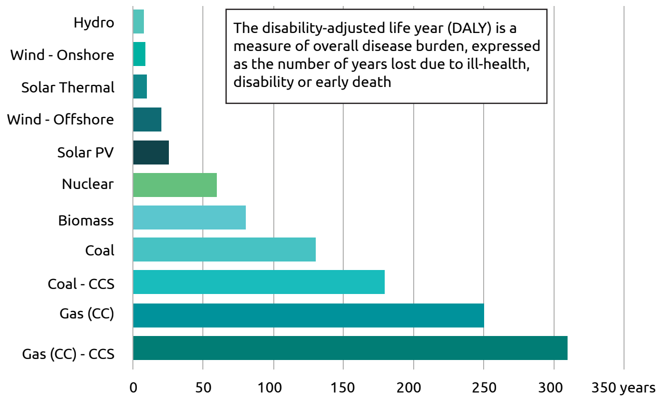
Nuclear energy development is part of the answer.

Nuclear power is one of the world's energy sources that emits the least greenhouse gas.

- Thanks to its nuclear footprint, France's electricity carbon intensity is under 50 gCO2 per kWh, i.e. 10 times less than the G20 average.
- Nuclear energy is not currently included in the European Union taxonomies which are designed to channel sustainable investments. However, it is included in green plans for the United Kingdom, United States, and China.

FIGURE 2

Nuclear energy is safer than fossil fuels



Source: IAEA
World Energy Markets Observatory 2021

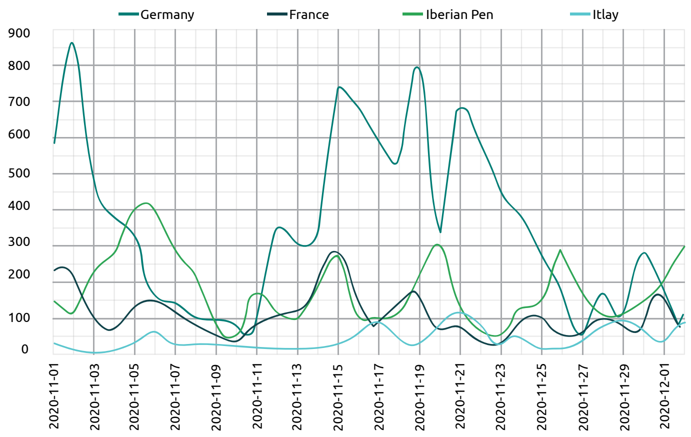
- The safest energy sources also have the smallest impact on the climate.
- Yet, these energies still account for less than 17% of primary energy (i.e. 4.3% for nuclear, 5.7% for renewables and 6.8% for hydro).

Nuclear is a 24/7 controllable electricity source

- Nuclear power contributes to balancing demand/supply on the grid with high renewables share.
- It enables a reliable and low greenhouse gas emitting electrical system.

FIGURE 3

Wind Generation



Source: AleaSoft
World Energy Markets Observatory 2021

- Nuclear power can therefore support greater deployment of intermittent solar and wind generation without the need for backup capacity from fossil fuel plants.
- “The need for flexibility in electricity generation and system management will increasingly characterize future energy systems over the medium to longer term. Improved frameworks for remunerating reliability, flexibility, and other services would favour nuclear operators,” states the International Atomic Energy Agency (IAEA).

Nuclear electricity is well-suited to produce clean hydrogen, one of the energy carriers that can help decarbonize our economy

- Presently, 95% of the hydrogen consumed worldwide is produced with fossil fuel (grey hydrogen). Its production is therefore highly emissive of greenhouse gases.
- Green hydrogen produced by water electrolysis must be powered with low-carbon electricity.
- Together with renewables, nuclear is a clean electricity source.
- To reach their carbon neutrality goals, 40 countries have published a hydrogen strategy or are developing one.

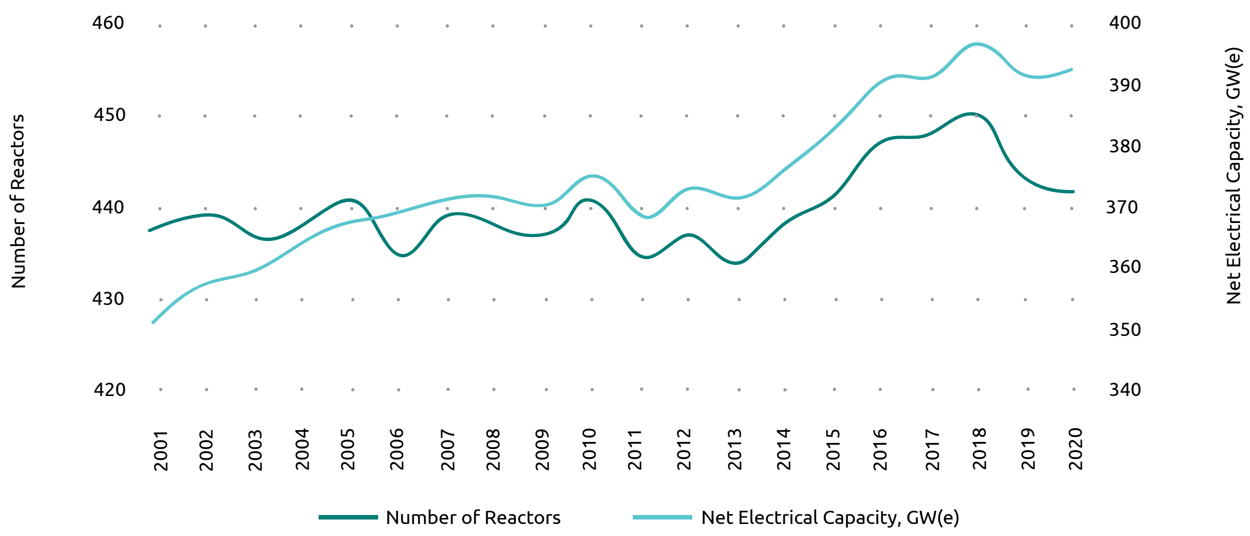
- The European Union plans to develop the low-carbon hydrogen industry:
  - It aims at building at least 40GW of electrolyzer capacity by 2030.
  - The equivalent in green electricity will have to be added, which is huge.
  - Nuclear power has to contribute to meet these goals.

Worldwide nuclear status and trends

In 2020, nuclear power provided about 10% of the world's electricity (a stable figure for many years), and 18% of electricity in OECD countries

FIGURE 4

Nuclear capacity trend



Source: IAEA PRIS (Power Reactor Information Service) Database
World Energy Markets Observatory 2021

- Global nuclear power capacity installed (443 reactors in 32 countries) was stable after a net 4.5GW decline in 2019:
  - New grid connections were offset by permanent shutdowns in Japan.
  - But increased capacity factors, notably in the United States, enabled global power generation stability.

- Nuclear energy consumption fell sharply in 2020 (-4.1%), driven mainly by declines in France (-0.4 %), United States (-0.2%) and Japan (-0.2%).

- However, this decline was lower than the 4.5% decrease

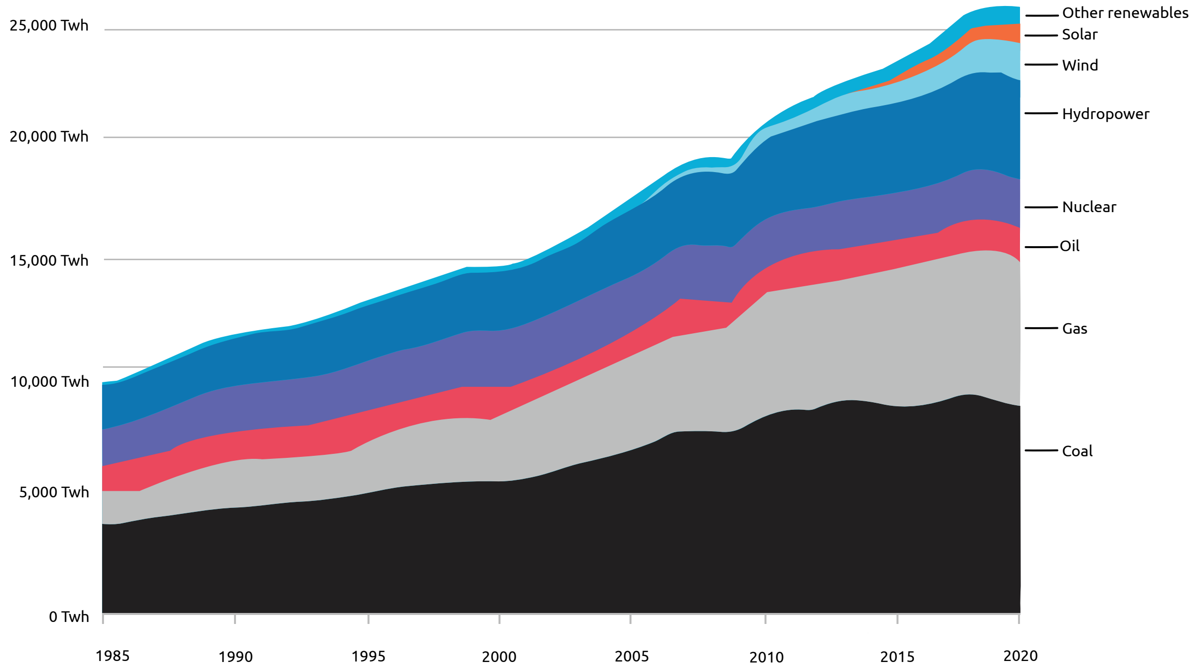
  of global primary energy consumption.
- The "big five" nuclear countries (by rank: the United States, China, France, Russia, and South Korea) generated 71% of global nuclear electricity in 2020.

- Five new reactors came online in 2020 (including locations in United Arab Emirates, China, Russia, and Belarus). Five reactors were closed, including sites in the United States, France, and Russia. Some of these closings were done for political reasons, such as the two French reactors at Fessenheim.

- Nuclear was, again, the world's second largest source of low-carbon power after renewables.

FIGURE 5

Electricity generated by fuel



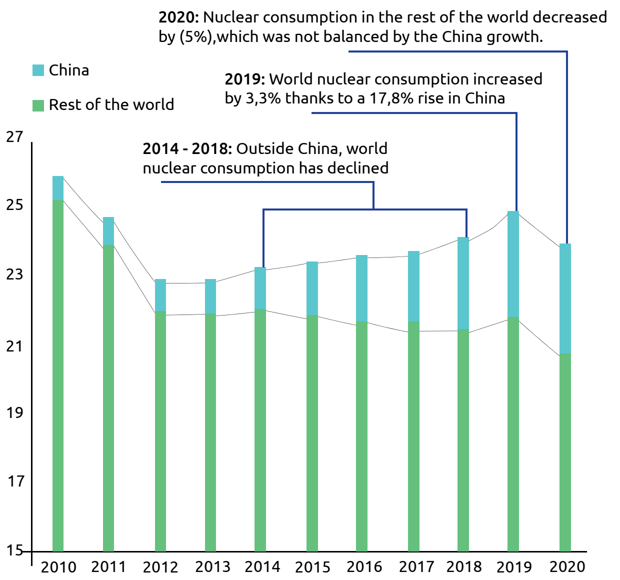
Source: BP Statistical Review of World Energy – Our World in data
World Energy Markets Observatory 2021

The share of Central and Eastern European, and Asian countries in global nuclear power generation has continued to increase

- The nuclear consumption of Central and Eastern Europe and Asia has been growing further in 2020, as driven by China which operates the second largest reactor fleet after the United States. China's nuclear power production surpassed that of France for the first time in 2020.
- In 2020, about 50 reactors (approximately 15% of existing capacity) were under construction, mostly in Asia. China is still leading in terms of growth, while Rosatom (Russia) ranks first for nuclear power plant construction projects abroad.

FIGURE 6

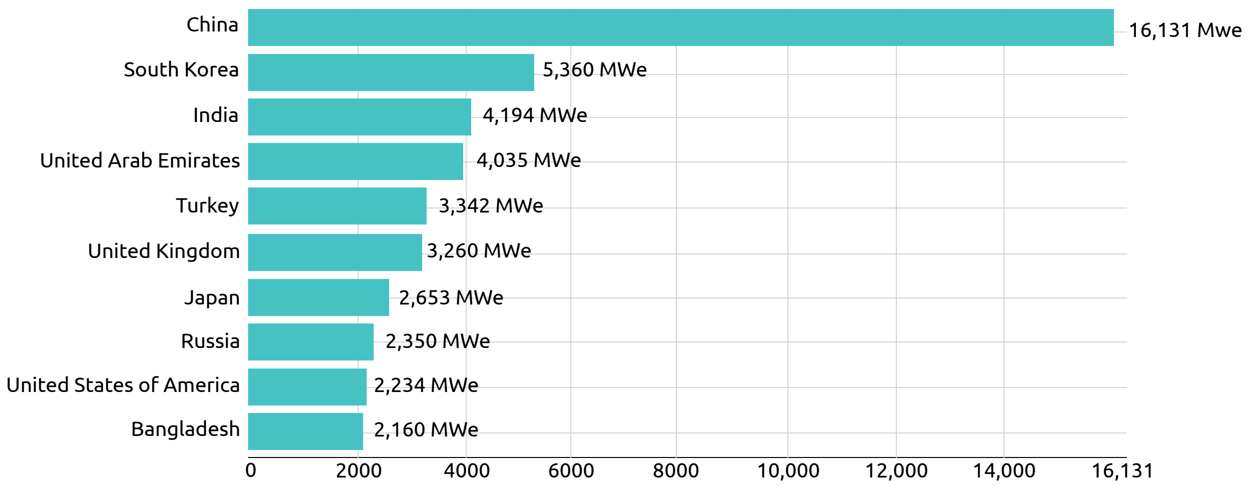
Nuclear energy consumption 2010—2020 in China and in the Rest of the World (ExaJoules – Input Equivalent)



Source: BP Statistical Review of World Energy – Our World in data, Capgemini Analysis
World Energy Markets Observatory 2021

FIGURE 7

Top 10 reactors under construction in 2020 - Net Capacity (MWe)



Source: IAEA PRIS (Power Reactor Information Service) Database
World Energy Markets Observatory 2021

- In its net zero emissions scenario, the International Energy Agency (IEA) points out that by 2050, two-thirds of new builds (mainly large-scale reactors) will be located in developing economies.

- With plants decommissioning and few new reactors in development, the nuclear share of total electricity generation in advanced economies should fall from 18% in 2020 to 10% in 2050.

Current nuclear investment levels are far too low to respond to climate challenges

- Nuclear and renewable energy are the only sectors where investments have been maintained in 2020.

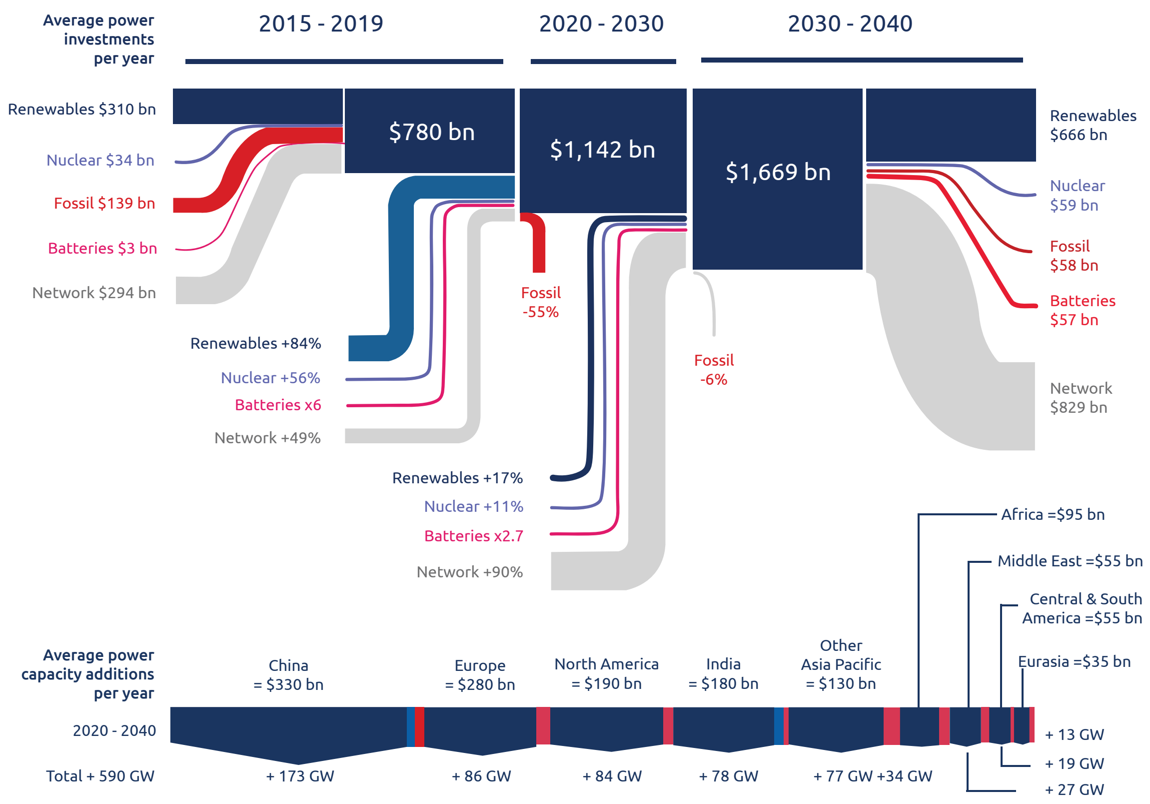
- Nuclear power investments, which accounts for about 5% of total global energy investments, grew to $42 billion in 2020 vs. $39 billion in 2019.

- Nuclear power investments are expected to increase in countries with well-defined nuclear expansion plans such as China, India, and Russia.

- Nevertheless, these yearly investment amounts are far from those required to meet the Paris Agreement objectives.

FIGURE 8

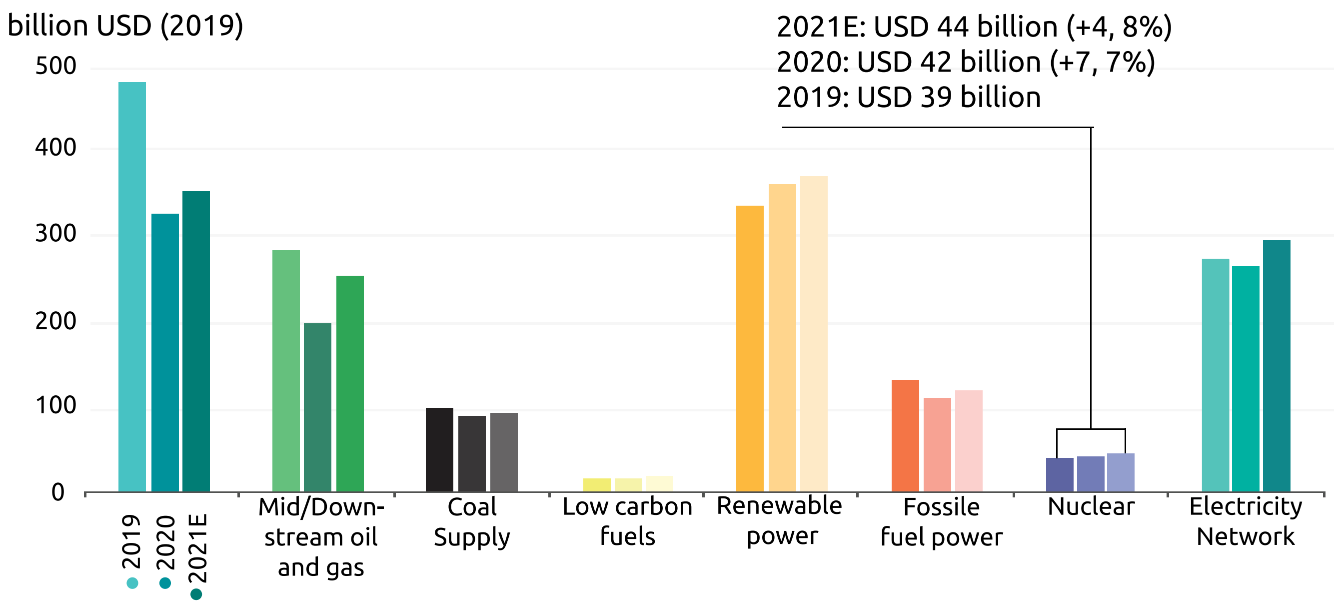
Global cumulative investments in low carbon technologies (annual average 2015-2019) and low-carbon power-sector requirements in line with the Paris Agreement (annual average 2020-2040)



Source: IEA 2021
World Energy Markets Observatory 2021

FIGURE 9

Global energy supply investment by sector, 2019-2021E



Source: IEA 2021
World Energy Markets Observatory 2021

Construction and decommissioning

Decisions are expected to be made regarding lifetime extensions and the pace of new construction

- The average age of the world's operating nuclear reactor fleet continues to increase. As of mid-2021, the average age is 31 years with 20% reaching 41 years or more.
- In most advanced economies, decisions have to be made regarding the renewal of an aging nuclear fleet and measures needed to extend the life of certain plants. Otherwise, nuclear power output in advanced economies will decline by two-thirds over the next two decades.
- EDF is investing €50 million in the "Grand Carénage" programme, which runs from 2014 to 2025. It aims to enhance the present reactor fleet's safety and extend their lifetime beyond 40 years.
- In emerging and developing market economies, decisions are expected to be made regarding the pace of new nuclear power plant construction. The rate of 6GW per year over the last 9 years is still not high enough to match the 24GW per year expected in the IEA's Net Zero Emission pathway by 2030.

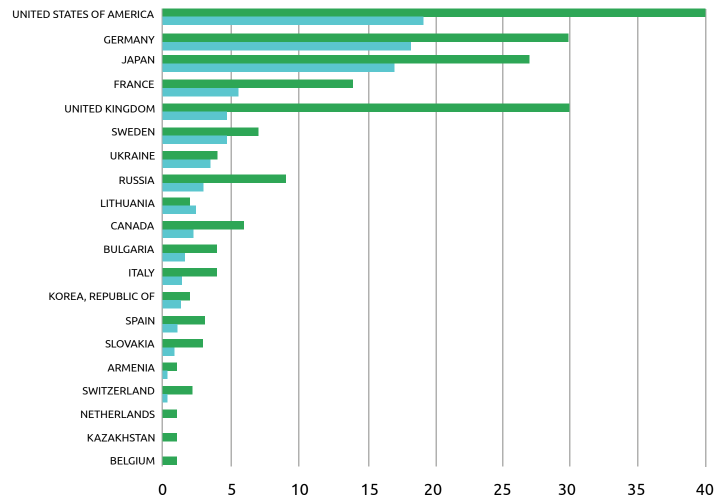
Reactor shutdowns are mainly in Europe

- 194 nuclear reactors (power and research) have been shut down worldwide since the early 1960s (totalling 89GW of capacity). More than half of these reactors are located in Europe.

- Of these 194 shutdown power reactors, 20 have been completely dismantled, but only 10 have been returned to a "greenfield" state and made available for further activity (as opposed to a "brownfield" state, which allows only industrial reuse with restrictions).

FIGURE 10

Permanent shutdown reactors



Source : IAEA PRIS (Power Reactor Information Service) Database
World Energy Markets Observatory 2021

The volume of reactors entering into decommissioning is increasing

- The pace of shutdowns has accelerated in recent years, particularly since the Fukushima nuclear accident in 2011. The rate should intensify over the next 30 years. More than 150 reactors worldwide are at the end of their lifetime.

- In Europe, 90% of the installed base will reach 40 years old by 2040 (i.e. the expected initial life of many plants). However, the lifetime of similar reactors has been extended beyond 50-60 years in the United States.

The decommissioning phase is often longer than the operating phase and requires significant expertise

- Decommissioning activities involve fuel evacuation, deconstruction of buildings, decontamination, and cutting, handling and disposal of waste.
- Dismantling operations challenges are specific to each reactor type and design.

- Dismantling of large nuclear power plants are very long-term projects with many regulatory constraints.

- The solution for very long life and very radioactive waste disposal has not yet been decided in many countries.

- Technical solutions for the treatment and disposal of certain reactor's components (such as graphite) have to be improved.

Decommissioning stakes are large and vary according to many parameters

Parameters include:

- Series effect (in particular, the number of same design reactors to be dismantled) and the reactor's size
- Dismantling technologies used
- Project ambition and scope (greenfield vs. brownfield final state, spent fuel reprocessing, etc.)
- Speed of dismantling knowing that radioactive levels decrease over time
- Number of reactors to be dismantled per site
- Environmental and nuclear regulatory constraints
- Labor costs and experience level
- Installation of the initial state and historical knowledge

Digital transformation

The nuclear industry, like other sectors, has launched its “fourth industrial revolution”

- It affects all value chain components: design, construction, maintenance, safety, and dismantling.
- Digital transformation is powered by the high volume of data generated along the very long project lifetime: design, operation, and dismantling phases (around 100 years). In addition, regulators’ studies requests and reports are very large.
- As an example, building a nuclear reactor requires the production and management of at least 4 million objects, 5 million documents and 500,000 tests.
- Digital technology has multiple roles to play in the sector: product lifecycle management, simulation, quality control, study of incidents or accidents scenarios, operator training, maintenance, etc.
- In Europe, 90% of the installed base will reach 40 years old by 2040 (i.e. the expected initial life of many plants). However, the lifetime of similar reactors has been extended beyond 50-60 years in the United States.

Design simplification, components standardization, and data management over the lifecycle can bring major benefits

- These points can decrease costs and improve competitiveness for a sector whose levelized costs of energy have increased in recent years (while renewable energy costs have dropped considerably).
- Benefits are significant during the construction phase, wherein costs represent about 80% of the total electricity generated cost.

In several areas, the nuclear industry remains at the forefront of new technologies

- Digital twins are a major pillar to optimize the operation and maintenance of physical facilities. In January 2020, EDF launched a Digital Reactor R&D Project. From design to decommissioning, through operation and maintenance, the Digital Reactor R&D Project will provide engineers and operators with an integrated environment to improve simulations.
- The increased use of robots and drones, particularly for dismantling, is limiting the operator’s exposure to radioactivity and facilitating inspections.
- Immersive 3D virtual reality rooms and helmets are used to simulate and prepare interventions.
- Some nuclear companies are developing digital platforms that will enable the various players to share project data. These platforms will enable quick digital information updates on equipment throughout their lifecycle (e.g. configurations and modifications by the various partners).

Source : Corys

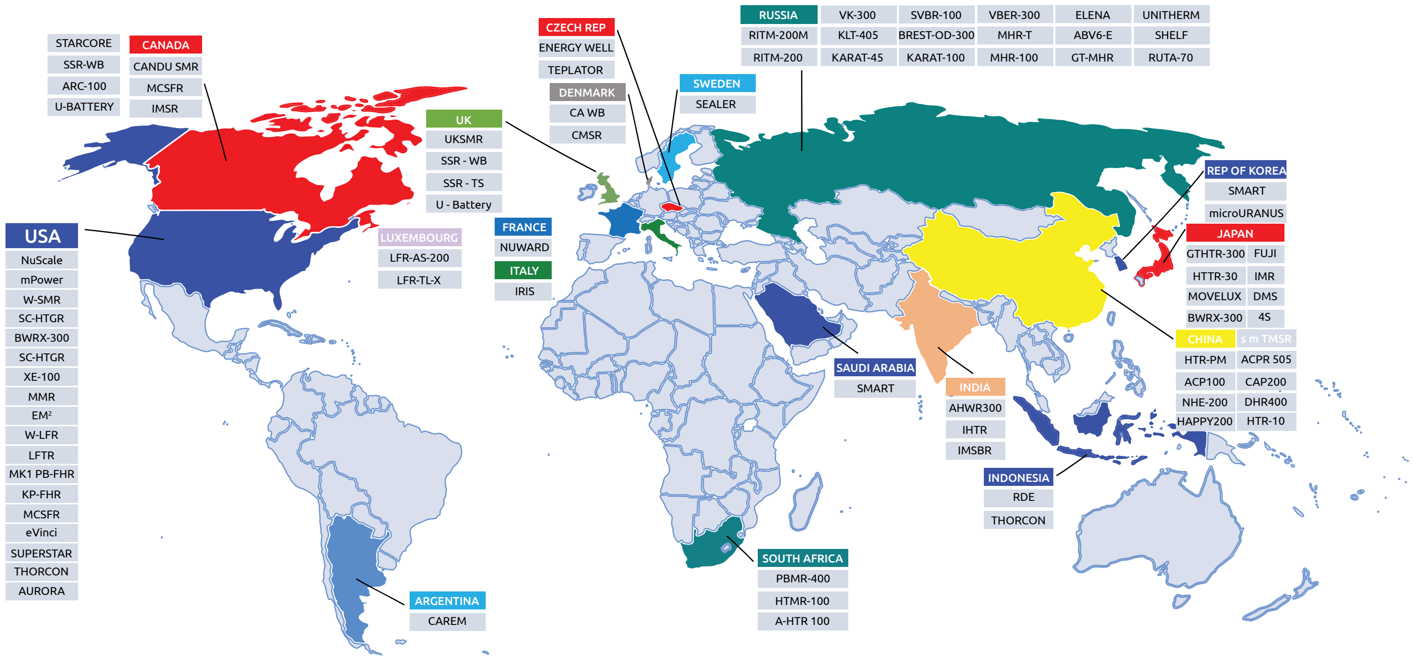
SMR

Small Modular Reactors (SMRs) are attracting the attention of many countries that want to reduce their carbon footprint and whose financial capacity is limited

- SMRs are modular reactors with a power output from 60MW to 300MW compared to more than 1,000 for conventional modern reactors. They promise significant cost reductions due to their modularity, factory manufactured components assembled on site, and simplified design. These features should help better control manufacturing costs and lead times.
- SMRs can be deployed in regions with a less developed grid. They could replace coal-fired power plants, contribute to green hydrogen production, or seawater desalination.
- Today, more than 70 SMR models of various technologies are being developed. Many countries are developing prototypes or building those reactors, including Russia, China, United States, Canada, Sweden, India, and France.

FIGURE 11

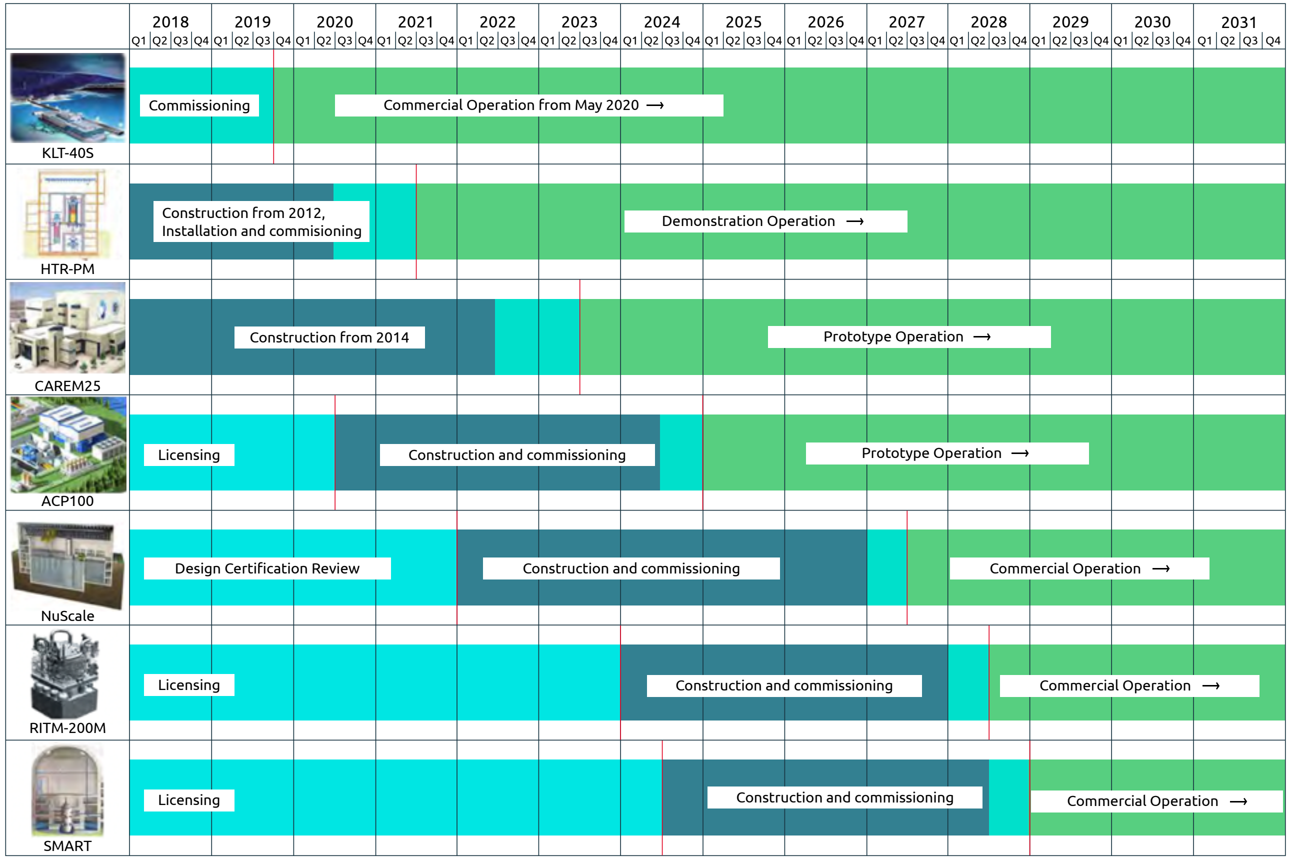
Global map of SMR technology development



Source : IAEA Advanced Reactors Information System (2020 Edition)
World Energy Markets Observatory 2021

FIGURE 12

General Timeline of deployment as of 2020



Source: IAEA Advanced Reactors Information System (2020 Edition)

- Two industrial demonstration SMRs are at an advanced stage of construction: in Argentina (CAREM, a simplified 100MW PWR) and in China (HTR-PM, a high-temperature gas-cooled reactor). They are scheduled to come on line between 2021 and 2023.
- The Akademik Lomonosov floating power generation unit in Russia, equipped with two KLT40S modules, was connected to the grid and began commercial operation in May 2020.
- In China, CNNC has begun the construction of a 125MW onshore SMRs (ACP100) that is expected to power 526,000 homes. It could be the first land-based SMR to enter into commercial service.
- Although SMRs have a lower initial investment cost per unit, their economic competitiveness remains to be proven as they require similar volume of studies and regulatory approvals than large reactors, despite having a smaller electricity output.

Conclusion

- The role of nuclear power in achieving carbon neutrality by 2050 is now recognized.
- In the context of increasing volumes of non-dispatchable electricity, nuclear is a clean schedulable electricity source and a good complement to wind and solar electricity.
- The extent to which nuclear power can enable energy transition depends on the industry's ability to drive down costs, accelerate innovation, and secure sufficient public support.
- Regarding public information, the UNSCEAR report on the Fukushima incident shows that misinformation to the public is at odds with the solid scientific evidence and facts. This is a challenge to scientists and governments around the world.
- In developed countries, nuclear reactors are aging. In the United States, Canada, United Kingdom, and France, operators are allowed to extend reactors' lifetime thanks to large investments aimed at replacing aging equipment and upgrading safety.
- Very long-term reactors decommissioning programs are growing mainly in western countries.
- The share of Central and Eastern European, and Asian countries in global nuclear power generation has continued to increase with China concentrating half of worldwide investment.
- Investment in new plants remains insufficient to reach the Paris Agreement objectives:
  - Governments should take clear decisions to renew their existing reactor fleet.
  - The absence of a timely decision could lead to real challenges as the nuclear output should double by 2050

02 Commodities & Technologies

02

02 Commodities & Technologies

Renewables Technology

Alexandra Bonnani
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Renewables Technology

Renewables technology

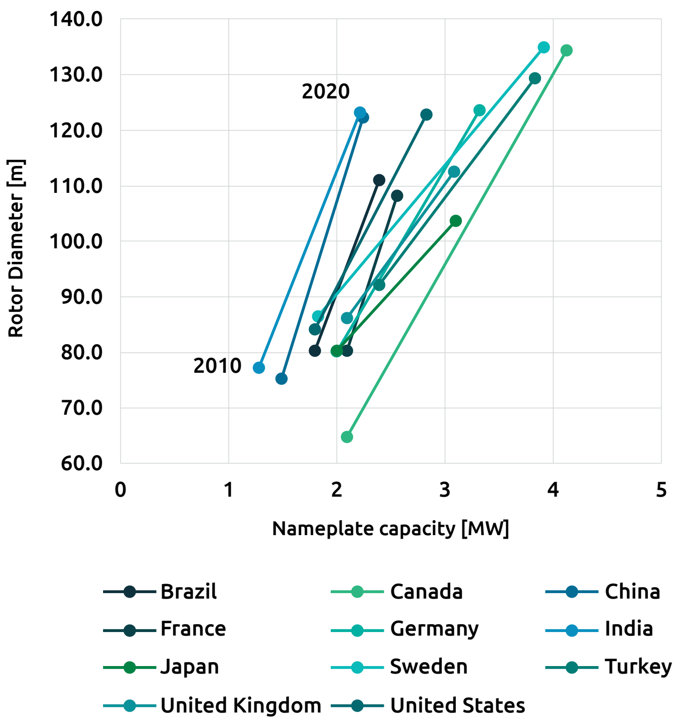
Onshore wind

- Wind turbine sizes are increasing. In 2020, the turbines reached an average power rating of 3.3MW in Europe.[1] This brings with it new legislative and logistical issues, which will need to be addressed by manufacturers.
- Wind turbine costs are decreasing:
  - The cost of turbines in China averaged at $538/kW in 2020.
  - As a global average, the total cost of installed turbines decreased year-on-year by 9.15% to $1355/kW[2].
- The repowering and recycling of components is becoming a key issue for wind power:
  - Older turbines are reaching their end of life. Over 180GW of capacity wills be 15 years or older by 2025.[3]
  - Pyrolysis allows for the recovery of hard-to-separate materials like carbon and glass fiber.[4]
- Digitalization is a key area of development and will be used to help: optimize the productivity of farms; reduce O&M costs; and integrate wind energy more seamlessly into power grids.

1 Wind Europe – 2020 Statistics and the outlook for 2021-2025
2 IRENA Renewable Power Generation Costs in 2020
3 IEA
4 https://www.energy.gov/eere/wind/articles/no-time-waste-circular-economy-strategy-wind-energy

FIGURE 1

Weighted-average onshore wind rotor diameter and nameplate capacity evolution, 2010-2020



Sources: IRENA (2021)

- The basic design of wind turbines has been consolidated across the industry:
  - The monopile three bladed horizontal axis wind turbines should remain the industry staple.
  - Other designs (such as vertical axis or bladeless vibrating turbines) are being developed for niche applications.[1]

The main technological trend in onshore wind is the move towards larger wind turbines, consisting of both longer blades and higher hubs. While this increases the weight per energy captured for a single turbine, it also reduces the total number of turbines to be installed, thus reducing overall cost.

1 Vortex Bladeless

Offshore wind

- Offshore wind dominates the R&D space. However, offshore wind represents a much smaller part of investment and added capacity, with only 6GW added in 2020 (as opposed to 105GW added by onshore wind).[1]

- In 2020, the total installed cost of offshore wind remained much higher than that of its onshore counterpart,[2] resulting in $3185/kW - a 14% annual decrease.

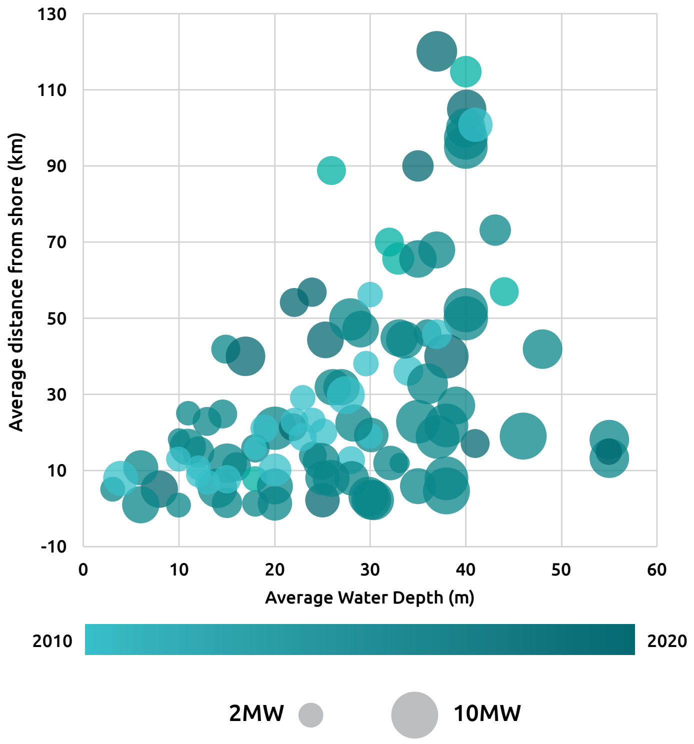
- Fixed foundation turbines represent nearly the entire offshore wind capacity:
  - Turbines are usually larger offshore than onshore. They are also getting bigger.
  - Monopile foundations are the most common in shallow waters. They are used for 80.5% of offshore turbines in Europe.[3] Jacket style foundation makes up only 19% of offshore turbines.
  - Traditionally, jacket style foundation were preferred for larger turbine sizes. However, recent improvement in monopile foundations have made them fit for turbines with more than 8MW capacity.

- Floating wind is still a very new technology:
  - The first floating wind farm opened in 2017 in Hywind, Scotland. Developed by Equinor, it has the capacity of 30MW and has the highest capacity factor of any wind farm in the U.K., thanks to strong winds from the coasts.[3]
  - 80% of potential offshore wind resource is in water deeper than 60m.[3]
  - To accommodate floating turbines, new technologies have been developed, such as dynamic floating high voltage cables.

- The current model for offshore wind is to connect individual farms to their neighbouring countries:
  - As offshore wind capacity grows and expands further at sea, interest is developing in large offshore hubs.
  - This would increase countries' interconnections and could also be a platform for Power to X (P2X) solutions, helping to solve intermittency issues. [4]
  - This kind of hub is planning to start operating in the early 2030s in the North Sea.[3]

FIGURE 2

Average distance from shore and water depth for offshore wind, 2010-2020



Sources: IRENA (2021)

1 IRENA Renewable capacity statistics 2021
2 IRENA Renewable Power Generation Costs in 2020
3 WindEurope 3. Equinor
4 IRENA Offshore Renewables An action agenda for deployment

Solar photovoltaic and CSP

- Globally, there are 707GW of solar photovoltaic (PV) capacity, which converts solar energy directly into current electricity. 6.5GW of concentrated solar power (CSP) capacity is also being used by solar heat to drive turbines.[1]

- The technology used for solar PV modules is getting cheaper and more efficient:
  - In 2020, the price of mainstream solar modules decreased to $266/kW,[2] showing a decrease of 9% year-on-year.
  - Mono-crystalline cells have a record laboratory efficiency of 26.7%. They are more frequently adopted over multi-crystalline cells (which reach 24.4% efficiency) and thin-film (23.4% efficiency).[3]
  - Perovskite cells and hexagonal lenses are reaching record laboratory efficiencies of 27% and 30% respectively.[4]
  - Larger wafers are being designed to produce PV modules, with capacities bigger than 600W.3
  - Bifacial passivated emitter and rear cell (PERC) technologies are increasingly being adopted to capture reverberated solar power. They reach a higher efficiency on-site at 22%.[2]

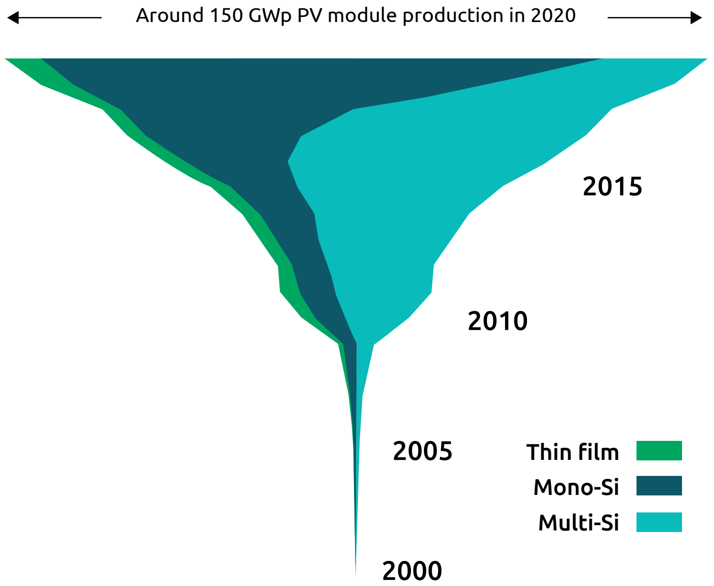
- Solar PV's efficiency is going beyond the cell level:
  - Solar PV is increasingly relying on a solar tracker to achieve greater capacity factors.
  - String and central inverters (which make up a total of 98% of the inverter market) can reach efficiencies of up to 98%.[3]
  - Digitalization is a key area of development for solar PV, as it allows for better integration into the grid (as well as enabling the prosumer residential market).
  - Floating solar PV is also being developed quickly. It increased from 1.1GW (in 2018) to 2.6GW global capacity (in mid-2020). This was mainly observed in freshwater.[4]

- Global CSP capacity only grew by 1.6% in 20201 with all

  new capacity being built in China:
  - In 2020, the total installed cost of CSP decreased to $4581/kW - 31% year-on-year.[2]
  - In the last five years, the capacity factor of CSP has remained stable at around 40%.[2]

FIGURE 3

Annual PV Production by Technology Worlwide (in GWp)



Source: Fraunhofer ISE: Photovoltaics Report 2021 , PSE Projects GmbH 2021, data from Navigant and IHS Markit

1 IRENA Renewable capacity statistics 2021
2 IRENA Renewable Power Generation Costs in 2020
3 Fraunhofer Photovoltaic report (2021) 3. RatedPower
4 IRENA Offshore Renewables An action agenda for deployment

Storage

- Pumped storage hydropower technology stores the most energy, which helps accommodate intermittency. However, stationary batteries are the fastest growing technology:
  - Lithium-ion (Li-ion) batteries make up 99% of new storage capacity,[1] providing short term storage and benefiting from synergies with the automotive industry.
  - Li-ion Iron Phosphate (LFP) cells reached $100/kWh in 2020.[2]
  - Li-ion Nickel Manganese Cobalt (NMC) (which make up 60% of stationary storage) should reach $100/kWh by 2023.[2,3]

- Li-ion chemistries are evolving to include lower amounts of cobalt, a mineral sourced up to 70% from the Democratic Republic of Congo.[4]

- Traditional Li-ion chemistries are nearing their energy density limits:
  - Lithium Sulfur (Li-S) batteries could reach four times their density.[5]
  - Solid-state batteries could double the density of liquid electrolyte Li-ion batteries.[6]

- Solid-state batteries can also solve safety issues associated with conventional Li-ion batteries, by replacing the flammable electrolyte liquid with a solid separator. They are not expected to be commercially available before the mid-2020s.

- Batteries are increasingly relying on digitalization to optimize their integration in the grid:
  - The first grid-scale battery was connected to the U.K. transmission network in June 2021. It uses AI to optimize revenue generation[7] and has 50MW capacity.

- A battery's end-of-life is essential in supplying critical minerals:
  - New designs are conceived to ensure good recyclability through pyrometallurgic, hydrometallurgical, or direct recycling processes.
  - Recycling a battery costs $62/kWh in Europe and $32/kWh in China.[8]
  - Reusing spent EV batteries as stationary batteries has also been considered.

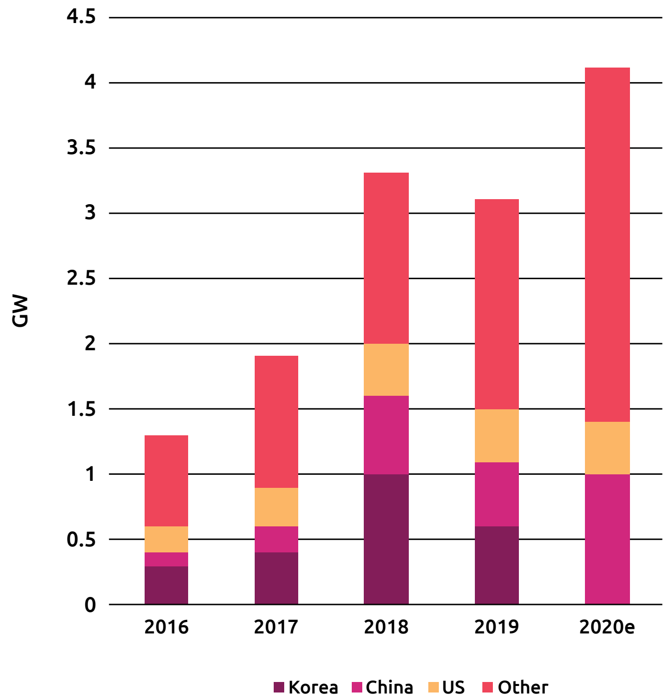
- Long-term storage is much less technologically ready. It is still unclear which of these technologies will reach market scale at a competitive price: iron-air batteries; redox flow batteries; or compressed and liquid air.
  - Mechanical solutions such as raising and dropping blocks have also been considered.

- Another contender for storing energy is the Power to Gas (P2G) approach, where energy is stored as hydrogen.

1 https://www.greentechmedia.com/articles/read/most-promising-long-duration-storage-technologies-left-standing
2 IHS Markit
3 IEA Innovation in batteries and electricity storage (2020)
4 IEA The Role of critical minerals in clean energy transitions (2021)
5 Saft Batteries
6 Advancing Battery Technology for Modern Innovations
7 Energy Superhub Oxford
8 https://www.argusmedia.com/en/news/2178338-eu-battery-recycling-could-be-profitable-by-2025

FIGURE 4

Annual battery storage capacity additions



*2020 is an estimation

Sources: IEA (2021)

Project hybridization

- The integration of variable energy sources is putting a strain on grid stability. Therefore, many projects are associating batteries with renewable sources to ensure stable delivery:
  - Around 40% of the new renewable projects by the four renewables supermajors (Enel, Iberdrola, Orsted, and NextEra) are hybrid.
  - At the end of 2019, 125 hybrid projects were operational in the U.S., with 184MW of wind + storage and 169MW of PV + storage. Despite there only being 2 CSP + storage projects, they totalled 390MW.[1]

- Examples of hybrid projects include:
  - Enel's Azure Sky wind + storage projects, set to start operation in early 2022. The Texas farm combines 350MW of onshore wind and 137MW of battery.[2]
  - Iberdrola's Port Augusta project - the first wind and solar hybrid project in the world. It does not include storage, but has a capacity of 210MW from wind and 107MW from solar PV.[3]
  - NextEra and PGE's Wheatridge renewable energy facility combines 300MW of wind, 50MW of solar PV, and 30MW of four-hour duration batteries. This facility will be operational by the end of 2021.[4]

- Hybrid projects are also an opportunity for the deployment of gas and green hydrogen to create power. As electrolyzers require DC current, they can be connected directly to solar PV without requiring inverters, for example.

- Integrating batteries directly into renewable projects does raise the question of their added value. For example, they cannot provide ancillary services to the entire grid.

1 Lawrence Berkeley National Laboratory

2 https://www.enelgreenpower.com/media/press/2021/03/enel-first-large-scale-wind-storage-hybrid-project-will-support-kellogg-company-renewable-energy
3 https://www.iberdrola.com/about-us/lines-business/flagship-projects/port-augusta-project
4 https://newsroom.nexteraenergy.com/NextEra-Energy-Resources-trifecta-renewable-energy-project-is-under-construction

02 Commodities & Technologies

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02 Commodities & Technologies

Technologies Main Evolution: Hydrogen

Richard Biagioni
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Technologies Main Evolution: Hydrogen

Decarbonized Hydrogen: A key lever for achieving a net-zero ambition

Hydrogen will play a role in the net-zero future by decarbonizing heavy industry and creating new H_2 uses

- **The ambition to achieve net-zero by 2050**, enacted in March 2020 by the European Union (EU), **became a worldwide clarion call with more than 100 countries** now sharing this ambition.

- Several **industrial giants** have **communicated practical targets,** including Air Liquide, TotalEnergies, BP, Shell, and many others.

- In this fight against climate change, **decarbonized hydrogen**, as an energy carrier, **is a key lever due to its storability, high energy density, and no post-combustion CO_2 emissions.**

- In the energy and transportation industries, **hydrogen is expected to play a vital role in the global transition** towards net-zero economies. The EU alone could **save up to 569 Mt CO_2e**, generate €338 billion of gross value added (GVA), and create 5.9 million jobs[1].

HEAVY INDUSTRY: A CRITICAL TARGET TO SIGNIFICANTLY REDUCE CO2 EMISSIONS IN THE SHORT TERM

- **Current use** of grey H_2 in **heavy industry** (highly carbonated) can **be replaced with low-carbon hydrogen.** In Europe, CO_2 avoidance could reach 9.9 Mt CO_2 per year[2] (see infographic).

- **Low-carbon H_2 use can be extended to additional industrial uses** to decarbonize **hard-to-abate sectors.** For example:
  - **Steel industry:** Direct reduced iron processes could **reduce emissions of 13.7 MTCO$_2$ per year in Europe[1].**
  - **Cement industry:** Using H_2 to supply high-temperature furnaces to produce clinkers used in Portland cement could **reduce CO_2 emissions by 35% by 2030[3].**

APART FROM INDUSTRY, ADDITIONAL SPECIFIC H_2 USES SHOULD BE ANTICIPATED

- The **transportation** industry is responsible for 26% of annual CO_2 emissions in Europe (940 Mt)[4]

1 Capgemini Invent report « Fit for net-zero » (55 Tech Quests to […] climate neutrality) - 2020
2 Clean Hydrogen Monitor (2020)
3 According to the major global cement producer CEMEX (February 2021)
4 in 2018 – Official European Commission website - Emission inventories

- **Electricity efficiency rates of battery electric vehicles (BEV) compared to fuel cell vehicles (FCEV) is 70-80% vs. 30%[1]. In addition, high costs of H_2 charging stations and scale disadvantages have led to the development of light-duty transport with BEV.**
- However, **some technical advantages of fuel cells** (scale, weight, autonomy, refueling time) **give H_2 FCEV a competitive edge in heavy-duty transport** (trucks, ships, trains and air transport) **— another hard-to-abate sector.**

- **Seasonal energy storage** of renewable electricity and **blending hydrogen into natural gas grids** are relevant levers to **(1) decarbonize gas networks** and (**2) tackle production variability** of renewable energy (sector coupling). But scaling to commercial and industrial end-users will **necessitate addressing technical and regulatory barriers and requires infrastructures investments.**

FIGURE 1

Key figures of hydrogen in European heavy industry

2 Bn€
Annual turnover
for **H2 Production**
(2019)

~100%
Part of European H2
production used
in **heavy industry**

9,9 Mt
H2 produced every year
in **heavy industry**
(excluding H2 as a co-product)

92%
Part of European H2
production carbonated
(from natural gas or coal)

Current Main Usages

47%
as a reagent
in **refining processes**

34%
as a based-product to produce
ammoniac and methanol

12%
as a based-product to produce
chemical & metallurgical products

70 Mt of CO2
CO2 annual emissions in Europe potentially avoidable using low-carbon hydrogen in heavy industry

Sources: Clean Hydrogen Monitor (2020) and World Energy Market Obversatory Capgemini (2020)
Scope : European Union of 27, United-Kingdom, Norway, Switzerland and Island

1 Study of Horváth & Partners - Automotive Industry 2035 – Forecasts for the Future

The industry must scale in the next decade. However, the rate will vary across countries and industriesdue to national strategies that consider existing infrastructure and local resources

Several processes are needed to produce low-carbon hydrogen

Two main technologies exist to produce low-carbon hydrogen:
1. Electrolysis of water from low-carbon electricity (renewable or nuclear); or **2. Steam reforming of natural gas with carbon capture.** Hydrogen is often categorized by color for popularization purposes: Green for renewable hydrogen; blue for hydrogen produced with carbon capture and storage (CCS) solutions; and yellow or pink for hydrogen from nuclear. However these categories are not standardized.

National strategies to scale-up hydrogen production in the next decade

To support the ongoing development of technologies and associated scale-up, in 2020, the European Union elaborated on its **hydrogen strategy** for a climate-neutral future. Afterwards, **several countries published their national strategies** based on this source. According to the European Commission, the objective is to install "at least **6 GW of renewable H_2 electrolyzers by 2024 and 40 GW by 2030**"[1].

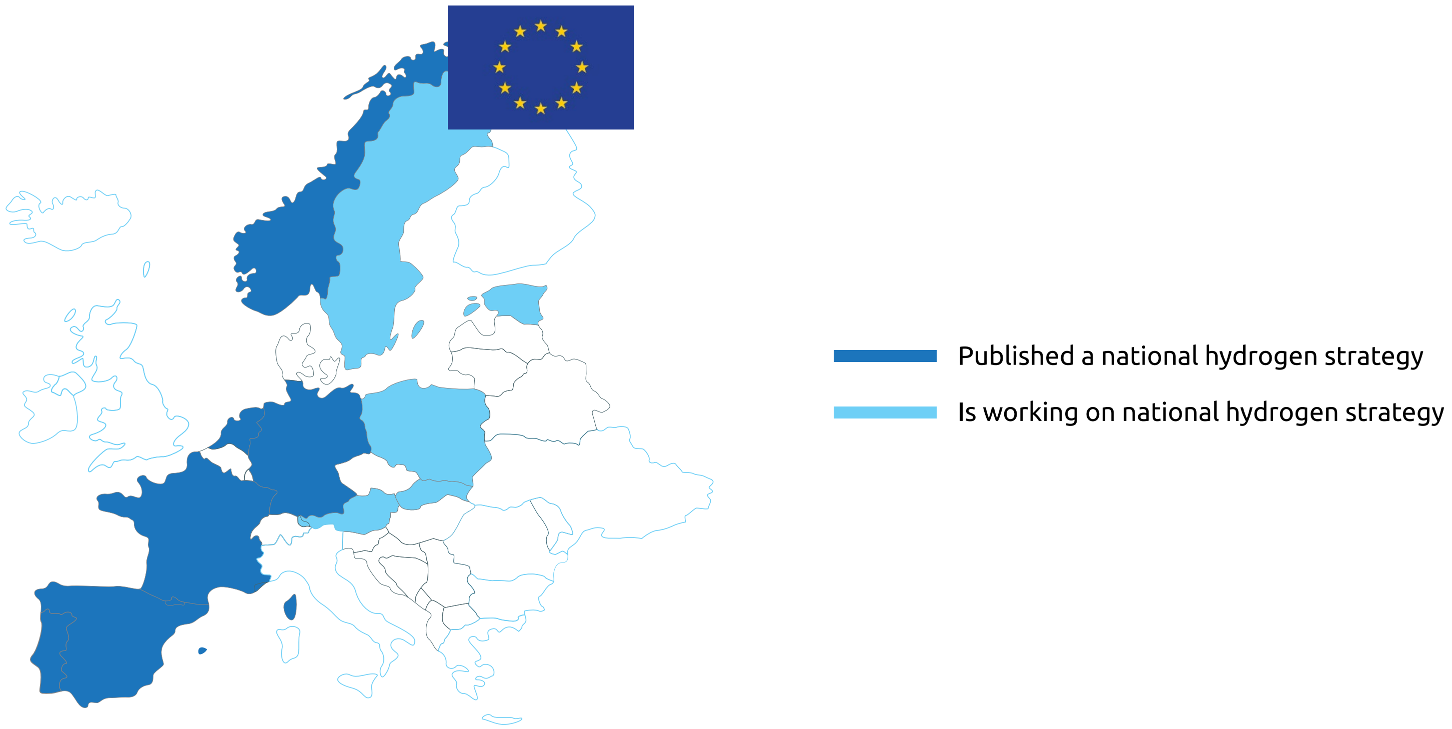
- **The French** hydrogen plan published in 2020 commits up to €7 billion of public aid by 2030 and makes heavy industry one of its priorities to avoid 9 Mt of annual CO2 emissions. It plans to **set up 6.5 GW[2] of electrolysis production capacity.**
- **The German** national hydrogen strategy published in June 2020 expects a national consumption of 90-110 TWh by 2030. By then, the country plans to **build up 5 GW of electrolysis production capacity and 10 GW by 2040[3].**
- **The Dutch** national strategy was published in April 2020. By 2025, it plans to **build up to 500 MW of electrolysis production capacity and 3-4 GW by 2030[3].** In terms of mobility, the Netherlands want to deploy 15,000 FCEVs and 50 hydrogen refueling stations by 2025, and increase that figure to 300,000 vehicles by 2030. Moreover, **sustainable aviation fuel** is part of the plan with a **blending rate of 14% of sustainable fuel in aviation by 2030 and 100% by 2050[3].**
- **The Spanish** strategy plans to allocate around **€9 billion of investments by 2030** to develop the hydrogen sector, notably with the ambition to set up 4 GW[3] of electrolyzer capacity.
- **Other member states** have also published national hydrogen strategies or are currently working on it, including Portugal, Austria, Lituania or Estonia.

Outside the EU, many countries including Japan, Australia, New Zealand, Norway, and South Korea published hydrogen development strategies

1 Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the committee of the regions, A hydrogen strategy for a climate-neutral Europe, (July 2020)
2 Decarbonized hydrogen development strategy on French territory (September 2020)
3 Clean hydrogen Monitor 2020 report

FIGURE 2

Map of European hydrogen strategies



U.S.:

Unlike many other countries, the U.S. **has no official national hydrogen strategy.** However, **some** states, such as California, developed their own roadmap. In addition, the U.S. DOE[1] has a program plan focusing on **developing the RD&D** side of the hydrogen economy (as opposed to only the **consumption side**). In this perspective, the **H_2@Scale initiative** was launched in 2020 **to study technology's end-to-end competitiveness** (from production to consumption).

The U.S. DOE hydrogen program plan also leverages existing hydrogen production, transport, and storage facilities.

1 US department of energy (DOE)

Scaling necessitates leveraging existing infrastructures and local resources

While **most national strategies and associated investment plans only focus on the consumption side,** the question of **local energy sources** used to produce decarbonized H_2 is crucial and must be considered for two reasons:
1. to produce low-carbon or green H_2; and **2. to make maximum effort to lower clean H_2 cost production**

- Though there are several ways to produce H_2 in an economically and environmentally responsible way, the strategy will depend in part on the location.

France – Leverage existing nuclear parks

- **To produce enough H_2** via electrolyzers to **decarbonize heavy industry only, 55 TWh of decarbonized electricity**[1] would be necessary each year.

- With a **total capacity of 28 GW$_2$, in 2020, current wind & photovoltaic (PV) parks produced** a total of **52.3 TWh of electricity**[2] (due to load factors of wind turbines and photovoltaic panels equal to ~20.7% and 13.5%[2], respectively).

- Because of these intrinsic small load factors, a **100% renewable scenario** to decarbonize heavy industry via renewable H_2 **would necessitate additional renewable capacities.** To handle this new electricity demand, **massive investments would be necessary** similar to the currently installed wind and PV capacities (28 GW).

- The **existing French nuclear plants** can **secure decarbonized H_2 production, making it controllable and less expensive. Controllable capacities maximize electrolyzers' load factor, thus reducing H_2 production costs.** Leveraging these existing industrial assets (61.4 GW power capacity) constitutes an enormous opportunity **to secure the new electricity demand from decarbonized H_2 production.** In addition, **massive refurbishment works are being made by the French operator EDF to** expand nuclear reactors' lifetime beyond 40 years through the Grand Carénage program, which has an estimated budget of €49.4 billion and an end date in 2025[3].

Norway – Leverage existing hydropower capacity and pipeline infrastructures

- Currently, Norway's **renewable electricity production is primarily hydropower** (94.5% in 2020)[4].
- Electricity production is already higher than in most other countries and the **electrification rate is high.**

- **Increase in power consumption** between 2**0 and 80 TWh by 2040** is expected, but **electricity generation** should **increase to 600 TWh in 2050,** resulting in an **excess power of 75% of generation**[5]**.**

- Norway probably has the **highest electricity power surplus in Europe and is in position to export low-carbon H_2.**

- **Leveraging existing gas pipeline infrastructures to avoid expensive and unpopular investments** in new grid capacity also seems a relevant move (though pipelines must be adapted and re-qualified).

1 French Academy of Technologies - French electricity growth perspective by 2050 (March 2021)
2 Renewable electricity panorama - RTE (December 2020)
3 EDF statement, 29 October 2020
4 Minister of Petroleum and Energy Tina Bru - Norwegian Hydrogen Conference in Oslo on June 3rd (2020)
5 GenCost 2020-21 and Australian Government – Department of Industry, Science, Energy and Resources (2021)

AUSTRALIA:

- **Australia boasts near-perfect conditions for renewable power production including** solar energy, PV, and wind plants.
- **The cost of variable renewables** (wind and solar PV) without transmission or storage are **the lowest costs in generation technology** by a significant margin (around A$40/MWh)[1].
- Share of **Australia's electricity coming from renewables reached 23%** in 2020. The ambition is to reach **50% by 2030[1].**
- This growth in **renewable electricity production** is forcing Australian energy companies to seek **ways of managing** imbalances between supply and demand.
- Australia has several renewable hydrogen export opportunities. An export agreement was already signed with Germany.

Australia's National Hydrogen Strategy aims to position the country as a **major global H_2 player by 2030[1]**, particularly on the **exportation market** by committing to invest AUS $275.5 million to develop the hydrogen industry.

1 GenCost 2020-21 and Australian Government – Department of Industry, Science, Energy and Resources (2021)

Different kinds of opportunities for industrial and energy companies

- Decarbonized H_2 is a key lever to achieve a net-zero ambition. It is considered **a source of transformation for industrial and energy companies:**
  - **New value streams** to unlock through new offers and products. For example, some chemical companies hope to move along the new hydrogen value chain to produce their own hydrogen and become energy producers.
  - **Performance improvements** to achieve core activities while decarbonizing.
- In a world where players target net-zero ambitions, **traceability becomes essential to match the regulatory criteria. Data and digital levers** will be explored (e.g., leverage data for energy systems, sizing, and optimization, etc.)
- According to Bloomberg, **the H_2 world market could be $700 billion by 2050** (around €600 billion).

Industrial strategic co-operation and transformation

- Many **companies are already transforming** themselves for hydrogen opportunities:

Air Liquide

Air Liquide announced an €8 billion investment by 2035 in assets, technologies and expertise to produce this molecule sustainably at an industrial scale.

Hynamics
Rosatom

EDF launched Hynamics, its division to produce and sell low-carbon hydrogen. On April 25, they announced a cooperative agreement with **Rosatom** regarding R&D for the decarbonation of industrial assets.

Engie
TotalEnergies

ENGIE and **TotalEnergies** partnered to design, develop, build, and operate the Masshylia project, France's largest renewable H2 production site.

ALSTOM

Alstom announced the acquisition of **Helion Hydrogen Power**, a Fuel Cell specialist.

Terega
GazelEnergies

Térega and **Enagas** (gas networks and storage operators), **DH_2 Energy** (green H2 producer), and **GazelEnergies** (energy company) announced on April 30 a partnership to study the deployment of green H_2 transportation and production infrastructures between France and Spain.

Schlumberger
CEA

Schlumberger and the **CEA** (French Atomic Energy Committee) announced on April 5 the launch of Genvia, which has the goal to accelerate and industrialize a high-performance solid oxide electrolyzer technology.

- As this market **becomes larger and more competitive,** industrial and energy **companies will need to reevaluate their hydrogen ambition and strategic positioning on the new H_2 value chain.**
- Technologic leadership and rapid scale-up are key. Therefore, **industrial cooperation** and **rapid transformation** are **necessary** to assume and solidify **new strategic positions.**

Estimated current cost of fossil hydrogen	Estimated cost of low-carbon hydrogen	Estimated current cost of renewable hydrogen
€1.5/kilogram	€2/kilogram	between €2.5 - €5.5/kilogram

02 Commodities & Technologies

02

02 Commodities & Technologies

Technologies main evolution: Carbon Capture, Utilisation and Storage (CCUS)

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Technologies main evolution: Carbon Capture, Utilisation and Storage (CCUS)

Carbon Capture Utilization and Storage (CCUS)

CCUS is likely to be a necessary lever in the decarbonization of hard-to-abate areas. As the market, value chain and technology matures, CCUS is hoping to store between five and 15 Gigatons per annum (Gtpa) by 2050

- **CCUS is set to capture between five and 15 Gtpa in the main decarbonization pathways by 2050 – a step up from 0.04 Gtpa seen today.** The latest IEA net zero pathway plans to increase Gtpa to 1.6 by 2030 and 7.6 by 2050.[1] CCUS is hoping to make up between zero and 300 $GtCO_2$ of the cumulated negative emissions in the IPCC 1.5°C scenarios by 2050.[2]

- **This would result in 4,400 capture unit with a 2 Mtpa capactiy, each costing $500 million.**[3]

- **CCUS might be the most practical solution for hard-to-decarbonize sectors.** This includes industries that rely on high heats and chemical reactions-especially those with a high concentration of CO_2. Maritime transport could see a more rapid decarbonation than if they just used indirect energy pathways such as e-fuels. The first prototype of CCUS on ships was launched by Mitsubishi in 2020.

- The technology for **direct air capture (DAC) has not been demonstrated to scale,** as it is not yet certain how bioenergy with carbon capture and storage (BECCS) makes an impact. However, both DAC and BECCS contribute significantly to decarbonation pathways, as they allow for the compensation of emissions from diffuse sources, such as cars and aviation. The IEA net zero pathways have targets of 13% for DAC and 18% for BECCS by 2050. DAC also allows for carbon capture in places with low electricity prices.

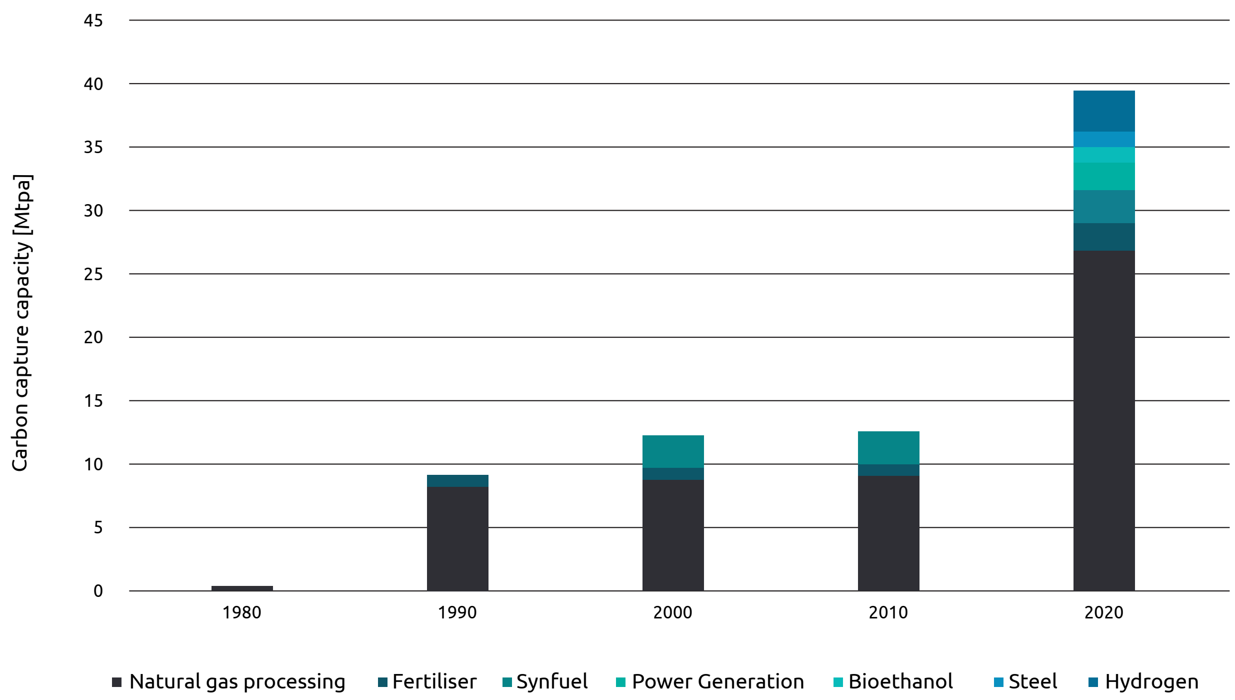
- **The IEA forecasts that in 2050, 63% of carbon captured will be from the energy sector.** This will be from either power generation or other fuel transformation, highlighting the critical role of CCUS in energy actors.

- **Blue hydrogen** (produced from natural gas) together with CCUS will also play a critical role in the energy transition, provided methane leaks with a high greenhouse impact are controlled.[4]

1 IEA: Net Zero by 2050
2 IPCC
3 Rystad Energy research and analysis
4 Howarth, RW, Jacobson, MZ. How green is blue hydrogen? Energy Sci Eng. 2021; 00: 1– 12. https://doi.org/10.1002/ese3.956

FIGURE 1

Carbon capture capacity per sector



Source: IEA (2020)

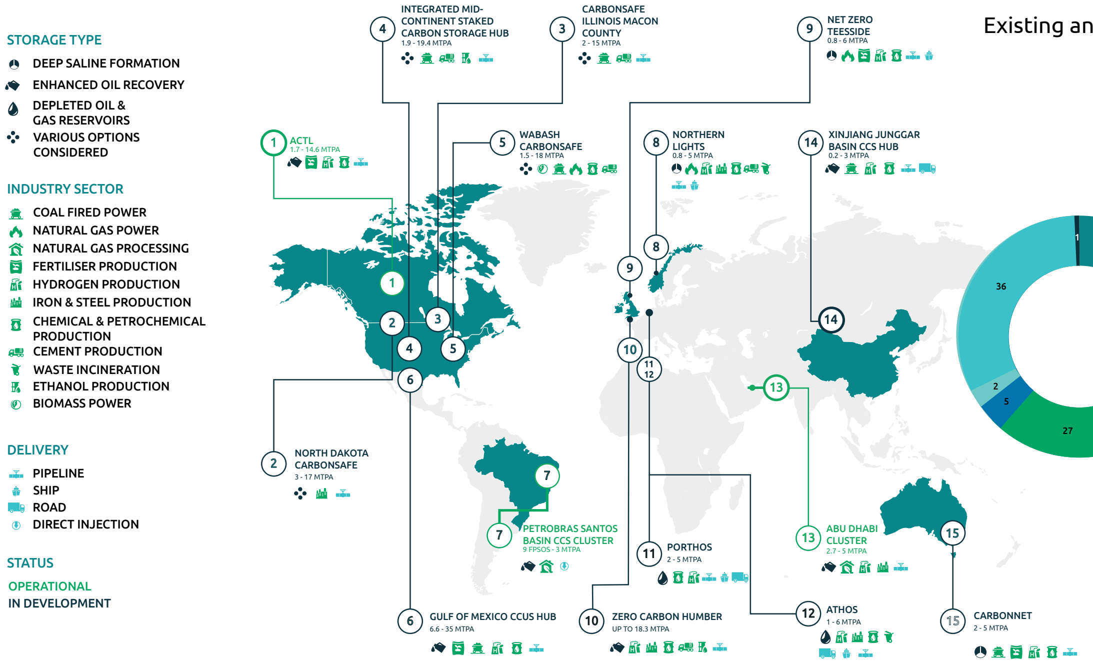
Technology is reaching commercialization readiness levels at the three stages of the CCUS value chain: capture, transport, and destination.

The destination can either be in the form of utilization of gas as it is (for example, in the food and beverage industry), as raw material in chemical processes, or as the permanent storage of carbon dioxide underground in depleted hydrocarbon fields and saline aquifers.

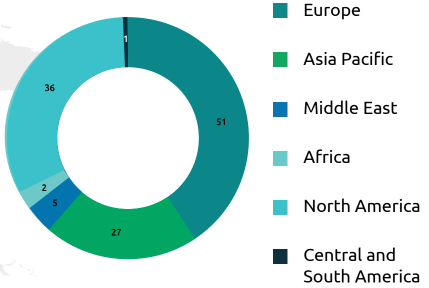
The global effort to deploy CCUS at scale is led by North America and Northern Europe

FIGURE 2

Map of hubs and clusters operating or in development



Existing and planned CCUS facilities



Source: GCCSI (2021)

Supported by strong policies and carbon prices, projects are being developed in clusters in North America and Northern Europe.

Stand-alone projects are also being operated and developed in East Asia and Australia. According to the IOGP, there are 27 such projects.

Incentivized by national mandates and carbon prices, the capture and storage capacity of large-scale projects in construction and development increased by 70% globally between 2017 and 2020.[1] Operational capacity should follow in the next five years.

- **The industry is seeing a surge in announcements.** Between 2018 and 2021, the number of projects increased from 15 to 51 in Europe alone. Among those, many are centered in clusters around the North Sea, creating a strong CO_2 value chain in the region. This includes many projects with capacities above 1 Mtpa.

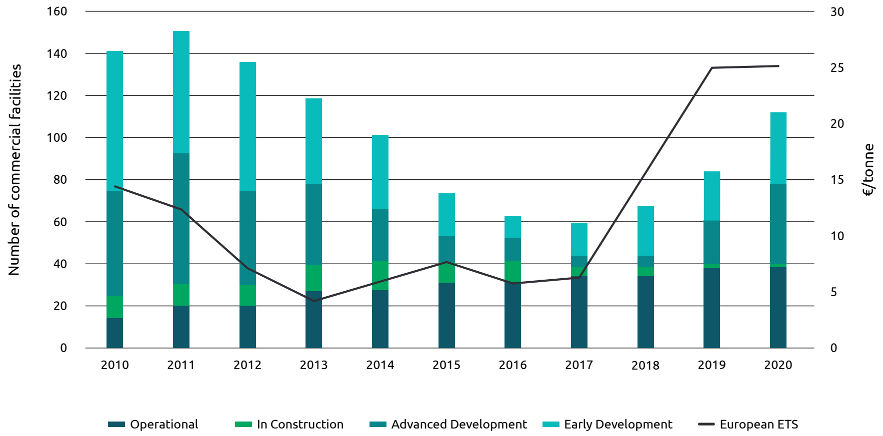
- **The cost signal for CO_2 is increasing rapidly.** The European ETS reached upwards of $67/tonne in early July 2020 (this was previously insufficient).

- China implemented their ETS in January 2021, which only reached $8.8/tonne in late July 2021.

- **The 2018 revision of the U.S. 45Q tax credit has opened subsidies for many CCUS projects.** It offers $31.77/tonne for permanent geological storage and $20.22/tonne for enhanced oil recovery (EOR) and utilization.[2] This incentivized at least ten large-scale projects so far in the U.S., most of which rely on EOR.[1]

FIGURE 3

Evolution of CCS capacity of the commercial facilities pipeline



Source: GCCSI, ICE(2021)

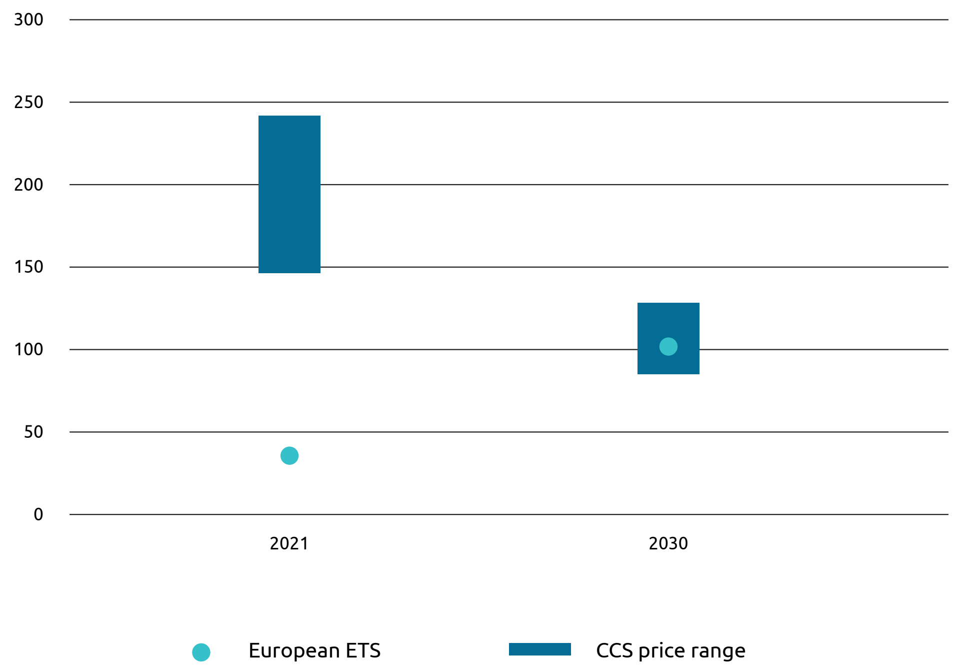
- **Direct subsidies from states provide other incentives for specific projects.** The Australian government awarded AUD $40 million to multiple projects in June 2021.[3]

- The Longship project received $1.8 billion from the Norwegian government.[4]
- **Announced European projects alone could capture 50 Mtpa by 2030.** This is still far from the IEA's global theoretical target of 5% of 7600 Mtpa by 2050.

1 GCCSI - Global Status of CCS 2020
2 IRS: https://www.irs.gov/pub/irs-drop/td-9944.pdf
3 https://ihsmarkit.com/research-analysis/australia-awards-a50-million-for-ccus-projects.html
4 https://www.regjeringen.no/en/aktuelt/the-government-launches-longship-for-carbon-capture-and-storage-in-norway/id2765288/

FIGURE 4

CCS prices evolution for Northern Lights project



Source: Equinor (2021)

The market for CO_2 will remain largely regional (like other industrial gases), because it relies on local incentives and infrastructures.

As states drive the carbon price up, industrial emitters are increasingly concerned over decarbonation. This creates the premise of a viable CCUS industry.

High concentration point source capture is (in the short-term) the most promising, with prices of capture generally below $40/tonne

- **Capture in power, cement, and steel is anticipated to drive the technology.** However, market structures in these sectors cannot support the high capture costs (between $50-100/tonne), due to lower CO_2 concentrations. Most of today's capture remains in natural gas processing.

- **Thanks to low costs and high CO2 concentration capture, projects such as Shell's Polaris CCS are being announced.** They are set to capture carbon from mono-ethylene glycol production.[1] Summit Carbon Solutions aims to provide a carbon capture of 15% of U.S. ethanol production by 2025.[2]

- **The 71MW and 1.4 Mtpa Petra Nova gas power station in the U.S. achieved costs 35% lower than the first commercial CCS power plant** in Canada in 2014 (0.73 Mtpa).[3] However, the post-combustion U.S. project could not stay competitive during the COVID pandemic and had to be shutdown in May 2020.[4]

- **Two 910 MW gas power stations will help SSE and Equinor to reach 30% of the U.K.'s 2030 CCUS goal.** Both the Peterhead and Keadbye 3 projects will capture 1.5 Mtpa, and are linked to the Acorn and Humber hubs, respectively.[5] History of gas with CCUS at Peterhead is not new. BP spent £500 million on the project before giving up in 2007. In 2011, Shell followed suit. Peterhead was also a finalist for a 2015 £1 billion CCUS competition, which was later abandoned by the U.K. government.[6] It is now planning to go online in 2026, if appropriate policy mechanisms are set in place.

- **With five planned projects, HeidelbergCement is leading cement with CCUS** ahead of Lafarge. It plans to build the first commercial facility by 2024 in Norway (in collaboration with Longship), aiming to capture 50% of the CO_2.

The economics of capture are closely tied to the concentration of CO_2.

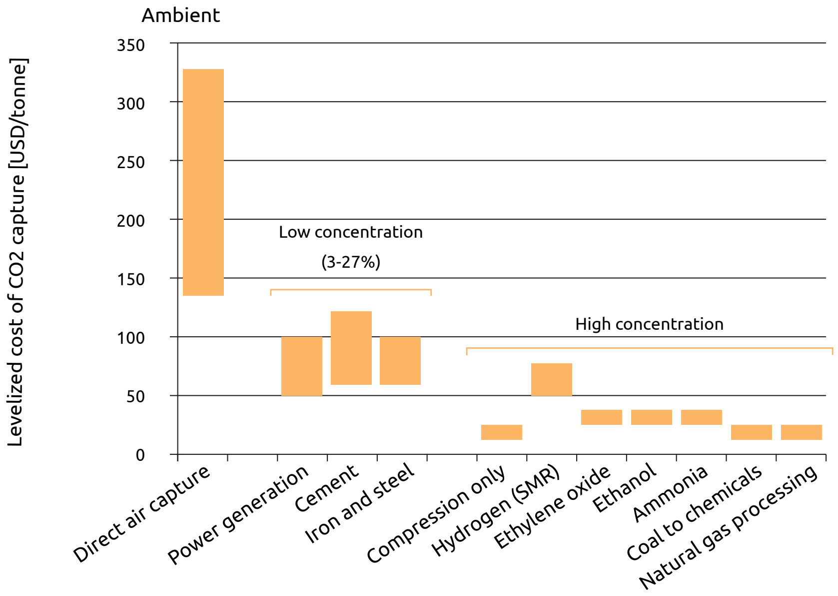
This disqualifies direct air capture (DAC) in the short- and medium-term.

In the ETS-driven European market, the first probable application is high CO_2 output in concentration industries.

1 Shell
2 http://www.ethanolproducer.com/articles/18396/carbon-connector
3 IEA
4 https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/052821-us-lng-undeterred-by-lessons-of-past-as-producers-embrace-carbon-capture
5 SSE
6 https://www.bbc.com/news/uk-scotland-57064161

FIGURE 5

Levelized carbon capture cost in 2019



Source: IEA (2020)

The transportation of CO_2 is not a technical problem–creating the CO_2 market to be transported is

- **Transport technologies for CCUS are well developed, with a TRL of nine in most areas.**[1] Pipe transport has been extensively developed in the U.S. already (more than 800 km).[2]

- **Transport costs account for around $3/tonne[3] for 100 miles of pipes,** although this varies widely between projects in terms of length, flow rate, and terrain.

- Examples of large pipe infrastructure include the **Acorn Project** in Aberdeenshire, estimated to launch in 2023. It plans to reuse 420 km of offshore pipes, taken from the deep seaport of Peterhead. This is where SSE plans to build a new gas power station, and Pale Blue Dot is developing hydrogen manufacturing capacities.

- **Repurposing hydrocarbon infrastructure is a large part of the CCUS industry strategy** throughout the value chain. This is because gas has familiar properties to natural gas and would only necessitate a moderate amount of work.

1 GCCSI
2 National Petroleum Council
3 Smith et al. (2021) The cost of CO2 transport and storage in global integrated assessment modelling

- **There is a potential transition issue and a conflict in use of infrastructure for CO_2 and hydrocarbon.** The Acorn Project hopes to extend to southern Scotland and the Grangemouth industrial cluster, through to the 280 km Feeder 10 pipeline. This onshore pipeline is still, to this day, a part of the gas National Transmission System. This is a strategic issue, as Acorn estimates the price of refurbishing the pipeline to be between 1-10% of the price of a newbuild.[1]

- **Deployment of CO2 transport by ship at scale is not as advanced:** ~3 Mtpa is used for both food and beverages.[2] The 2019 revision by the London Protocol, which allowed for the international transport of CO_2, opens the door to a large market of long distance maritime shipping.[3]

- **Shipping CO2 adds between $35 and $64/tonne**[4] to the Northern Lights project's value chain (also part of Longship). It is creating a coastal infrastructure fit to receive the gas from tanker ships along southern Norway. It also plans to construct new vessels. These should resemble LPG carrying tankers and be able to transport 7,500 m[1] of fully pressurized CO2 between 13 and 15 barges. The capacity of shipyards to quickly ramp up production of such ships could create a bottleneck in the deployment of CO_2 shipping.[5]

- **A direct injection from ships into offshore wells is not as mature.** Therefore, Northern Lights will receive gas from the boats, then transfer it via pipelines to the injection well.

Transporting CO_2 via ship is not as viable as pipes at present. However once the shipping reaches scale, it will provide a more flexible option over long distances as compared to pipes.

1 Accorn
2 GCCSI
3 IEA – CCUS in the Global Energy Transition
4 Smith et al. (2021) The cost of CO2 transport and storage in global integrated assessment modelling
5 Northern Lights

Led by the O&G sector, technology for large-scale storage is on the horizon. Its scalability still depends on finding the right locations, business cases and regulatory schemes.

- **Storage adds an average $8/tonne for a CCUS project.**[1] This value is particularly sensitive to the site's conditions. For instance, just the required monitoring standards alone can double the cost.

- **Most projects to date have been focused on EOR,** excluding other financial incentives. However, the volume of carbon to be stored will necessitate injecting into depleted gas and oil fields (DGOF), as well and saline aquifers (SA).

- **The largest existing storage facility, the Gorgon CO_2 Injection project, so far consists of directly injecting** up to 4 Mtpa of carbon from natural gas processing into a neighboring geological reservoir for the next 40-45 years.[2] The Chevon-ExxonMobil-Shell joint venture started operation in the $2.4 billion facility in August 2019. This took place in western Australia, ten years after the final investment decision. However, in January 2021, pumping sandy water from the reservoir in replacement of CO_2 , clogged pumps. This forced an undisclosed amount of CO_2 to be vented into the atmosphere.[2]

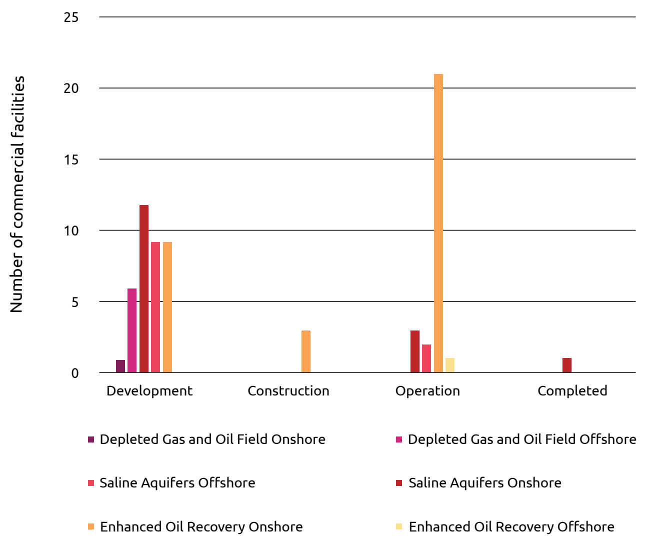
- **The Northern Lights project will store CO_2 from any source.** The Equinor-TotalEnergies-Shell joint venture project is expected to go online in 2024 and will store 1.5 Mtpa of carbon dioxide. It will sit 2.6 km under the seabed, under its initial configuration with a single injection well. There are considerations being made to add more injection wells between 2025 and 2027, boosting the storage capacity to 5 Mtpa.[3]

While more large-scale projects are being developed outside of enhanced oil recovery, prices for storage remain very dependant on specific sites and technologies.

With its expertise in reservoir engineering, the O&G industry is leading the way in carbon storage, decarbonating its Scope 1 emissions, and maintaining its social license to operate.

FIGURE 6

Number of commercial facilities per storage option



Source: GCCSI(2021)

1 Smith et al. (2021) The cost of CO2 transport and storage in global integrated assessment modeling
2 BoilingCold
3 Northern Lights

Between 2020 and 2070, the utilization of carbon may represent 8% of captured carbon. This important area sees the fast maturation of technology, scales and business models, with intensive research and first pilots.

- **8% of captured carbon could be reused,** according to the IEA 2020-70 Sustainable Development Scenario. This is a step up from the 230 Mtpa used in 2020 (125 Mtpa from the fertilizer industry, 80-90 Mtpa from EOR).[1]

- **Key sectors of utilization include synthetic fuels, chemicals and building materials.** Together they could represent more than 10 Gtpa. However, according to the IEA, they are likely to be much less due to economic limitations.

- **Not all utilization of carbon has the same effect on climate** as it does in drinks. Greenhouse gases will end up in the atmosphere at the end of the product's life.

- **Burning fuels made from CO_2 will release carbon straight back into the atmosphere.** This is a preferable alternative to releasing new carbon from fossil sources, as it would have two uses per unit of warming. However, if this CO_2 has been pulled from the atmosphere from DAC or BECCS, putting it back when burning synthetic fuel will have a close to neutral effect on climate.

- **The mineralization of carbon into construction materials makes it sufficiently inert** to consider it as permanently stored, as well as contributing to the decarbonation in this hard-to-abate industry.

- **Using CO_2 as a feedstock for polymer production can also make the carbon sufficiently inert** to consider stored, and replace plastics made from fossil fuels.

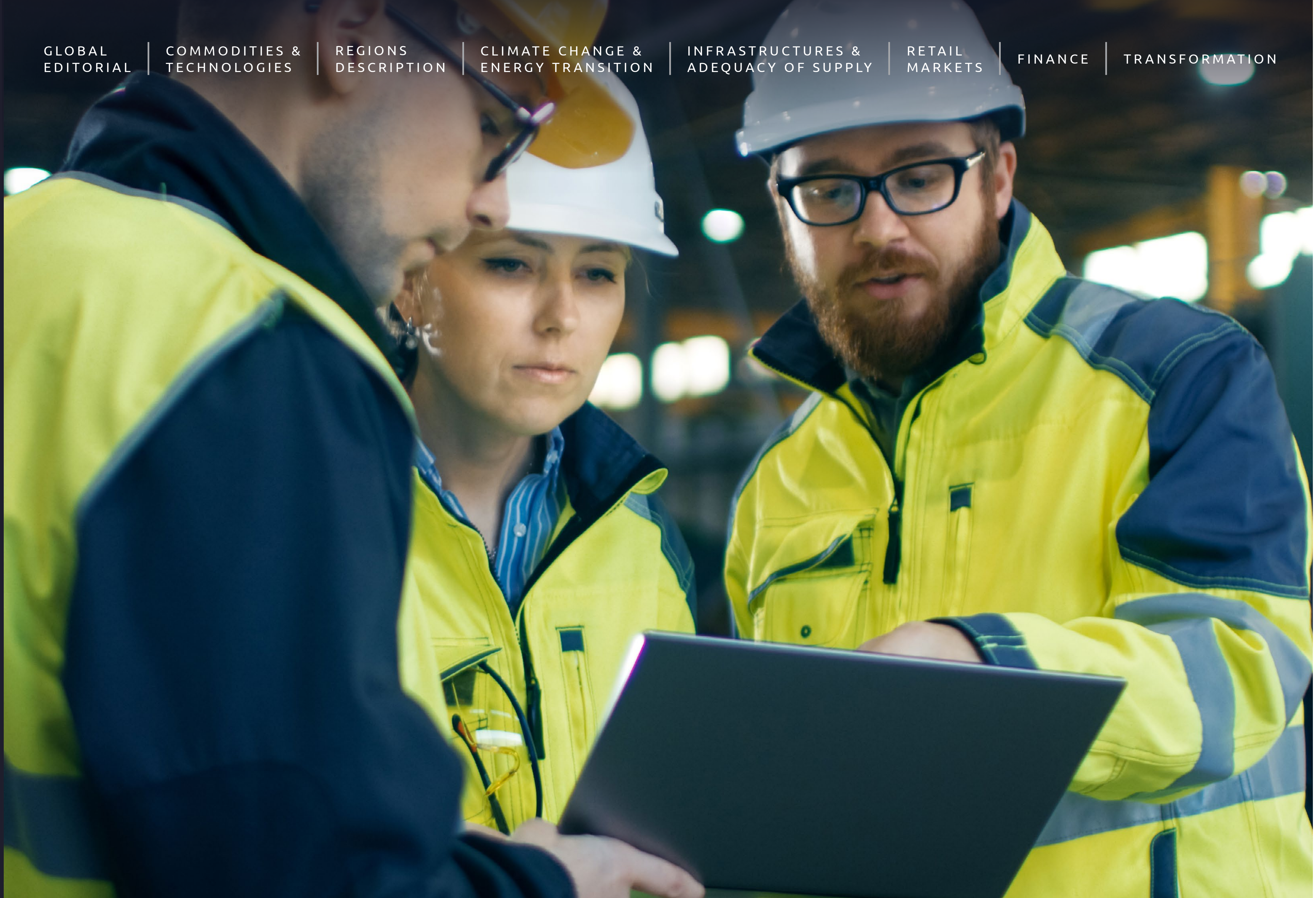
- **Synthetic fuels will be in direct competition with the electrification of transport and hydrogen. However, according to the IEA,** it could be the main use case of CO_2 , particularly in the aviation industry where it could fill 40% of the energy needs by 2070.[1]

- **Norsk e-fuel** plans on producing ten million liters per year of e-fuel by 2023, scaling up to 100 million liters per year by 2030, and only using renewable energy and direct air capture. This would represent the utilization of 0.25 Mtpa of carbon.[2]

- **CarbonCure (founded in 2007) and Solidia (founded in 2008) have a notable lead in the deployment of carbon cured concrete.** CarbonCure claims to have avoided 0.05Mt last year, but is now aiming for 500 Mtpa by 2030.[3]

1 IEA – CCUS in the Global Energy Transition
2 Norsk E-Fuel
3 CarbonCure

03 Regions Description



03 Regions Description

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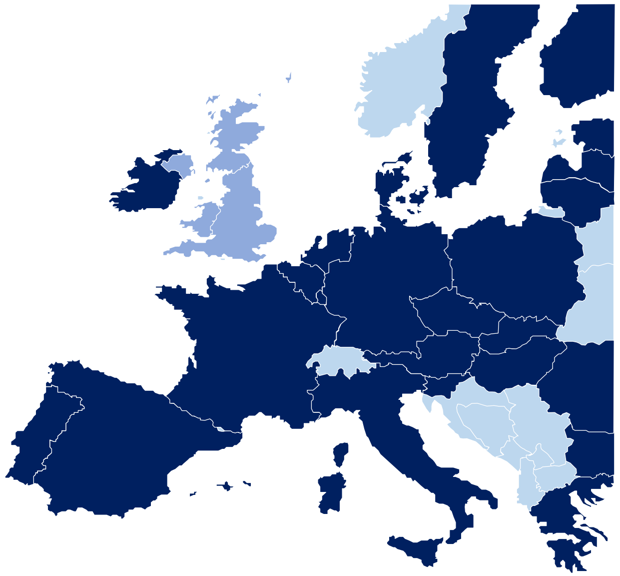
03 Regions Description

Europe ID Card

Augustin Danneaux

Country Description

Quick introduction



Region: European Union

All data is for EU27 (unless otherwise specified)

Population: 447 million

GDP: USD $15.75 trillion

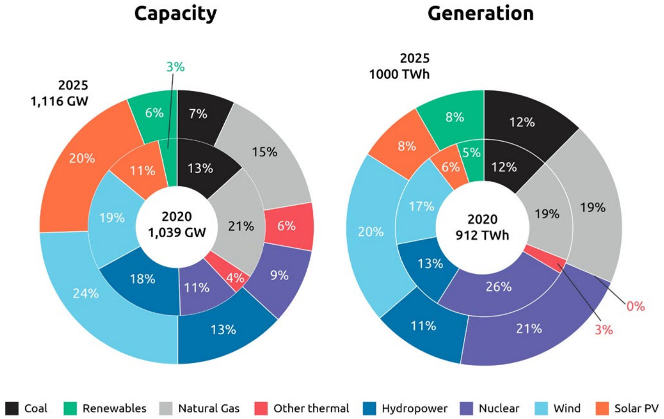
Energy

2020 Total energy consumption: 1307 Mtoe

-7% from 2015

Electricity

Average 2020 electricity price: **€29.3/MWh**



Gas

Total gas production: **54.58 bcm**

Total gas consumption: **396.7 bcm**

Renewable energy

Share of renewables in final energy consumption: **8%** (Enerdata)

2020 added wind capacity: **10GW**

2020 added solar capacity: **19GW**

Environment

Total CO2 emissions: **2,470 MtCO2**

GHG emissions growth rate: **-3.7% (EU27+UK)**

55% GHG reduction objective compared to 1990 by 2030

Electric vehicles

Number of electric vehicles: **3.2 million**

+10% EV registration in 2020

286,000 charging stations

Network

USD $51 billion in grid investments in 2020 (IEA)

Age: **1/3** of the electricity grid exceeds 40 years old

In 2020, Spain was the only country not to meet its **10%** interconnection target

In 2030, the interconnection target is **15%**
Nordstream 2 completed in September 2021

Energy Players

Power: Centrica, CEZ, E.ON, EDF, EDP, Enel, ENBW, Engie, Fortum, Iberdrola, Naturgy, Ørsted, RWE, SSE, Uniper, Vattenfall

Oil and Gas: BP, Eni, Equinor, Repsol, Shell, TotalEnergies

Region Highlights

- Adopted in June 2020, the €750 billion European recovery plan will allocate 30% of funds to climate change issues.
- The Fit for 55 package, signed in July 2021, aims for a 55% reduction in emissions by 2030 compared to 1990 and net-zero emissions by 2050. The package also raised the idea of a Carbon Border Adjustment Mechanism (CBAM).
- The European energy market is characterized by a robust carbon emission trading system (ETS) that reached prices over €60/tonnes in August 2021.
- 21 countries are expected to be coal free by 2030.
- Electricity wholesale prices reached lows in 2020H1 at less than €5/MWh but have been rising steadily since to peaks above €195/MWh in September 2021. This is due to high demand, low wind speeds, and rising prices for CO_2 and natural gas.
- European utilities were resilient during the pandemic, increasing their average EBITDA margin to 21.7%.

03 Regions Description

03

03 Regions Description

North America
ID Card

Aditi Ghosh
Nupur Sinha
Augustin Danneaux

Region Description: U.S.

Quick introduction

Country: U.S.

Population: 333,341,930 (As of Sept. 2021)

GDP: USD $20936.60 billion

Electricity

Total electricity generation (2020): **4009 billion kWh**

Average electricity price: **10.66 ¢/KWh**

Electrification share (average): **100%**

Gas

Total Natural gas production: **960 bcm**
Total Natural gas consumption: **871 bcm**

Energy Players

Revenue for main players:

- Exelon: USD $33.0 billion
- Duke Energy: USD $23.9 billion
- Southern Company: USD $20.4 billion
- Pacific Gas & Electric: USD $18.5 billion
- NextEra Energy: USD $18.0 billion
- American Electric Power: USD $14.9 billion
- Edison International: USD $13.6 billion
- Consolidated Edison: USD $12.2 billion
- Sempra Energy: USD $11.4 billion
- FirstEnergy: USD $10.8 billion
- The AES Corp: USD $9.7 billion
- NRG Energy: USD $9.1 billion

Renewable Energy

Renewables share of energy consumption: **19.4%**
Renewables consumption in United States: **6.15 EJ**

Environment

Total CO_2 emissions: **4.56 billion tonnes of CO_2**

Country Highlights

- U.S. CO_2 emissions will begin rising after 2030 due to increasing energy requirements stemming from economic growth
- Texas is the highest emitter of CO_2 amongst all states due to its high industrial share
- Most carbon pricing developments in the U.S. are taking place on the subnational level
- There is a continuous decline of the U.S. coal industry, placing even the best performing coal plants at risk
- Wind and solar have accounted for most of the new additions in renewable energy capacity in the past decade
- U.S. battery storage installations topped 1 GW for the first time in 2020
- The U.S. annual average retail price of electricity was 10.66¢ per kWh, an increase of 1.1% over the 2019 price

Region Description: Canada

Quick introduction

Country: Canada

Population: 38,140,802 (As of Sept. 2021)

GDP: USD $1643.40 billion

Electricity

Total electricity generation (2020): **635.6 million MWh**

Average electricity price: **USD $0.111/KWh for households and USD $0.094 for businesses**

Electrification share (average): **100%**

Gas

Total Natural gas production: **172 bcm**

Total Natural gas consumption: **117 bcm**

Energy Players

Revenue main players:

- Hydro-Québec: USD $10.1 billion
- BC Hydro: USD $4.7 billion
- Hydro One: USD $5.4 billion
- Ontario Power Generation: USD $5.4 billion
- ENMAX: USD $2.0 billion
- TransAlta: USD $1.6 billion

Renewable Energy

Renewables share of energy consumption: **1.7%**

Renewables consumption in United States: **0.54 EJ**

Environment

Total CO_2 emissions: **517 million tonnes of CO_2**

Country Highlights

- In 2020, Canada implemented its strengthened climate plan to ensure that the country not only meets, but exceeds, its 2030 emissions reduction goal
- To set Canada on a path to achieve a prosperous net zero emissions future by 2050, the government introduced the proposed Canadian Net-Zero Emissions Accountability Act in Parliament on November 19, 2020
- Canada increased its carbon taxes by 467% through its Environment and Healthy Economy Plan
- Renewables accounted for 46% of total energy infrastructure investment in Canada in 2020
- Canada continues to advance its role as a leader in CCUS with recent announcements of governmental support at the federal and provincial levels for projects

03 Regions Description

03

03 Regions Description

China Energy ID Card

Ankita Das
Nupur Sinha

Country Description

Quick introduction

Country: **China**

Population: **1.4 billion**

GDP: **$14.3 trillion**

CO_2 footprint

Total 2020 CO2 emissions: **9,899 Mt**

2020 CO2/capita emissions: **6.59 tonnes**

Energy Demand

By 2040, the IEA predicts that Chinese oil demand will increase by a further 4 million barrels per day before plateauing

By 2040, the IEA forecasts China to be the largest importer of natural gas with Chinese gas demand reaching 600 bcm

Renewable energy

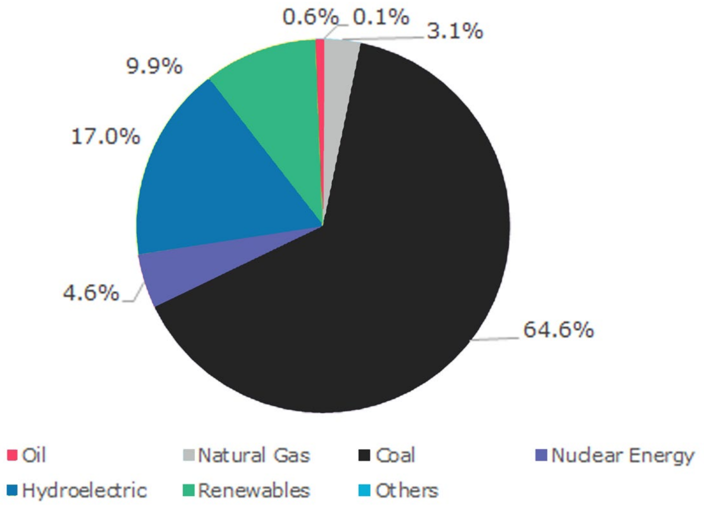
Under current policies and investment patterns, the share of modern renewables in China's energy mix will rise to 16% by 2030

Gas

Total natural gas production: **6.98 EJ**

Total natural gas consumption: **11.90 EJ**

LNG imports: 94 bcm



Coal

Total coal production: **80.9 EJ (2020)**

Coal consumption: **82.27 EJ (2020)**

Electricity

Total electricity generation: **7779.1 TW**

Oil

Total oil production: **3,901 thousand barrels** daily (4.4% of the world's total)

Total oil consumption: **14,225 thousands barrels** daily (16.1% of the world's total)

Oil refining capacity: **16,691 thousand barrels/day** (16.4% of the world's total)

Electric mobility

Number of electricity charging stations: 1.68 million units; 806,000 public and 874,700 privately-owned charging stations

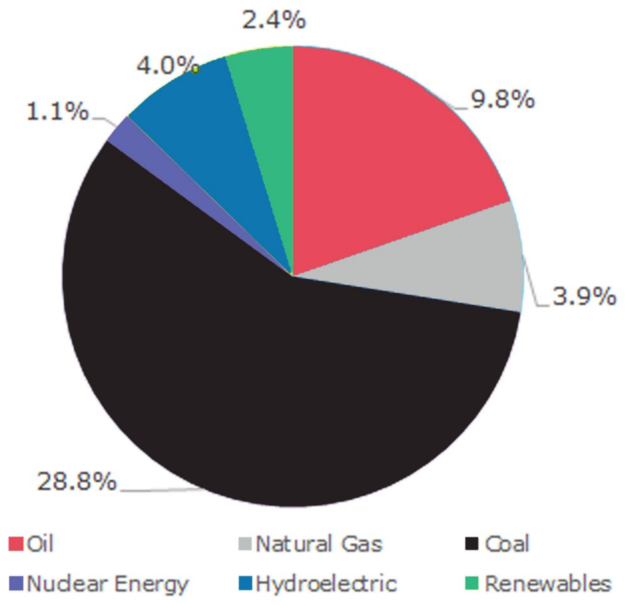
Number of electric vehicles (2020): 4.92 million

It is estimated that China's new energy vehicle ownership will amount to 17.82 million units by 2025; the number of charging piles will reach an estimated 9.39 million units by 2025

Nuclear

Consumption: 3.25 EJ, (13.6% of the world's total consumption of Nuclear Energy)

45 nuclear power reactors in operation, 12 under construction, 2 EPR reactors built



Country highlights

Key policies: In the 14th Five-Year Plan, approved by the National People's Congress, China has outlined energy and climate policies for the next decade that are an extension of the current strategy

Quick facts:

- China's primary energy demand rose 2.1% in 2020, driven by a rapid economic recovery from the pandemic
- China's renewables consumption growth accounted for more than one-third of global growth in renewable energy consumption in 2020
- While China's carbon emissions continued to grow for a fourth consecutive year, rising by 0.6% in 2020, its carbon intensity decreased by 1%
- China's energy mix continues to shift to a greener one, with coal's share decreasing to 57% in 2020, compared to 58% in 2019

03 Regions Description

03

03 Regions Description

South East Asia
ID Card

Ankita Das
Nupur Sinha
Augustin Danneaux

Region Description

Quick introduction

Region: Southeast Asia
(Hong Kong, Singapore, Malaysia, Philippines, Vietnam, and Taiwan)

Population: 276,322,029

GDP: USD $2,267.51 billion

Electricity

Total electricity generation (2020): **864 TWh**

Access to electricity (average % of population) (2019): **99%**

Energy

Regulatory model:
Hong Kong and Malaysia: Regulated market, Singapore, Philippines and Vietnam: Partly deregulated
Taiwan: Subsidized, quasi-monopolized

Environment

Energy-related CO_2 emissions:
Hong Kong: 68.2 Mt CO_2
Singapore: 211 Mt CO_2
Malaysia: 256 Mt CO_2
Vietnam: 283.9 Mt CO_2
Taiwan: 275.9 Mt CO_2
Philippines: 127.4 Mt CO_2

Renewable Energy

Renewable energy consumption (average): **0.074 EJ**

Energy Players

Hong Kong: CLP Group (USD $10,225 million), The Hong Kong and China Gas Company (USD $5,258 million), Hong Kong Electric Company (USD $1,334 million)
Singapore: Singapore **Power (USD $2,971.8 million)**
Malaysia: Tenaga Nasional Berhad (TNB) **(USD $10,569.2 million)**
Philippines: Manilla Electric (USD $5,362.9 million)

Recent Developments

- **Singapore:** Singapore plans to increase its renewable power capacity four-fold by 2030
- **Malaysia:** Royal Dutch Shell will power its Timi gas development project off the coast of Sarawak with a solar and wind hybrid renewable power system
- **Vietnam:** Vietnam has committed to investing more than $128 billion to achieve bullish targets in its latest power development plan, which seeks to expand gas and renewable generation capacity over the next decade
- **Taiwan:** Total enters a 640 MW offshore wind project under construction in Taiwan
- **Philippines:** PH Renewables, Inc. has begun construction on a 115 MW solar park in Rizal, Luzon

03 Regions Description

03

03 Regions Description

India Energy ID Card

Ankita Das
Nupur Sinha

Country Description

Quick introduction

Country: India

Population: 1.38 billion

GDP: $2.871 Trillion

Electricity

Total installed capacity of electricity (2020):
386.9 GW (CEA) – as of July 2021.

Total electricity consumption (2019-20):
~1,291,494 GWh (CEA).

Average electricity price:
0.077 $/kWh (household price) and **0.116 $/kWh** (business price).

Average electrification share:
99.6% (IEA's electricity access rate)

Gas

Total gas production: **1,133,364 MMcF**

Total gas consumption: **1,753,143 MMcF**

Energy

Energy mix (renewables excluding hydro vs. fossil fuels vs. gas):
3,5% vs. 84,8% vs. 6,3% (BP)

Evolution of energy demand (in the last five years):
+18% (28.77 EJ to 34.06 EJ) (BP)

Renewable energy

Share of renewables in final energy consumption (BP: Primary energy consumption): **4.5% (excluding hydro)**

Total investments in clean energy: **$11.1 billion (2018)**

Environment

Total CO_2 emissions: **Eq2,302.3** million tonnes of CO_2 (BP)

GHG emissions growth rate: **2% (2019**)

Electric mobility

Regional sources

Electric charging stations: **1800 (March 2020)**

Number of electric vehicles: **400,000 (2019)**

Type of electric vehicles: **BEV, PHEV and HEV**

Market growth: **30%** (2018-2030 evolution)

Network

Regional sources

Total length: **445,496 ckt. km (July 2021)**

Transmission network:
Tension: **11kV** distribution network
Age: Qualitative analysis

Energy Players

Power: NTPC Limited, Adani Group, Tata Power, JSW Energy, Torrent Power etc.

Renewable energy: Tata Power Solar Systems Ltd., Suzlon, ReNew Power Ventures etc.

Oil and Gas: Reliance Industries Ltd., Oil and Natural Gas Corporation (ONGC) and Indian Oil Corporation Ltd. (IOCL)

Country Highlights

Policy support:

- In June 2021, the Indian Renewable Energy Development Agency Ltd. (IREDA) invited bids from solar module manufacturers, coming in at INR 4,500 crore ($616.76 million). This set up solar manufacturing units under the central government's Production Link Incentive scheme (PLI).
- The power sector now allows 100% foreign directed investment (FDI), boosting overall FDI funds.
- Schemes such as Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) and the Integrated Power Development Scheme (IPDS) are expected to augment electrification across the country.

Growth in investments, according to the India Brand Equity Foundation (IBEF):

- Non-conventional energy sectors received an FDI inflow of $10.02 billion between April 2000 and March 2021.
- By 2028, India anticipates investments in renewable energy worth $500 billion.

03 Regions Description

03

03 Regions Description

Australia Energy ID Card

Nupur Sinha
Ishan Deep

Country Description: Australia

Quick introduction

Region: Australia

Population: 25,776,339 (Sept. 2021)

GDP: US $1985.44 billion (2020)

Electricity

Total electricity generation (2020) : **265.2 TWh**

Average electricity price: **0.227 US$/KWh** (residential price)

Electrification share (average): **100%**

Gas

Total gas production: **142.5 bcm (2020)**

Total gas consumption: **40.9 bcm (2020)**

Energy

- Energy mix: Renewables 64.4TWh vs Fossil Fuels 147.4TWh vs Gas 53.1TWh (2020)
- Regulatory model: Australian Energy Regulator (AER) regulates the wholesale electricity and gas markets, and is part of the Australian Competition and Consumer Commission (ACCC). ACCC enforces the rules established by the Australian Energy Market Commission

Renewable energy

In 2020, renewable energy was responsible for **24%** of Australia's total electricity generation

Environment

- Total CO2 emissions: **372.3 MtCO2 e (2020)**
- CO2 emissions growth rate: **-7.4%**

Electric mobility

- Electric charging stations: **2,307 (2020)**
- Number of electric vehicles sold : **6900 (2020)**
- EV Market growth (2020): **2.7% increase**

Network (Regional sources)

- Length: 850,000 km of distribution grid and 45,000 km of transmission grid (2020)
- Tension: 216 - 253 V (households)
- Age: Electricity supply began during colonial era of 1880s and can be marked as an ~140 years old network

Energy Players

- Generation and Retail: “Big Three” AGL, Origin Energy and EnergyAustralia
- Market share: Big Three holds 64% of small electricity and 83% of small gas market
- Second tier’ retailers have built significant market share in some regions - Ergon Energy, Alinta Energy and Red Energy have emerged as strong ‘gentailers’
- 26 corporate power purchase agreements were announced in 2020, directly contracting 1.3 GW and supporting more than 4.5 GW of renewable energy generation

Country Highlights

Key policies:

- In Sep 2020, Technology Investment Roadmap released with a primary focus on Low Emissions Technology
- To support long-term fuel supplies, the Australian Government has developed a comprehensive fuel security package. It will increase domestic fuel storage.
- The National Energy Productivity Plan (NEPP) is a package of measures to improve Australia’s energy productivity by 40% between 2015 and 2030. The NEPP is delivered jointly between the Australian Government and the state and territory governments.
- The Australian Government is developing bilateral energy and emissions reduction agreements with state and territory governments to improve energy reliability and affordability which will help energy markets adopt lower emissions technologies.

Key facts:

- Due to Covid-19 as of March 2020, there were significant reduction in operational demand in the National Electricity Market (NEM). Overall, demand was down 6.7 per cent, with South Australia experiencing the biggest reduction of 11.1 per cent and a new record low
- There were 378,451 rooftop solar installations in 2020. The average system size also passed 8 kW for the first time in 2020, while the industry’s 3 GW of installed capacity easily beat the previous record of 2.2 GW set in 2019.
- Australian Government wants the private sector to step-up and make timely investments in the gas market. If the private sector fails to act, the Government will step in – as it has done for electricity transmission – to back these nation building projects
- The Australian Renewable Energy Agency has identified approximately 22,000 potential pumped hydro energy storage sites around Australia with merit for investigation.
- In 2020, 76 large-scale wind and solar projects were under construction, representing more than 8 GW of new capacity
- Australia’s Renewable Energy Target (RET) is a Federal Government policy designed to ensure that at least 33,000 gigawatt-hours (GWh) of Australia’s electricity comes from renewable sources by 2020.
- The battery storage sector rose to prominence in 2020, with 16 utility-scale batteries under construction at the end of 2020, representing more than 595 MW of new capacity.

04 Climate Change & Energy Transition

04 Climate Change & Energy Transition

04

04 Climate Change & Energy Transition

Climate Change
Global Perspective

Alain Chardon
Augustin Danneaux
Mathieu Carrasco Leiva
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Alejandro Benguigui Nadal
Javier Benitez Provedo
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Climate Change Global Perspective

After the disastrous summer of 2021, and as temperatures continued to increase at a steady rate, the decarbonization of the economy must accelerate at an unprecedented rate

- **Summer 2021 provided an alarming foreshadowing** of the diversity of future climate disasters, with heat domes and raging wildfires in North America, Greece, and Turkey, while deluges and deadly floods struck Germany, Belgium, India, and China.
- **At 1.02°C over pre-industrial levels, 2020 was the warmest year on record** (tied with 2016), and the temperature is inching closer and closer to the 2100 1.5°C threshold set by the Paris Agreement.
- The 1.5°C threshold will be met before 2040. To ensure a 66% chance of stabilizing at 1.5°C with little or no overshoot,[1] the IPCC model pathway requires a **45% reduction** of all greenhouse gas (GHG) emissions (down to **25 GtCO2e/year**) by 2030. Equilibrium between sources and sink of GHG (net zero) is required by 2050.
- The challenge at hand, as stated in Kaya's equation, is to decrease the GHG content of energy (decarbonate), lower the energy intensity of economy (save energy), and invent new GDP and well-being business models.

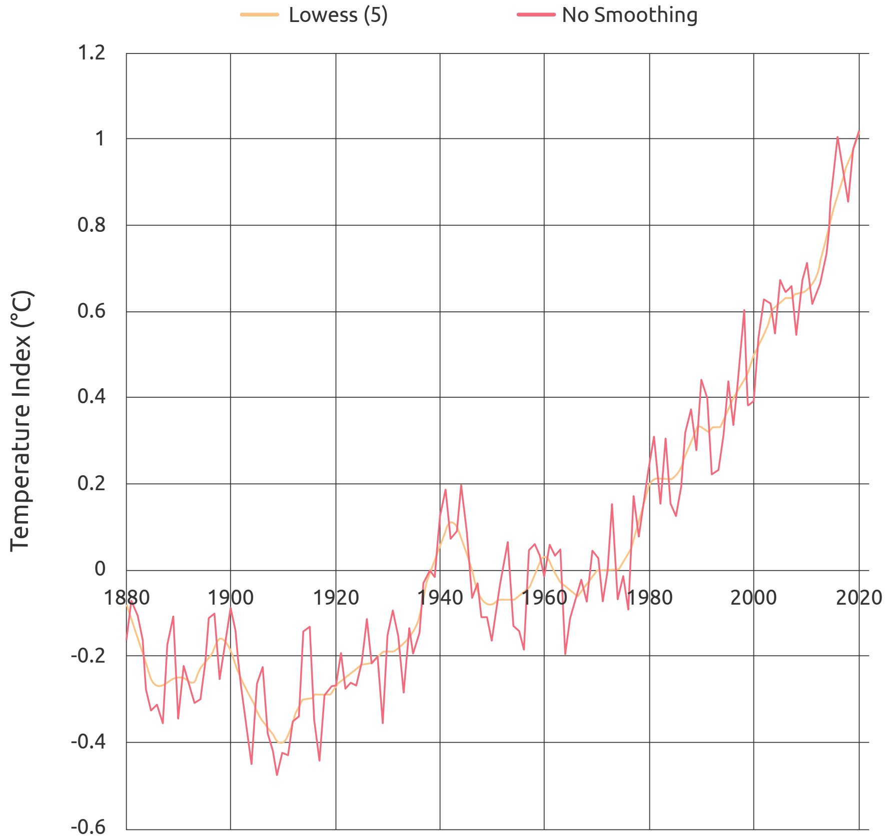
$$\text{GHC} = \frac{\text{GHC}}{\text{Energy}} \times \frac{\text{Energy}}{\text{GDP}} \times \text{GDP}$$

- **The global economy's GHG intensity must fall by 7.6% each year (5.2% for a 2°C pathway).** This is assuming a yearly GDP steady growth of **~2.5%**, which was the average value for the past decade (setting aside the 2020 outlier). In 2019, the global GDP reached a historic high at $87.7 trillion before undergoing an unprecedented drop in 2020.
- Meanwhile, there are now strong signs of an economic recovery; May 2021 witnessed the highest GDP growth rate in the past 15 years. The need to reduce the GHG intensity of the economy is hence more acute than ever.

1 IPCC : Special Report: Global Warming of 1.5°C

FIGURE 1

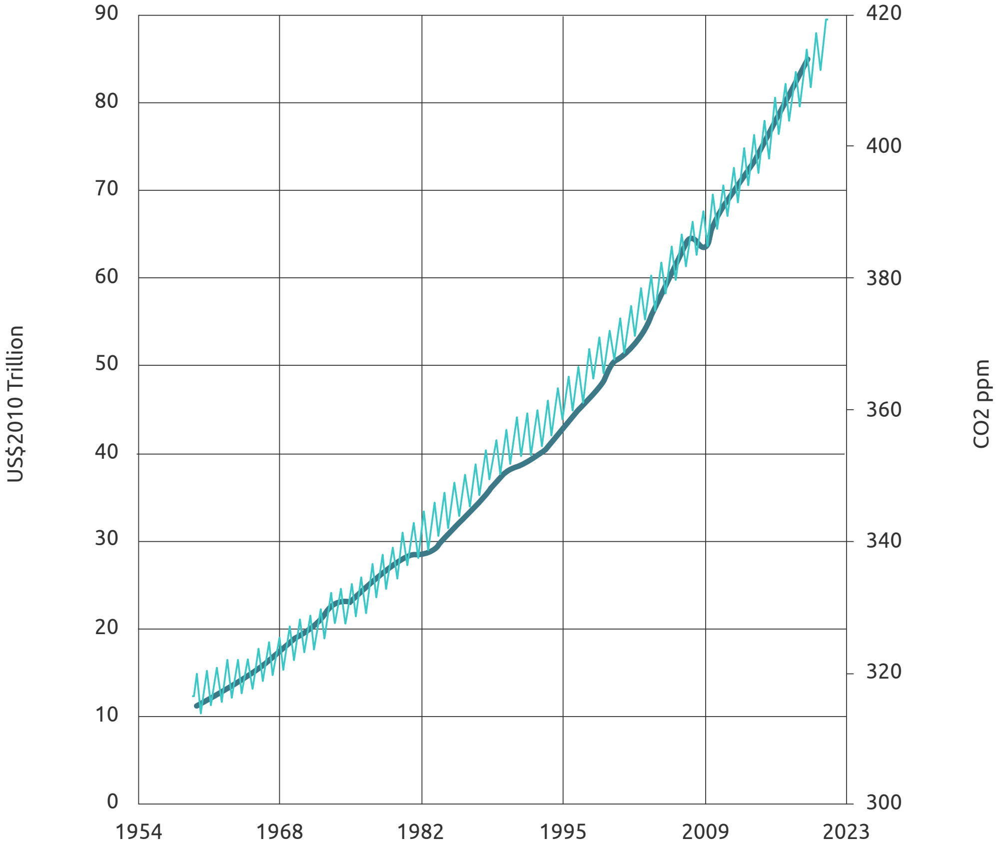
Average global temperature



Source: NASA (2021)

FIGURE 2

Global GDP compared to atmospheric CO2 concentration



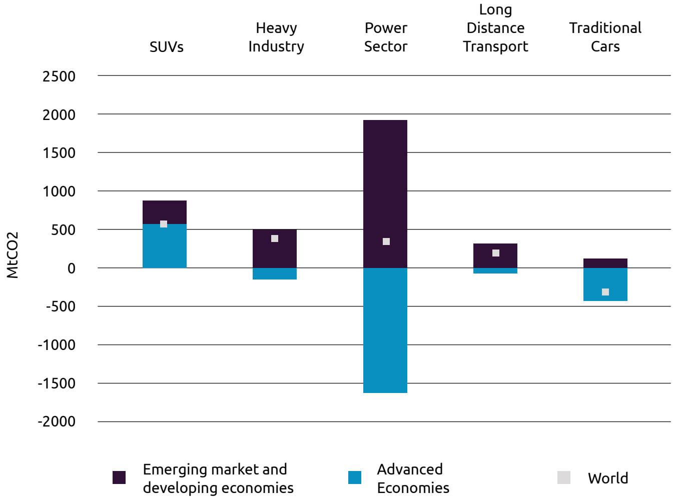
Source: World Bank (2021), Global Monitoring Laboratory (2021)

To remain below 1.5°C, the CO_2 intensity of energy production must decrease annually by 6%, ten times more than the average intensity decrease observed over the past decade (0.6%)

- **Energy represents 73%** of all greenhouse gas emissions[1]. Its global consumption has increased by 1.9% annually in the past 20 years.[2]
- **A 6% annual decrease** (-3.7% for a 2°C pathway) of the carbon content of energy is necessary over the next ten years at the current rate of decoupling between energy and GDP (-1.6%/year[2]). In the past ten years, the annual decrease of the carbon content of energy was 0.6%.
- **There is still a dynamic of absolute increase of emissions.** Gains in many sectors in advanced economies negated by the development of emerging markets. This increases the relative importance of emissions in Asia, a continent still largely dependant on coal power generation. In advanced economies, the automotive SUV sector emissions alone increased by 0.57 $GtCO_2$ in 2020, while a total decrease of 1.7 $GtCO_2$ was needed globally for the energy sector; this showcases the challenges ahead.
- **However, energy-related emissions dropped to 31.5 Gt of CO_2 in 2020 during the pandemic.** This was done at the cost of a 3.9% decrease in GDP.[3] During this time, the absolute concentration of GHG in the atmosphere still went up.
- There will be no way to reach net zero without a significant global move towards massive energy savings and the decarbonization of energy production.

FIGURE 3

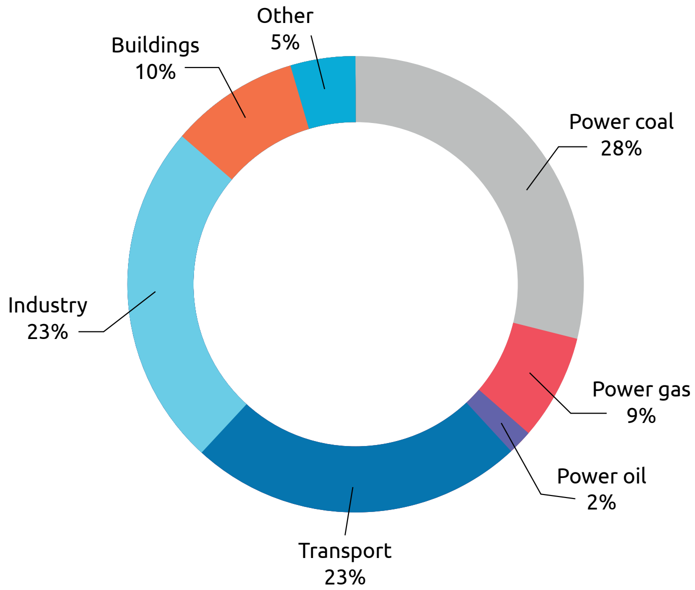
2019-20 Emission evolution by sector



Source: IEA, 2021

FIGURE 4

Global energy-related CO2 emissions by sector

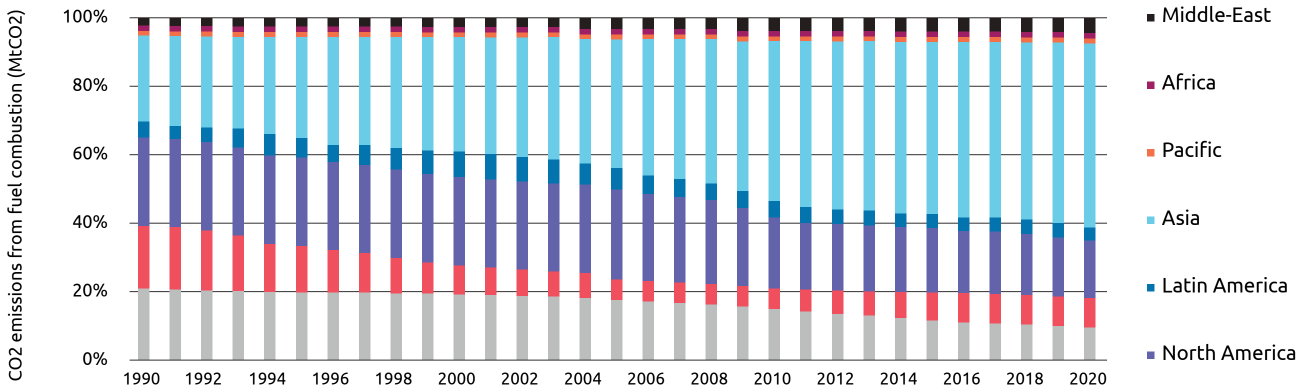


Source: IEA, 2021

1 IEA
2 Enerdata
3 IMF World economic outlook

FIGURE 5

Energy related emissions by region



Source: Enerdata, 2021

The historical 2020 drop in GHG emissions doesn't reflect real decarbonization.

Despite the profound impact of the pandemic on economies and lives around the world, it is not enough to put the planet on the road to 1.5°C.

In 2020, the COVID pandemic led to 5.8% GHG emissions reduction – although it comes at the expense of a major economic downturn – revealing the need for deep changes in order to make this level of reduction economically sustainable

- An analysis of the lockdown measures undertaken by different regions to address the **COVID-19 crisis illustrates the magnitude of the global effort that would be necessary in order to achieve carbon neutrality.**
- During this period, the intensity of the **lockdowns varied significantly, not only between geographical areas but also in duration.** In April 2020, 89% of CO_2 global emissions were produced in areas subject to some level of confinement (Fig 6).
- These lockdown policies resulted in a **significant reduction in activity.** In general terms, aviation and surface transportation were the activities most impacted (Fig 7), although the extent of the decrease depended on local policies.
- In addition, it was observed that the same policies **had different impacts on CO_2 generation depending on the local context:** Urban / rural; Residential / Industrial; etc.
- The **reduction in activity significantly improved the levels of air pollution** such us NO_2, SO_2, etc. In general terms, the **global CO_2 reduction was approximately in line with requirements to meet carbon neutrality targets.**
- Two main conclusions can be taken from this analysis:
  1. In the absence of massive structural changes, **the economy would suffer a huge blow if activity reduction were the only path to meeting climate objectives.**
  2. **It is imperative to develop profitable technologies to transform the economy** toward a more sustainable model.

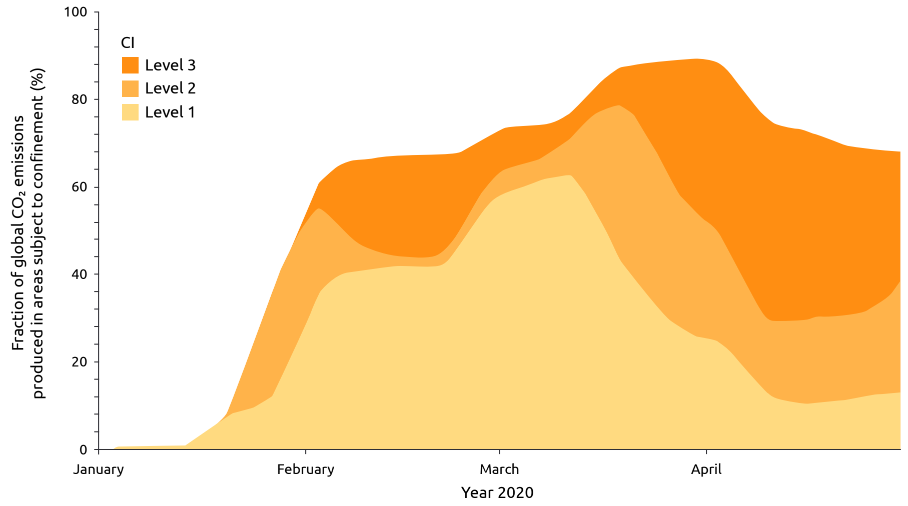
The global activity reduction due to the COVID-19 crisis resulted in CO_2 reduction rates that should be sustained in the long term to meet carbon neutrality targets.

However, in the current economy and energy system structure, the cost of this reduction is not viable.

It is imperative to develop profitable technologies to meet carbon neutrality targets and reshape businesses' operations.

FIGURE 6

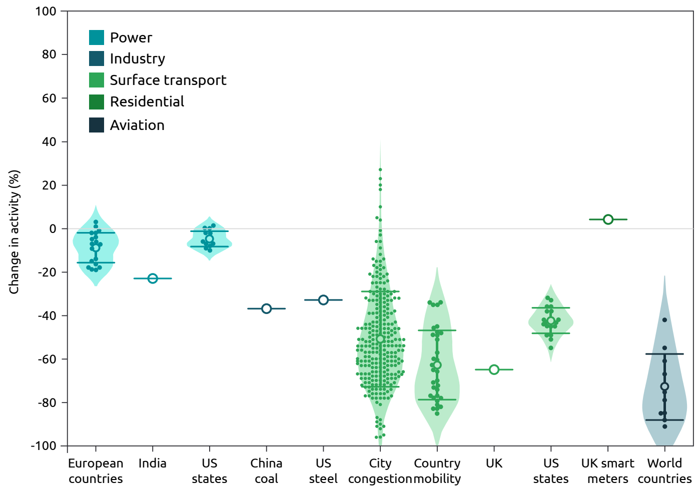
Fraction of global CO_2 emissions produced in areas subject to confinement



Source: Le Quéré, C., Jackson, R.B., Jones, M.W. et al. Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. Nat. Clim. Chang. 10, 647–653 (2020). https://doi.org/10.1038/s41558-020-0797-x

FIGURE 7

Change in activity by sector during confinement



Source: Le Quéré, C., Jackson, R.B., Jones, M.W. et al. Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. Nat. Clim. Chang. 10, 647–653 (2020). https://doi.org/10.1038/s41558-020-0797-x

Current pledges and targets from the countries responsible for 70% of global emissions are still far from achieving the 1.5°C target of the Paris Agreement

- Since the Paris Agreement in 2015, the GHG theoretical scenarios based on the pledges made by governments are improving. Nevertheless, **they are not yet reaching the 1.5°C target.** The global temperature is currently about 1.2°C above pre-industrial levels.

- **The policies currently in effect will raise the global temperature to +2.9°C.**

- **Pledges and targets set in the last year could slow the temperature increase to 2.2°C.** As of April 2021, 44 countries plus the European Union have compromised to reduce their emissions to meet the net-zero target. In other words, **the nations responsible for 70% of the global CO_2 emissions are committed to net-zero emissions target.**

- The **optimistic scenario of +2°C** includes previous announcements made by the U.S. and China committing to net-zero targets as well as the pledges made by Brazil, Kazakhstan and Panama, among other countries.

- According to the IEA, to achieve the Net Zero Emissions (NZE) scenario and keep the limit to 1.5°C, much work is needed. **Countries need to strengthen their 2030 nationally determined contribution (NDC) targets.**

- Those countries that submitted NDC targets that are not track to reach the 1.5°C target should reconsider their efforts and attempt to align.

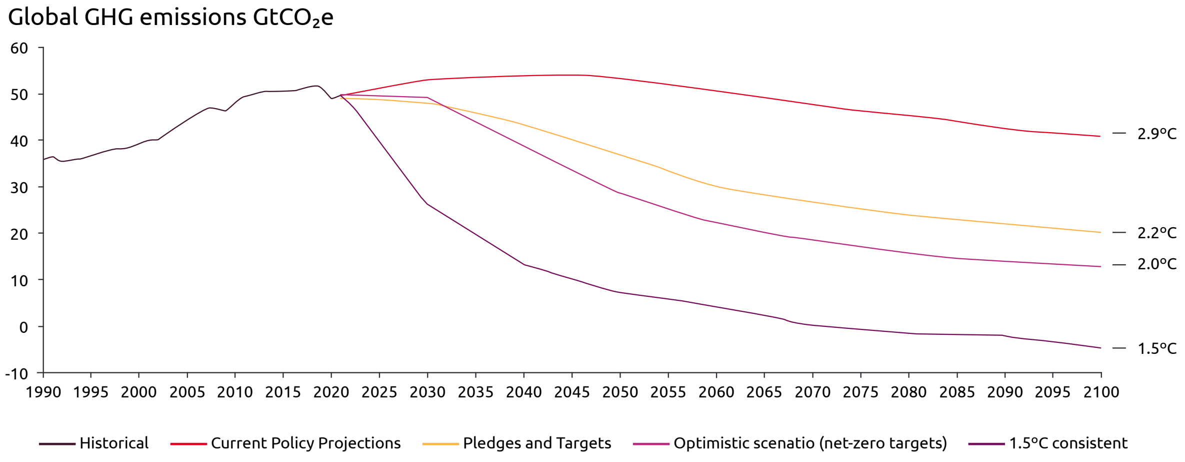
- **China (which represents 25% of global emissions share)** has not officially submitted its NDC, which makes it possible for leaders to consider strengthening their current unofficial plan.

- South Korea and New Zealand have promised to update their NDC.

- The following countries are currently submitting targets that are **less ambitious** than their first NDC: Russia, Brazil, Mexico, Australia, Singapore, and Vietnam.

FIGURE 8

2100 Emissions and expected warming scenarios



Source: Climate Action Tracker (2021)

- In the NZE scenario, CO_2 emissions would fall to 40% until 2030 and to net zero in 2050. It includes a **75% reduction in methane use** by 2030, while **solar energy would become the primary energy source** by 2050, providing nearly 70% of global demand.

- Developed countries with strong NDC targets will also have to scale up their climate finance if the 1.5°C target of the Paris Agreement is to be met.

https://climateactiontracker.org/documents/829/CAT_2020-12-01_Briefing_GlobalUpdate_Paris5Years_Dec2020.pdf
https://climateactiontracker.org/documents/853/CAT_2021-05-04_Briefing_Global-Update_Climate-Summit-Momentum.pdf
https://climateactiontracker.org/documents/790/CAT_2020-09-23_Briefing_GlobalUpdate_Sept2020.pdf
https://iea.blob.core.windows.net/assets/beceb956-0dcf-4d73-89fe-1310e3046d68/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

Key levers to achieve global Net Zero ambitions by 2050 combine mature and industrialized solutions with emerging technologies - all of which require new infrastructures and huge scaling up

- **According to IEA's Net Zero Emissions (NZE) report[1], a blend of existing mature and novel solutions could enable CO_2 emission neutrality by 2050.** This not only implies achieving the SDS ambition to hold the temperature rise below 1.8°C[2], but doing so by following a path that may hinder climate change progress in the coming century.

- **Renewables such as wind, solar, and bioenergy will continue to be the most prominent solutions to reduce emissions until 2030,** mainly due to the polluting nature of today's power generation landscape. This trend is expected to wane given the impact of high shares of RES on supply security – unless dispatchable RES and energy storage exceed forecasted growth.

- **Hydrogen's potential relies on the ability to scale owing to its numerous applications.** Nowadays, its production accounts for 6% natural gas and 2% coal use, thus being responsible for 830 MtCO2 per year.[3] Scale-up is crucial to lower costs for electrolyzers and to reduce the price of green hydrogen.

- **Currently, energy efficiency is the most comprehensive solution to reduce emissions, yet it will be overtaken by electrification after 2030.** Efficiency will particularly impact fuel usage in transport and heating/cooling consumption in the building sector.[1] This role will be taken over by electrification, leveraging a less carbon-emitting power supply, and having a cross-cutting impact on industry, buildings, and transport.

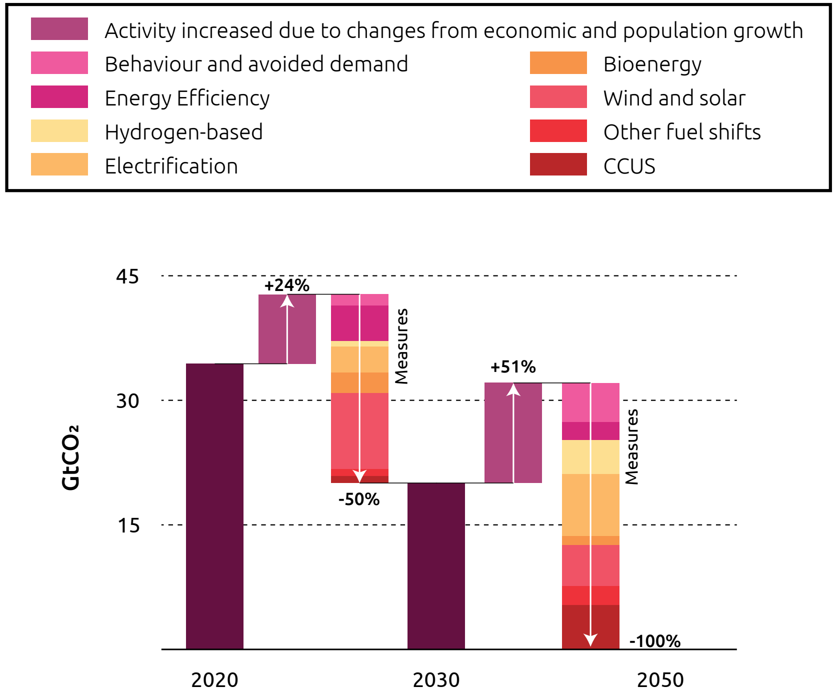
- **As opposed to other solutions, CCUS takes advantage of traditional assets, though** its true potential is expected to be harnessed only after 2030. Most suitable applications can be found in cement manufacturing and thermal power plants[1], but it also synergizes with the traditional hydrogen industry to produce so-called "blue" hydrogen.

- **It is important to acknowledge that NZE ambitions will ultimately rely on citizens' behavioral change and consumption habits.** Reducing energy demand at the very end of the value chain will become increasingly important as behavioral changes must take place gradually.

1 https://www.iea.org/data-and-statistics/data-product/net-zero-by-2050-scenario
2 https://www.iea.org/reports/world-energy-model/sustainable-development-scenario
3 https://www.iea.org/fuels-and-technologies/hydrogen

FIGURE 9

Emissions reductions by mitigation measure to reach Net Zero Emissions in 2050 (NZE scenario)



Sources: Net Zero by 2050 Report - IEA May 2021

RES such as wind, solar, and bioenergy will play a major role in energy transition in the coming years.

However, the focus now needs to be put on decarbonized heat, electrification, green hydrogen, CCUS, energy savings in all sectors, and behavioral change in order to achieve Net Zero by 2050.

Carbon pricing and markets: The coverage of global GHG emissions by carbon pricing tools increased by 6.6%, led by momentum in climate commitments, though volumes are still limited when compared to the Paris Agreement's aims

- As of July 2021, **41 countries have enshrined net-zero targets**[1] in laws or policy documents, or have proposed legislation to do so, despite the global pandemic. Most of these jurisdictions aim to achieve carbon neutrality by 2050, though China and Ukraine are shooting for 2060 and some European nations envision earlier dates.

- As of April 2021, **21.7%**[2] **of global GHG emissions were covered by carbon pricing tools such as a carbon tax or an Emissions Trading System (ETS)** in 45 countries and 35 subnational regions, as compared to 15.1% in 2020.

- This 6.6% increase is **largely due to the launch of China's national ETS in February 2021,** becoming the world's largest carbon market with a plan that regulates around 4,000 $MtCO_2e$ per year. The launch of an extended U.K. ETS, following its departure from the EU, and Germany's national fuel ETS, including all fuel emissions not regulated under the EU ETS (mainly heating and road transport), also contributed to this increase.

- **Unfortunately, only 3.8% out of the 21.7% of global GHG emissions in 2021 are covered by a carbon price above \$40/tCO_2e,** recommended to be Paris compliant. Indeed, while welcoming the fact that a clear convergence towards carbon scheme can be observed worldwide, there is still a huge range of carbon prices, going from less than \$1 to \$137/tCO_2e in 2021.

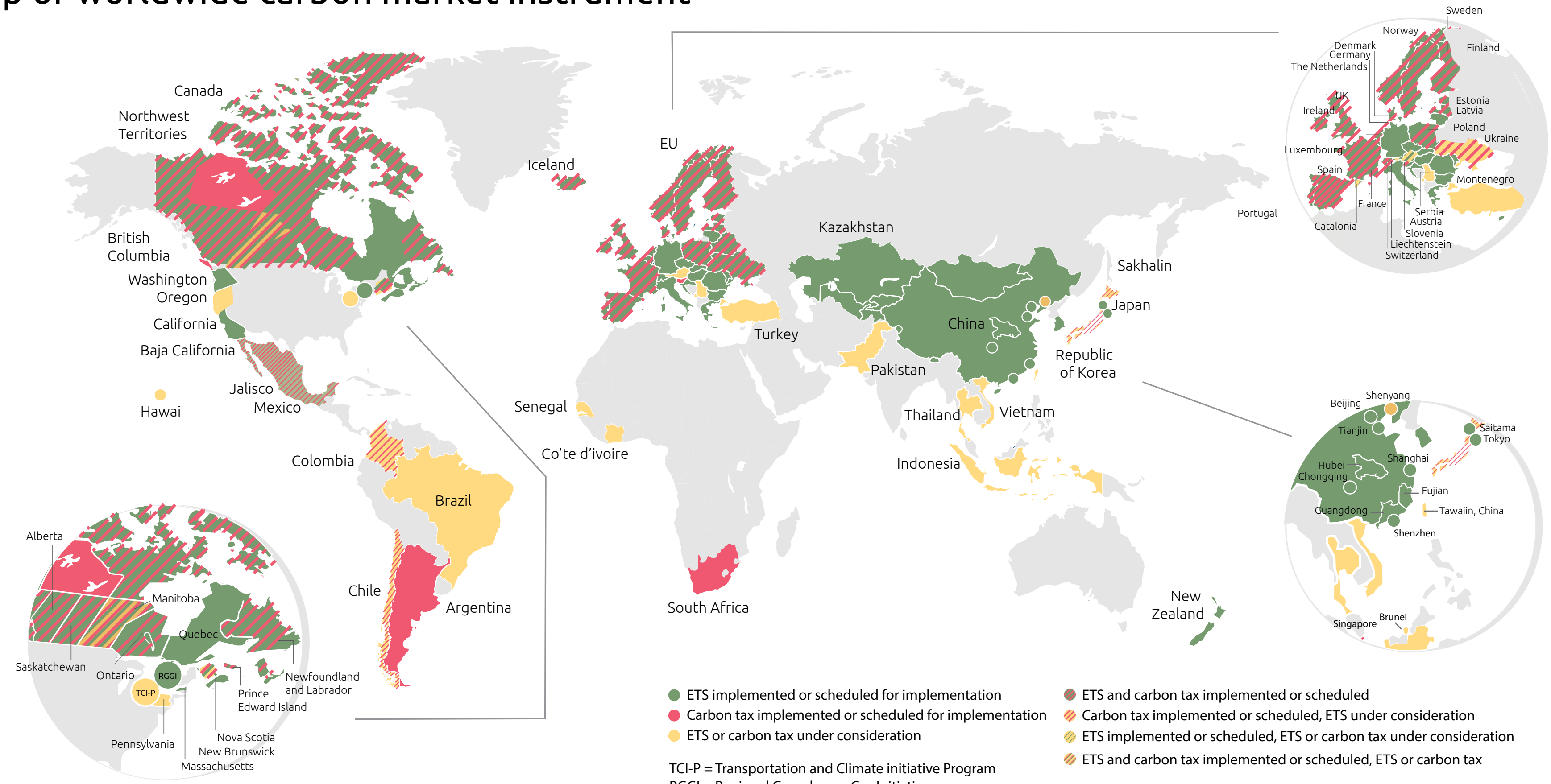
- With **\$53 billion** in 2020 for **11.7$GtCO_2e$ covered,** global revenue generated by carbon pricing **instruments increased by around \$8 billion** compared to 2019. This is mainly due to the increase **in the EU allowance price reaching \$50/tCO_2e** today (while it was around \$30 in 2020). 51% of 2020 revenues stemmed from carbon taxes, while the other 49% were generated by carbon quotas. It was respectively 53% and 47% in 2019.

- **Regarding voluntary carbon markets (Verra, Gold Standard, etc.), the 6% increase in 2019 up to 0.104 $GtCO_2e$ market volume and \$0.320 billion**[3] **market value seemed encouraging. To reach the 1.5°C goal, voluntary** markets will likely need to expand more than fifteen-fold to hit around 2Gt by 2030. This derives from a rapid increase in companies' and countries' needs for carbon offsets that could generate a demand-supply gap. As demand grows, prices currently at their lowest (\$1-5/tCO_2e) should increase and lead to growing offset supplies fostered by rising economic viability.

1 Net Zero Emissions Race (Energy & Climate Intelligence Unit)
2 State & Trends on Carbon Pricing, Carbon Pricing Dashboard (World Bank)
3 State of the Voluntary Carbon Markets 2020 (Ecosystem Marketplace)

FIGURE 10

Map of worldwide carbon market instrument



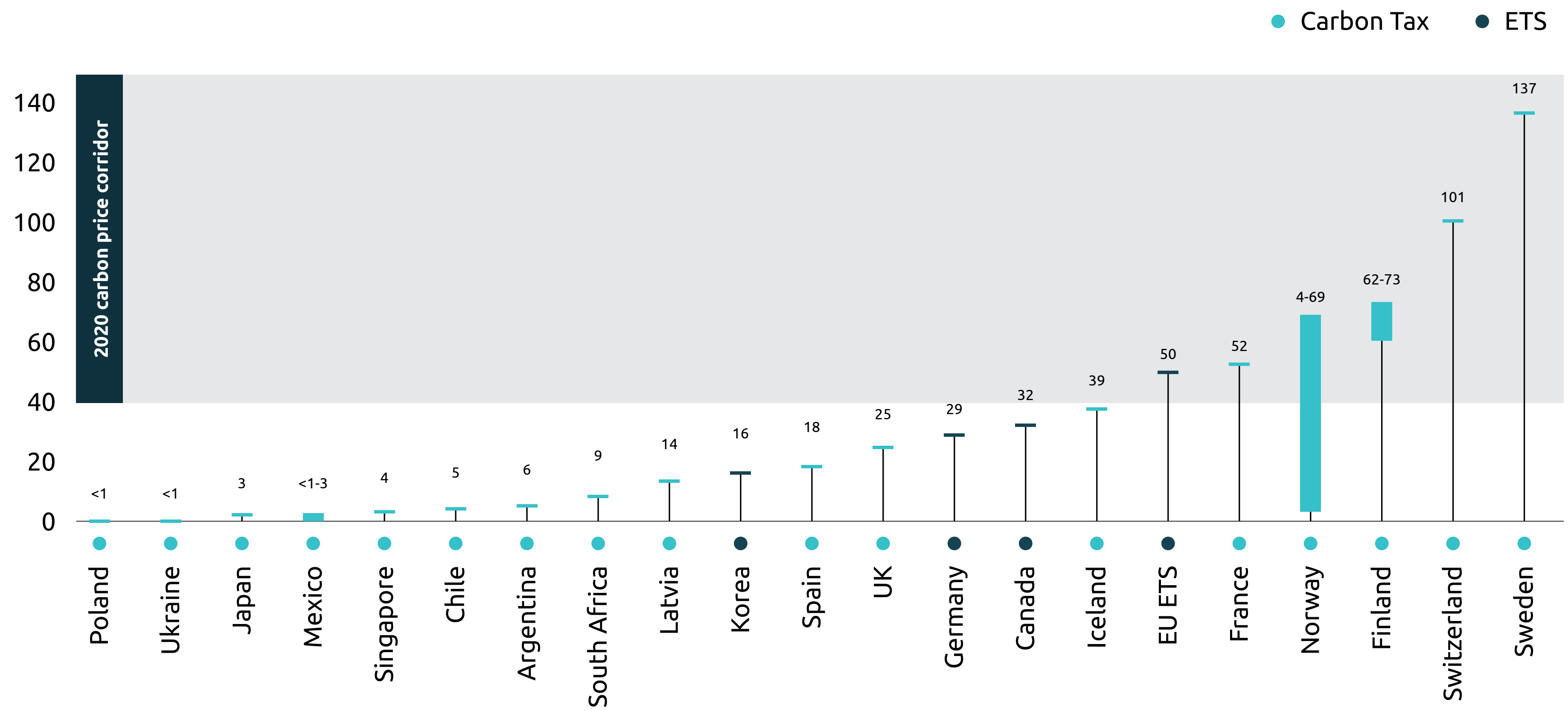
- ETS implemented or scheduled for implementation
- Carbon tax implemented or scheduled for implementation
- ETS or carbon tax under consideration
- ETS and carbon tax implemented or scheduled
- Carbon tax implemented or scheduled, ETS under consideration
- ETS implemented or scheduled, ETS or carbon tax under consideration
- ETS and carbon tax implemented or scheduled, ETS or carbon tax

TCI-P = Transportation and Climate initiative Program
RGGI = Regional Greenhouse Gas Initiative

Source: World Bank, 2021

FIGURE 11

Current carbon pricing (in USD/tCO2e)



Sources: World Bank 2021

The new reality for carbon markets is founded upon lessons learned from the former Kyoto Protocol's flexible mechanisms; most modalities nevertheless remain to be agreed upon in 2021-2022

	Kyoto Protocol (KP)	Paris Agreement (PA)
Signatories & GHG Coverage	36 mitigating countries that covered 21% GHG global emissions. Signatories divided into 2 categories: Annex I countries (AI) with emission-reduction/limitation commitments and non-Annex I (NAI) with no quantified mitigation requirements.	194 signatories that cover 98% GHG global emissions. Compelling headway as it brought for the first time almost all nations to adopt emissions limitation commitments. Difference between AI and NAI countries no longer stands.
Legal Agreement	Strong legally-binding agreement with overt penalties for non-compliance. Weakened by low demand due to low political will, first embodied by the U.S. non-ratification, then by the lack of comprehensiveness between mitigating and ratifying countries.	Seen as a voluntary, periodic pledge-and-review system with weak enforcement mechanisms. It is an executive agreement and no longer a treaty mandated under international law. "Softer" agreement but expected to foster collective goodwill and increase confidence to mitigate global emissions.
Targets	AI countries had clearly defined historical baselines and targets: 5.2% reduction compared to the 1990 level for the period 2008-2012 and 18% reduction compared to the 1990 level for the period 2013-2020 (Doha Amendment).	PA made it compulsory for countries to publicly communicate their national climate action plans, called **NDC** (Nationally Determined Contributions). But targets are now voluntarily set for a given period and can be of different natures, making them hard to compare.
Carbon Mechanisms	3 carbon instruments were used under KP: **IET** (International Emission Trading), **CDM** (Clean Development Mechanism) and **JI** (Joint Implementation). They enabled the trade of carbon allowances and credits between AI countries (AAUs under IET and ERUs under JI) and credits between AI and NAI countries (CERs under CDM). CDM and JI were baseline-and-credit project-based mechanisms, while IET was a cap-and-trade system.	Two new mechanisms replaced the three created under KP: CA (Cooperative Approaches) and **SDM** (Sustainable Development Mechanism). **CA** allows mechanisms operated by governments, NGOs, or corporations to transfer and account for international emission reduction units through ITMOs. SDM is a baseline-and-credit, project-based system considered an upgraded CDM, which owns broader international decisions and enables an indirect connection between emission reductions and (sub)regional or national ETS.

	Kyoto Protocol (KP)	Paris Agreement (PA)
Governance	CDM and JI were overseen respectively by the CDM EB and the JISC. IET had no dedicated supervising body. Its operations followed CMP rules and a UNFCCC international transaction log (ITL) authorized unit transfers between national registries.	The new logic is to minimize politicization. CA is described as a decentralized system allowing for bottom-up linkages governed by CMA rules. SDM is a centralized mechanism that will be overseen by a new UNFCCC body, similar to CDM EB.
Environmental Integrity	**Additionality:** Under CDM or JI, criticism was raised regarding the difficulty of proving that an offsetting credit was perfectly measurable and additional. That means the emission reduction would not have occurred without the project that generated the credit. In parallel, setting a baseline not sufficiently stringent in a cap-and-trade system like IET could have generated a surplus of emissions permits. In both cases, usage of credits and allowances could have resulted in a net increase in global GHG emissions and threatened the environmental integrity of the agreement.	**Double-counting:** While bringing more flexibility to carbon markets, PA appears to be even more ambiguous than KP by offering a large range of potential linkages across different instruments (carbon taxes, ETS, green and white certificates, etc.) and jurisdictions (multilateral, national, subnational). By doing so, it leaves open the door to double-counting risks. Thus, the CMA needs to clarify the broad accounting framework for ITMOs through transparent governing rules and an adequate corresponding adjustment to ensure environmental integrity and foster sustainable development.

Both at COP24 in Katowice and COP25 in Madrid, negotiations broke down and parties failed to agree on the precise rules that will govern international cooperation and carbon markets. Therefore, as new carbon mechanisms came into force in 2020, the global conceptual framework was already built, but no specific obligation to pledge for an improved NDC target was defined; neither was the detailed rulebook to operationalize the new carbon market instruments created by the Paris Agreement.

2021 is a crucial year regarding the climate change global governance, with ambitious COP26/CMA3 goals, reinforced regional commitments, and the establishment of a new carbon market era

- **The most eagerly awaited climate change-related event of 2021 is the next United Nations Climate Change Conference,** also known as COP26/CMA3*. After being postponed in 2020 due to the COVID-19 pandemic, it will take place in two rounds: the Pre-COP in Milan at the end of September 2021 (to launch preliminary negotiation rounds) and the actual summit in Glasgow in November.

- **The summit's first success lies in achieving pre-COP26 objectives, as requested by the Paris Agreement. But the UNFCC already warned that:**
  - Governments' climate actions plans fall far short of what is needed to limit global warming to 1.5°C by 2100, according to the NDC synthesis report published in February 2021.
  - Developed nations' 2010 pledges to mobilize $100 billion in climate finance every year until 2020 have not yet been met.

- **Thus, high expectations hinge on the COP26's official negotiations[1] to:**
  - Raise ambitions in countries' NDCs and back them up with concrete action on a common timeframe.
  - Ensure COVID-19 recovery plans worldwide are in line with the Paris Agreement and the Sustainable Development Goals.
  - Establish detailed rules for international carbon market mechanisms under Article 6 of the Paris Agreement: How will ITMOs be defined and generated, and by which body? Can the old CDM credits still be used to meet new targets? How to prevent double-counting of emissions reductions by multiple entities? How to interface regulated markets and international transfer of voluntary offsets?
  - Create a dedicated loss and damage funding mechanism for vulnerable countries.
  - Integrate Nature-Based Solutions (NBS) into the Paris implementation strategy.
  - Extend the yearly delivery of $100 billion from developed to developing countries in the period from 2020 to 2025.
  - Set new post-2025 goal for global climate finance.
  - Foster global commitment to urgently stop investing in unconventional hydrocarbons, oil, and gas by 2021, 2025 and 2035, respectively.
  - Endorse coal phase-out by 2030 in OECD countries and by 2040 elsewhere.

- **Despite seemingly ambitious objectives,** doubts remain among skeptics regarding the COP26's ability to enforce more restrictive measures while embracing most countries, unlike previous multilateral negotiations. For some experts, significant progress is now more likely to be achieved on the smaller scale than on an international level.

- **Besides formal negotiations, industry-specific and cross-sectoral side-events are also planned before, during, and after the COP26** and have proven to be a true source of climate change commitments. For instance:
  - **The Race to Resilience campaign,** launched in January 2021, brought together cities and corporate stakeholders (especially insurance companies) in adopting climate risk.
  - **The 2050 Climate Ambition** gathered 40 of the world's leading cement and concrete companies (among the GCCA) to set a carbon-neutral target for 2050.
  - **The Net-Zero Banking Alliance** encouraged 53 banks to align their lending and investment portfolios with net-zero emissions by 2050.

1 UKCOP26.org

- **Moreover, pledges made by the 3 biggest GHG emitters (50% global emissions altogether) are crucial to ensuring that global mitigation has a chance to be effective:**
  - **China** is called upon to play a more central role in global climate strategy and is expected to announce stronger near-term targets ahead of the COP26. However, current geopolitical tensions about Xinjiang litigations regarding Uyghurs' fundamental rights may undermine China's will to strengthen cooperation on climate change and find global consensus during COP26.
  - **The United States** reasserted its commitments by officially re-joining the Paris Agreement. Their withdrawal was the main pitfall to avoid since the Kyoto Protocol's non-ratification. Current debates on how the Biden plan will integrate the most ambitious measures proposed in the Green New Deal will also be at stake.
  - **The European Union** presented its "Fit for 55" package in July 2021 setting out a dozen climate-related legislative proposals with a primer on EU ETS that entered its 4th phase. Other important measures include the implementation of tougher Carbon Border Adjustment Mechanisms to increase levies on imports of emission-intensive products, hoping it will not exacerbate trade tensions with China.

Glossary

- **AAU:** Assigned Amount Unit
- **CA:** Cooperative Approaches
- **CDM EB:** Clean Development Mechanism Executive Board
- **CER:** Certified Emission Reductions
- **CMA:** Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
- **CMP:** Conference of the Parties Serving as the Meeting of Parties to the Kyoto Protocol
- **COP:** Conference of the Parties
- **ERU:** Emissions Reduction Unit
- **ETS:** Emissions Trading System
- **GCCA:** Global Cement and Concrete Association
- **GHG:** Greenhouse Gas
- **IET:** International Emission Trading
- **ITMO:** Internationally Transferred Mitigation Outcomes
- **JISC:** Joint Implementation Supervisory Committee
- **NDC:** Nationally Determined Contributions
- **SDM:** Sustainable Development Mechanism
- **UNFCCC:** United Nations Framework Convention on Climate Change

04 Climate Change & Energy Transition

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04 Climate Change & Energy Transition

Is pure clean power a fantasy?

Philippe Vié

Is pure clean power a fantasy?

Accelerating to net zero

We are not on track to mitigate global warming, even with the pandemic drastically reducing emissions in 2020. One-hundred percent clean energy is possible because sources of wind and solar power are practically infinite and unit costs keep falling. With electrification, demand is predicted to soar as EVs, and electric heating become the norm and green hydrogen is called upon to even out supply. So, is 100 percent clean power a fantasy? What role can nuclear have in getting us to net zero? What mix of technology and policy will it take to reach escape velocity and leave fossil fuels behind?

At Capgemini, we've been observing energy markets for more than 20 years through the medium of our annual thought-leadership exercise: The World Energy Markets Observatory[1]. As a company, we are deeply committed to the fight against climate change and we are acutely aware of the fact that energy use is responsible for 73% of the planet's emissions[2].

Year after year, we have seen the surge of clean energy – solar and wind, of course – but other sector and digital technologies offer solutions to global warming as well: biogas, bio-fuels, storage, hydrogen, carbon capture and storage, artificial intelligence, automation, IoT, etc. Over time, we have seen a drastic decline in clean energy costs, which would have been totally unexpected and unpredictable 20 years ago. This decline creates a virtuous cyclical effect: prices decline when markets grow, initially boosted by subsidies, incentives, or appropriate economic signals (carbon taxes and related floor prices). As markets expand and technologies advance, prices diminish even further – a kind of Moore's Law for wind and solar renewable technologies. As a result, solar and onshore wind LCOEs have become competitive in all markets with all other sources of electricity generation, except perhaps fully amortized hydro.

Pure clean power isn't a fantasy. It will happen. It is just a matter of time.

The technical feasibility of 100% clean power can be seen in some countries. However, achieving pure clean power everywhere will only be possible by solving multiple challenges. Let's consider the six main challenges:

1 World Energy Markets Observatory (www.capgemini.com/wemo)
2 IEA 2020

Challenge #1: X5 or X6, the clean energy capacity for today's demand, X10 by 2050. Renewables account for about 20% of the generated electricity today (fossil fuels account for over 70%), notably in Europe. In some countries (Germany, Portugal, Scandinavia), this ratio is closer to ~40% to 60%. By 2050, electricity demand should double due to economic development and electrification (with significant growth in developing countries, and nearly flat demand in Europe and the US.) Who will support this investment? How long will it take to build related assets? To be clear, being 100% renewable powered means moving from 300bn pa investments in clean energy today[1] to 2,500bn pa for 30 years[2].

Challenge #2: Public acceptance of solar and onshore wind invasion. Nobody wants a wind turbine in their backyard. Nor do they want a significant landscape transformation to accommodate solar development projects. Acceptance is better for offshore wind, but this is a less competitive clean source than onshore wind.

Challenge #3: Growing the Smart Grid at scale. Existing electric grids were built to convey centralized generated electricity to the consumer in a one-way flow. Renewables, distributed, and intermittent sources require a different electric grid, one that should also be more resistant to the extreme weather conditions that are a consequence of global warming. Smart grids are feasible, as we have seen demonstrated by thousands of experiments all over the world. It is a huge investment. ~EUR1bn to EUR2bn per 10TWh[3] transiting annually on a good existing electric grid, and 10 to 20 years to achieve it if you start today.

Challenge #4: Develop flexibility up to 30% to 50%. In a 100% clean power paradigm, production intermittency (power generated only when the wind is blowing, or the sun is shining) must be managed or the real-time load, demand balance will need a significant level of intelligence (smart grid) and flexibility. Various solutions to meet this challenge exist, including: storage, increased intermittent production predictability, demand – response, grid balancing advanced features (smart grid again), renewables hybridization (combining renewables with storage or hydrogen production), V2G – vehicle to grid, smart charging, smart heating, etc. The more (low carbon) dispatchable generation (nuclear for example), you can maintain, the less flexibility required (%).

Challenge #5: Conservation. Meeting a growing demand with more intermittent generations mean also developing energy efficiency (industry, buildings, electric transportation) and adopting energy-savvy consumption patterns. Younger generations (i.e., Greta Thunberg) in some countries may be ready for this. But it is vital that consumers and stakeholders also show the way, by defining national or local ways to conserve energy.

Challenge #6: Setting meaningful carbon prices to ensure clean energy competitiveness compared to fossil-fuel electricity generation. Certainly, the most efficient lever, as demonstrated in numerous simulators, and it has been considered from a political angle. Setting carbon prices is a political decision.

These six challenges must be met to transition to 100% clean power. We should consider the electricity costs on top of electricity generation (network management and flexibility, for example) that are not fully compensated by the declining cost of renewables.

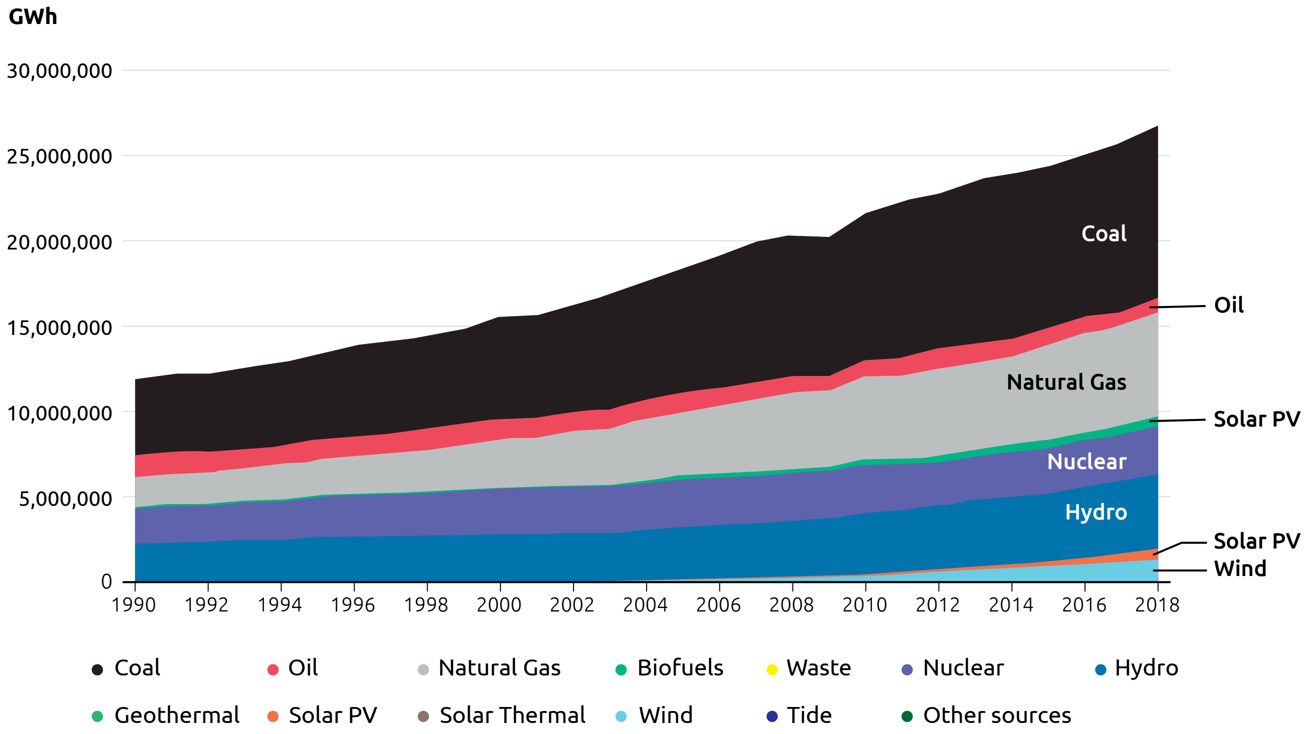
Let's take a glance at the consumer perspective of what needs to be done to achieve pure clean energy, beyond onshore wind and solar farms acceptance:

- **Becoming prosumers.** A significant portion of consumers will also be producers (rooftop panels) or will bring their batteries to contribute to the electric system.
- **Participating in eco-friendly communities** (green, local, engaged in the energy transition).
- **Influencing with their environmental policy votes.**
- **Accepting their responsibility to meet the load** (shifting their energy usages to non-peak hours, being energy savvy – and in general adapting their lifestyles to fight climate change).
- **Voting with their wallets by paying more for green electricity.**

1 Sources: Bloomberg New Energy Finance and IRENA
2 Source: ACT45 Figure
3 Capgemini Analysis

FIGURE 1

Electricity generation by source, World 1990-2018

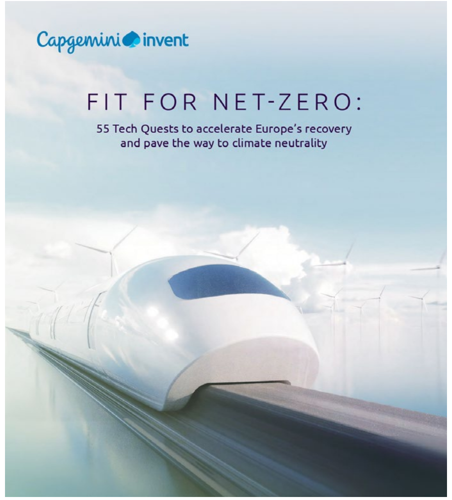


Source: IEA

Beyond renewables, many technologies can help meet net- zero targets.

A recently published report by Capgemini Invent and breakthrough Energy at European scale[1] demonstrates this fact by taking a deeper look into the role the technologies will play. In Europe, our research shows that these technologies (55 technologies covered in the report) can bridge the gap for 55% GHG reduction by 2030 and 100% by 2050.

The report also predicts a net economic value creation of EUR800bn and the creation of 12.6m jobs, from the development of these 55 technologies by 2030.



1 Fit for Net Zero. A report that identify 55 high-impact climate technology projects that can help Europe meet 2050 net-zero emissions target. Download at:
https://www.capgemini.com/news/capgemini-invent-fit-for-net-zero-report/

The main technologies contributing to decarbonation (at a European scale) are:

Nuclear can play a major role for the transition to 100% clean power.

Nuclear is a low-carbon dispatchable generation source (lower than or comparable to wind/solar emissions, if you consider the full cycle, rather than just the generation time) that will play a major role on the road to 100% clean power in nuclear-friendly countries.

Nuclear represents 10% of worldwide electricity generation in 2020. The IEA states that this level (10%) should remain stable until 2040, if 150 additional reactors are built (there are 455 today) or if SMR technology[1] is leveraged. Leveraging nuclear reduces the need for significant investments and limits the flexibility needed to ensure the security of supply within electric systems. There is also a concern of nuclear opponents that will work to have it banned in many countries.

Conclusion: 100% low carbon electricity is desirable and essential. It is already underway and unstoppable. But achieving it will take time.

It will take at least 10–20 years for the most engaged states or countries to reach this point (with a bold roadmap), which means a progressively higher share of renewables in the electric mix – from 20% in average today to 100% at some point between 2040 and 2050. But this will not happen everywhere. California and Hawaii are fully committed to becoming 100% renewables powered, while Germany, Portugal and Scandinavia are the closest European contenders. During the first 2020 lockdown, we saw a decrease in consumption and priority given to low-to-null-variable cost electricity production. As a result, we were in an unexpected situation, reaching 2025–2030 clean power forecasted levels. This endangered the stability of the European grid (in Germany, the UK, and Portugal, the situation was too complex to manage) with a share of renewables above 40%.

Meeting the 100% clean power targets is a process that will take most countries between 20 and 30 years - and it will be accomplished only with the proper political willpower and resources, including thousands of billions pa (globally).

The first movers will be progressive countries that have political courage to endorse related transition costs and impacts. A nuclear / renewables mix would facilitate the transition. A global agreement followed by commitments and action plans is a must, but so is local engagement (territories, states, provinces, countries, regions).

We recommend starting the journey to pure clean power immediately.

Call to action

- **Politicians** – Have the courage to enforce state climate change and push for a low carbon society. Show the way through regulations, reasonable carbon prices, actions on public demand and real estate, as well as a 'sustainable development' public programs that encourage call for action.
- **Consumers, Individual** – Change your behavior, ban non-green electricity, and influence policies by making positive environmental choices – do not make any compromises.
- **Economic stakeholders and decision makers** – Keep pushing forward and take the laggards with you. Large companies are paving the way with tangible demonstrated benefits.
- **Renewables developers, grid operators, financial institutions** – Be bullish. Money is available to finance the projects, stock markets will applaud
- **Everyone** – Accept any change for a better planet that leverages technical progress in any suitable dimensions.

1 SMR stands for Small and Modular Reactor

04 Climate Change & Energy Transition

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Renewables, Networks and Energy Transition Investments

Philippe Vié
Florian Schall
Charles Dagicour

Renewables, Networks and Energy Transition Investments

Investments in renewables, grids, and other energy transition domains are growing

Why, when, and who? A quick update.

Mitigating climate change requires a significant acceleration in the commercial development of multiple technologies including: clean power generation with renewables (wind, solar, hydro); hydrogen; storage; CCUS; transportation; and heating/cooling electrification. Smart grids, of course, are now the backbone of every exchange.

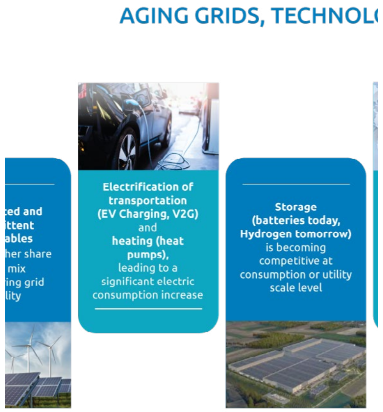
In this article, we will cover investments in energy sector technologies. Should you wish to get a holistic overview of the contribution of all these technologies, deep and digital, we recommend reading our recent paper, ***Fit for Net Zero – Europe's 55 Quests for Net Zero Emissions,***[1] which was published by Capgemini Invent in conjunction with Breakthrough Energy, the European leg of Gates Ventures. Europe, along with Gates Ventures, has announced in June 2021 an investment of €820M to build several large-scale commercial projects that will help mature four chosen technologies, serving as a booster for promising technologies that are not yet competitive with fossil fuel today.

We also share analysts' predictions and compare players' announcements from utilities, as well as Oil & Gas players, on their diversification route from fossil fuels to new energies. We also detail:

- Investments to be made by 2030 in renewables (mainly solar and wind) and the smart grid
- Priorities for hydrogen, storage, CCUS, transportation electrification, and biofuels
- Overarching trends and priorities, including what each player is betting on and who may become the leaders for today and tomorrow in each domain

By the time you read this article, new announcements will likely have been made, detailing new ambitions. As such, take this as a snapshot from this point in time (summer 2021).

In the 2020 edition of WEMO, we stated that the average investment of Oil & Gas operators outside of their core business only represented 0.8% of their CAPEX. The International Energy Agency (IEA) said in June 2021, that we are now at 4% on average, a significant progress, with far more than 10% for most European IOCs. Progress has been made, but acceleration is still needed.



Europe's 55 quests for Net Zero Emissions

Renewables: Anticipated growth through 2030 thanks to new investments

- The IEA and multiple other experts state that mitigating climate change requires organizations to increase investments in renewables by multiples of 5 to 10, starting now and continuing for the next 30 years.

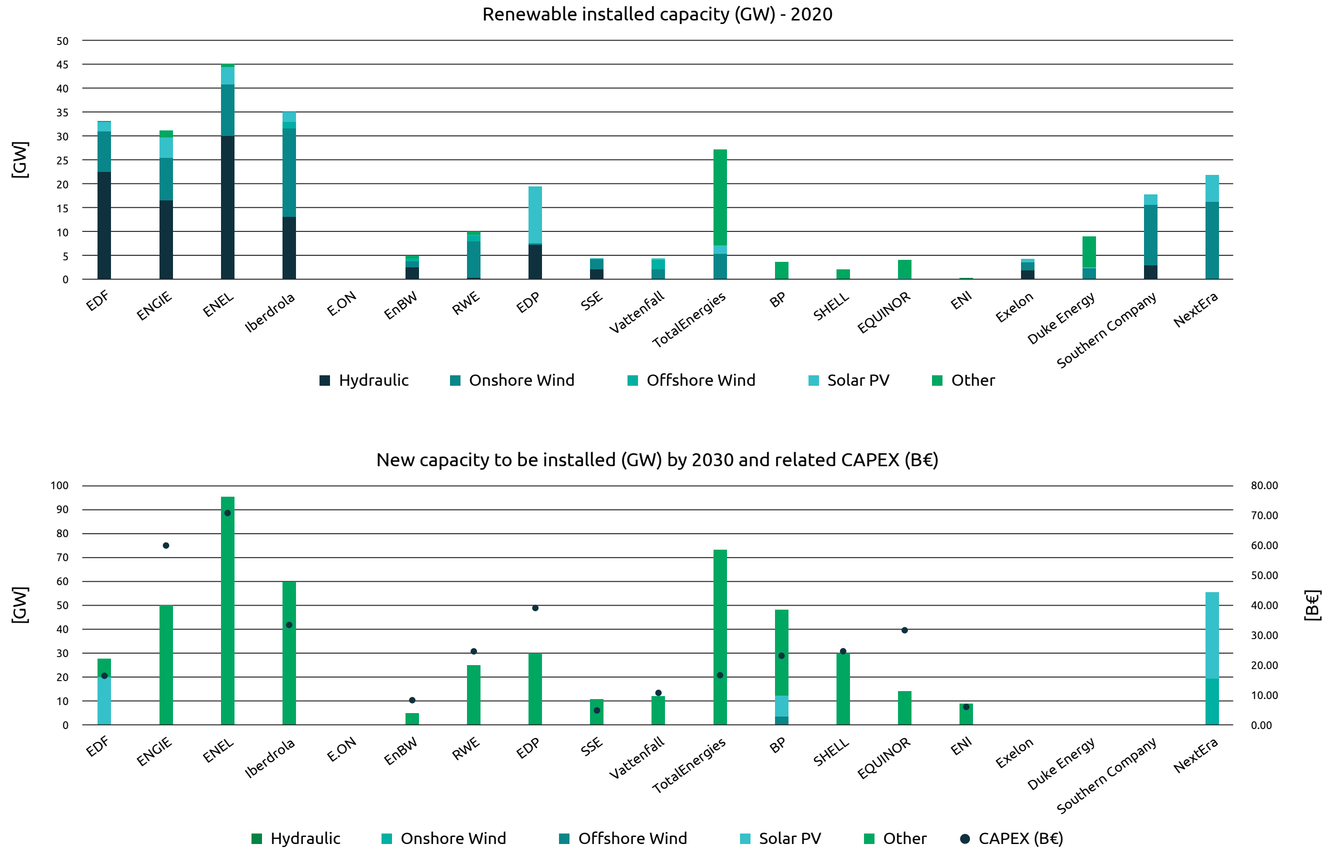
- According to BNEF, there are four renewables supermajors today: ENEL, IBERDROLA, ORSTED, and NextEra. These organizations have a common track record:
  - Shifting early from fossil fuels
  - Leveraging regulatory support
  - Investing massively in renewables with clear choices (technologies, geographies)

- Our survey shows that these organizations will remain majors and could be joined by two or three additional Oil & Gas majors, (notably European, TotalEnergies, BP, and Shell) as well as one or two utilities wanting to accelerate significantly and join the pack (Engie).

- We should note also that:
  - Investment can be announced without details on the technologies.
  - U.S. IOCs have not yet shifted.

FIGURE 1

Renewables: Anticipated growth through 2030 thanks to new investments



Sources: Eurostat 2021

- All renewables supermajors are investing in hybrid assets, combining wind, solar, and storage for a significant share of their new installations (~40% of new investments).
- Communications about new capacities and related investments are not totally consistent among players.

The number of renewables majors will probably grow from 4 supermajors today to 8 to 10 majors by 2030, with 3 Oil & Gas European IOCs joining the pack. Most of the 2030 renewables majors are European, with NextEra being the only U.S. company in the league. This investment pace doesn't meet climate change needs.

Grid investments should include scaling-up smart grid

- IEA predicts that investments in aging electric grids will double in the next decade. Between 2025 and 2030, up to $400B pa will be invested in electric grids. The share of Digital (compared to hardware) will be up to 30% of the $400bn for the Distribution Network, less for Transmission Networks, already partly Digitized.

- It may come as no surprise that many experts say that for every dollar invested in renewables, another dollar will also need to be invested in the grid to manage generation assets distribution and intermittency.

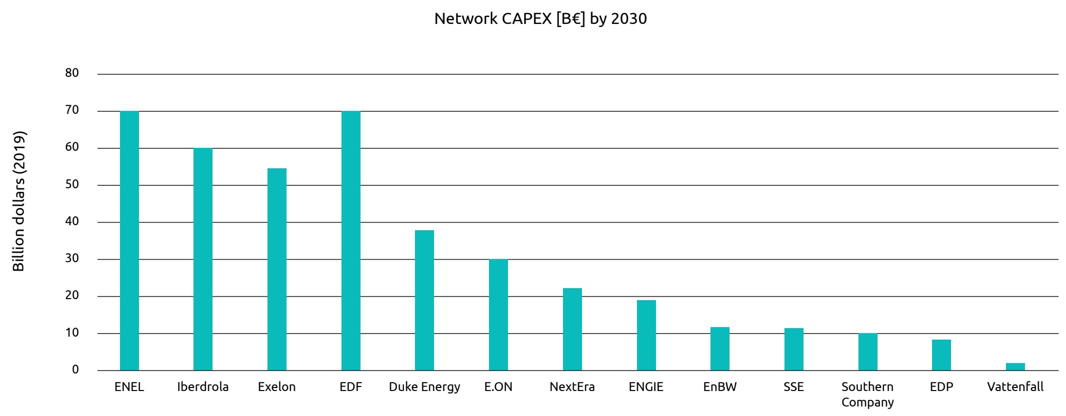
- There are many triggers for the deployment of the electric grid at scale. The smart grid concept appeared in the early 2000s along with the first wave of smart metering. Twenty years after, there's a burning platform to scale smart grids, considering:
  - Grid stability endangered by a higher share of distributed and intermittent renewables, shifting a one-way flow grid to a two way-flow.
  - Self-consumption and related extra-energy injected in the distribution grid (which lowers the transiting volume in grids and requires increased investments to manage it).
  - Massive electrification expected (led by electric vehicles (EV) charging, vehicle-to-grid technology, heat pumps development, etc.).
  - Storage and flexibility development.
  - Years of smart grid experimentations, including thousands of projects worldwide.
  - Technology maturity (IoT, communication networks, such as 5G, AI, and RPA, substation intelligence, and ability to communicate).
  - Electric grid point of convergence with other grids (gas, hydrogen, heating and cooling networks). Gas to Power and Power to Gas.
  - Need for new services that are network performance or customer satisfaction oriented.

- Growing the smart grid at scale will take between 10 and 15 years for the most advanced DNOs and tens of billions in investments, which is consistent with plans announced by the largest network operators.

- Perhaps without surprise, the four largest European DNOs (EDF covering RTE and Enedis in France, ENEL in Italy, Spain, and Latin America, Iberdrola in Spain, UK, Latin America, and North America and EON in Europe) are leading the pack. State Grid, the Chinese giant T&D network operator, may also be part of this group though no communication has been captured so far from the organization. EON will probably accelerate its investments in Smart Grid. Gathering EON + RWE + Innogy stakes in grid (the German mercato) provoked a slower start.

FIGURE 2

Network CAPEX [B€] by 2030



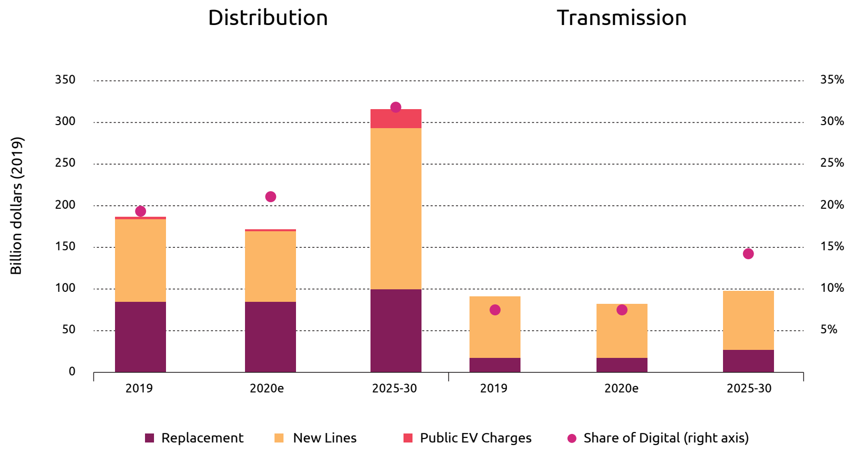
Sources: companies communications

- In the U.S., only two companies, EXELON and Duke Energy are showing investments in networks comparable to the largest European players.

- The Texas storm and outage in March 2021, as well as recent announcement on infrastructure development by the U.S. federal administration from a COVID recovery ans Energy Transition combined perspectives, will likely boost the ambitions of the U.S. for Smart Grids. This is a wake-up call.

FIGURE 3

Annual investment in electricity networks 2019-2030 in the Stated Policies Scenario



Sources: World Energy Outlook, IEA, 2019; World Energy Outlook, IEA, 2020;
Electricity security in tomorrow's power systems, IEA, 2020

FIGURE 4

Energy transition choices for selected leading utilities

	Électricité de France (EDF)	ENGIE	Enel	Iberdrola	NextEra Energy
SOLAR	2.2 GW installed, 20GW in project by 2030	3,8 GW capacity ~50GW new capacities by 2030 (solar + wind)	3.15 GW today (~+95GW renewables by 2030)	1.9 GW today, + 60GW + renewables by 2030	5,47 GW solar end of 2020. 55 GW global renewables by 2025
WIND	8.4 GW installed, ~7GW additional by 2030	9,2 GW in portfolio including offshore (ocean wind). Acceleration (+50GW 2030)	10.8 GW today (~+95GW renewables by 2030)	13.2 GW today +60GW renewables by 2030	16 GW wind capacity end of 2020. 55 GW global renewables by 2025
HYDROELECTRICITY	22.5 GW installed, no extra room for growing the capacity in France	16.3 GW installed	30.15 GW installed	18,6 GW today	--
BIOMASS	Limited and not growing capacity (coal plant conversion)	--	--	--	--
STORAGE	Ambition to grow 8GW and become a leader	Second life batteries	Initiatives without details at that stage	Initiatives without details at tha stage	Growing storage along with renewables (hybrid farms). Already 180MW capacity (limited) but plans to invest $1bn in 2021. Serious acceleration.
HYDROGEN	Creation of Hynamics, share holder of McPhy (electrolysers) and Eifel	Ambition to become a global leader in hydrogen, partnering with industries (consumers)	--	3 corridors in regions and 5MW electrolysers each	Plans to build a 20MW electrolyser.
EV CHARGING	100,000 IZIVIA charging stations today	--	780,000 public and private charging points by 2023	150,000 charging stations to be installed, multiple partnerships. EV100 member	EV charging program, notably in Florida.
BIOFUELS, BIOGAS	--	Biogas ambition	--	--	--
CCUS	Air capture demonstration	--	--	--	--
OTHERS	--	Heat and cooling networks. Bio-diversity initiative	Digital and platformization Startups collaboration.	Circular economy, biodiversity protection.	Circular economy, biodiversity protection.

Sources: companies communications

Utilities' energy transition update

- Energy transition has been a core mission for utilities for several years. This started with energy efficiency efforts, such as replacing traditional bulbs with more efficient ones, a long time ago.
- While most of the leading utilities have invested in renewables, their choices against other energy transition domains, such as storage, biomass, hydrogen, and CCUS, vary.
- We compare here the actual positions and choices made by utilities, as well as Oil & Gas players, due to the blurring lines between the Energy & Utilities sector and Oil & Gas, as well as diversifications projects.
- Generally, utilities emit about 10 times less than O&G IOCs, notably for our panel. Some, like EDF, rely mainly on low-carbon electricity generation (nuclear and renewables). Others (ENGIE, ENEL) still operate coal or gas plants, though decommission roadmaps exist.
- Key positions of utilities in energy transition:
  - All players are betting on renewables development with more or less intensity.
  - Other significant choices include Hydrogen (EDF, Engie), EV charging (ENEL, EDF), and storage (EDF).
  - ENGIE is also betting on biogas, heating and cooling networks as well as client solutions. This is perhaps obvious for an original gas centric player.
- NextEra is an interesting case to study. The company is markedly bigger in renewables today as compared to the other European companies and has plans to continue to invest heavily. As such, NextEra will remain in the frontrunners league. That said, it will be interesting to consider the company's position in energy transition, given that the company has never declared a net-zero emissions target. While the company's CEO thinks the targets are "disingenuous," NextEra continues to invest significantly in hydrogen, storage, and green mobility.

Oil & Gas energy transition update

- The 2020 WEMO report stated an average investment of IOCs outside of their core business of only 0.8%, which was mainly oriented on renewables and biofuels. This amounts to basically nothing. However, as of June 2021, the IEA reported a significant increase of up to 4%, with European majors floating between 10 to 20%. A level of investments, for European leaders, in the range of leading Utilities.
- The following pages show a picture of four IOCs' energy transition commitments, actual emissions, and energy transition pillars: BP, SHELL, TotalEnergies, and Exxon Mobil.
- BP, SHELL, and TotalEnergies have clear objectives on climate change mitigation, under the pressure of their stake and share holders, but also in a diversification perspective with the forecasted end of the fossil fuels era.
- Exxon Mobil sticks to historical core business, and hasn't announced any significant Energy Transition projects, beyond shy 2025 emissions reduction targets.
- The large European players with deep pockets are clearly pivoting to becoming utilities and are in the race for becoming renewables majors (or even supermajors). These companies have also announced investments in hydrogen and e-mobility to mitigate Scope 3 emissions.
- All operators, including Exxon Mobil, show interest in CCUS, as demonstrated through R&D and commitments for the future based on results already achieved.
- Biofuels is a "no brainer" for all in helping to meet

  demand for their clients, as well as leverage their large R&D investments and existing refining facilities.

FIGURE 5

Energy transition strategies of selected Oil & Gas majors

	BP	Royal Dutch Shell	ExxonMobil	TotalEnergies
Mission statement	Our purpose is **reimagining energy for people and our planet.**	Shell's purpose is to **power progress together with more and cleaner energy solutions.**	**Affordable and sustainable energy solutions are required to advance global prosperity. We invest in technology and communities to bring the world better energy.**	**Become the responsible energy major.**
GHG emissions (actuals – Gt/Y)	1.2	1.7	0.12 (Scope 1 & 2 only, no reporting Scope 3 so far)	0.45
Energy Transition Commitments/Roadmap	2025: -20% emissions 2030: -30-35% emissions 2050: -100% emissions	2023: -6 to 8% emissions 2030: - 20% emissions 2035: - 45% emissions 2050: -100% emissions	2025: -15 to 20% GHG compared to 2016) 2025: -40 to 50% methane intensity And -35 to 45% methane flaring New plan under activist's pressure	Carbon neutral by 2050 (1+2), Carbon neutrality by 2050 in Europe (1+2+3) 60% carbon intensity reduction by 2050 (15% 2030)
Energy Transition Investments	US$ 0.5 – 5 bn / y 2020 - 2025 ($60 bn by 2030)	US$ 3 bn / y low carbon electricity	$10bn over 20 years (since 2000). ExxonMobil sticks to historical core business, and hasn't announced any significant energy transition projects, but moves forward on hydrogen and CCS	US$ 1.5 – 2bn / y low carbon electricity
Energy Transition Pillars	Natural gas/ Renewables/ City solutions/ Mobility/ Reduction in Oil Productions/ Carbon Pricing/ Energy Management	Natural Gas/ Renewables/ Helping Customers Decarbonate/ Mobility/ Hydrogen Market/ Utilities	Scope 1 & 2 emissions, methane flaring reduction + Hydrogen and CCS	Natural Gas/ Renewables/ Energy Efficiency/ Sparing use of oil/ Helping customers decarbonate/ Carbon Sinks/ Carbon Price

FIGURE 6

Energy Transition domains of selected Oil & Gas majors

	BP	Royal Dutch Shell	ExxonMobil	TotalEnergies
SOLAR	1.5 GW installed, 8GW in pipeline	1.6 GW capacity	--	~5 GW installed, ~14GW in pipeline
WIND	1.7 GW in US, 3GW in UK pipeline	6 GW in portfolio or development	--	~1 GW installed, ~5GW in pipeline
HYDROELECTRICITY	--	2018 market feasibility study for North America	--	--
BIOMASS	BP Bunge Bioenergia in Brazil	IH^2 biomass for fuels	--	La Mede site
STORAGE	BP Ventures acquisition	Limejump subsidiary	--	Saft
HYDROGEN	>10% green hydrogen market by 2030	Global leaders in green hydrogen	Low carbon hydrogen production with Gas + CCS: blue hydrogen	Along with Engie, large hydrogen project
EV CHARGING	10,000 > 70,000 points by 2025	60,000 > 500,000 points by 2025 > 2,500,000 by 2030	--	150,000 by 2025
BIOFUELS	Partnership with Qantas for aviation	HEFA, synthetic fuels, biogas production	R&D (Algae) + agreement with Global Clean Energy Holdings to purchase 2.5 million barrels of renewable diesel per year for five years, starting in 2022	La Mede biorefinery
CCUS	Net Zero Teesside project	-25Mt / y by 2035	Latest reporting in 2017: 6.6 million metric tons of CO2 for storage	10% of R&D allocated
OTHERS	Cities partnership with Microsoft	Shell Energy Utilities/Broadband	Plastic waste management	Electricity retailer (Lampiris, Total Direct Energie, EDP SP)

Energy Transition: All can be winners

- Significant funds (CAPEX) totalling tens of billions in the next decade and thereafter is needed for every large player to meet its ambition.

- Shareholders and stock markets encourage the investments in renewables. Let's consider that:
  - The capitalisation of ORSTED on the stock market is comparable to BP's, a company twenty times ORSTED's size. BP's capitalisation has benefited of the economic recovery, market tension and barrel price increase.
  - The same effect has occurred in North America, with NextERA stock value being comparable to ExxonMobil's.

- All operators are investing to grow renewables.

- Utilities have started earlier and four renewables supermajors appeared (ENEL, IBERDROLA, ORSTED, NextEra).

- With their diversification imperative and deep pockets, European major IOCs joined the race recently and could be assuming leadership positions.
- So, it will be possible to find money for growing renewables; One should consider also the portfolio rotation (growing assets and selling them with a significant pay-back).

- It's impossible to become a champion on every dimension of the energy transition. No company could afford it. They have to make choices on technologies and in geographies. So, what are the best bets? A difficult question indeed. There are choices: Investing in EV charging infrastructures or in the hydrogen value chain? Storage or CCUS? Biofuels or biogas? Wind or solar or both (with hybridization)? Onshore or Offshore wind?
- Without forgetting to maintain a significant R&D effort to grow new promising technologies and bring them to high TRL[1] / BRL[2] levels.

- Now let's consider the networks (Smart Grid) investment. For networks, there is a question about investments compensation given the copper and fiber dilemma. Compensation schemes from regulations cover hardware investments; in many cases, not enough is directed to the software side of the Smart Grid. Regulation must evolve, so long as Smart Grids are the backbone of energy transition.

- **Easier to formulate than to execute, there's a winning energy transition route for all.**

- **Clear choices, consistency and resilience are needed.**

- **European IOCs are in the race.**

1. TRL : Technology Readiness Level
2. BRL : Business Readiness Level

04

04 Climate Change & Energy Transition

04 Climate Change & Energy Transition

Oil & Gas Carbon Neutrality Imperative and Best Foot Forward

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Oil & Gas Carbon Neutrality Imperative And Best Foot Forward

Introduction

Sustainability as a cornerstone of future developments

Year 2020 has seen extremely low oil demand and prices, forcing the industry to drive extensive cost optimizations and focus on the most profitable projects. Relatively high oil prices seen in 2021 (see figure) are a source of optimism.

In this environment, the International Energy Agency (IEA) is now demanding a stronger involvement from Oil & Gas companies in the energy transition. Pressure comes from all sides:

- **Shareholders**, worried about the risk on their investment, may either divest or make the change happen. For instance, the press covered extensively how an activist fund, owning only 0.02% stakes in ExxonMobil, forced the oil giant to accept two of its nominees on its executive board by leveraging the concerns of other shareholders[1].

- **Governments**, such as the Netherlands, are sentencing their own national champion, Shell, for delaying most of its transition efforts beyond 2030. Shell has been obliged to cut its 2019 carbon emissions by 45% by 2030. More generally, countries are setting their own net-zero goals. The European Union and the United States have stated their net-zero ambitions by 2050 and China has set its carbon neutrality goal by 2060.

- **Supra-government**, such as the Organization for Economic Co-operation and Development (OECD), and even the United Nations are pushing toward low-carbon in Oil & Gas especially as it relates to methane emissions reduction.

- **Employees** strive to align purpose with their responsibilities. This behavior is even observed in the top-executive ranks[2].

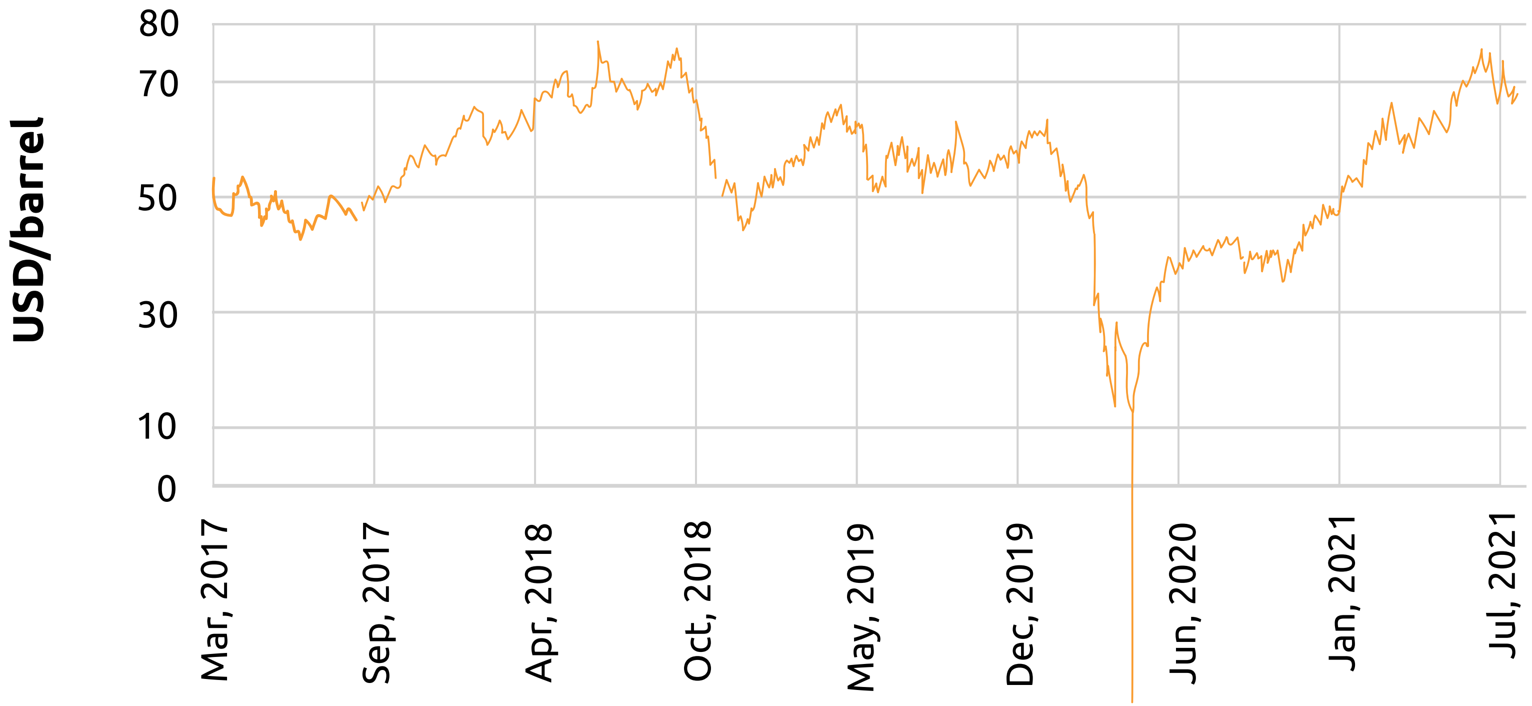
- **Market dynamics**, such as Oil & Gas assets, suffer writedowns[3] from price slumps and/or carbon tax anticipations, while renewables valuation soars[4]. Therefore, International Oil Company (IOC)s[5] feel the urge to create new revenue streams beyond their historical activities.

As it stands, the transition of Oil & Gas companies have yet to accelerate, and have not convinced investors, nor turned public opinion. There is still much to be done to reach the targets that these companies have set in their climate strategies.

1 Forbes, Activist Shareholder Wins Two Seats On ExxonMobil's Board Amid Battle Over Climate Change (May 2021)
2 Financial Times, Shell executives quit amid discord over green push (December 2020)
3 Financial Times, Shell warns of up to $22bn hit on assets from oil and gas slump (June 2020)
4 For instance, the 'Solar Invesco' ETF valuation went +270% over the past 5 years
5 IOC = International Oil Company; NOC = National Oil Company

FIGURE 1

Crude OK WTI spot prices



Sources: EIA (2021)
World Energy Markets Observatory 2021

Consequently, all oil companies have adopted a strategy for their transition. Even though international Oil & Gas companies are primarily focusing on scope 1 and 2 emissions, we see a few exceptions such as Eni, Equinor, and TotalEnergies (for products sold in Europe).

The traditional categories – National Oil Company (NOC), IOCs, and independents – are now being progressively replaced by the willingness of companies to shift toward other sources of energy (Oil & Gas vs. energy provider). Some companies are adopting bolder strategies than others (see figure on the right).

- NOCs and U.S. IOCs have remained steady with their Oil & Gas identity and play a necessary role in the energy mix. Chinese NOCs, however, may soon propose roadmaps aligned with China's carbon neutrality pledge. Middle Eastern countries face less pressure and do not have targets in place; however, the United Arab Emirates is considering becoming the first OPEC member to set a net-zero goal. NOCs remain reluctant to pledge for net-zero in a volatile and uncertain market.

- European IOCs (BP, Eni, Equinor, Galp, Repsol, Shell, and TotalEnergies) pledged to a net-zero objective by 2050. For some, the net-zero objective includes scope 3 emissions.

- Eventually, the previous group may achieve the same level of transformation demonstrated by Ørsted, which went from being an IOC to the world's largest offshore wind company.

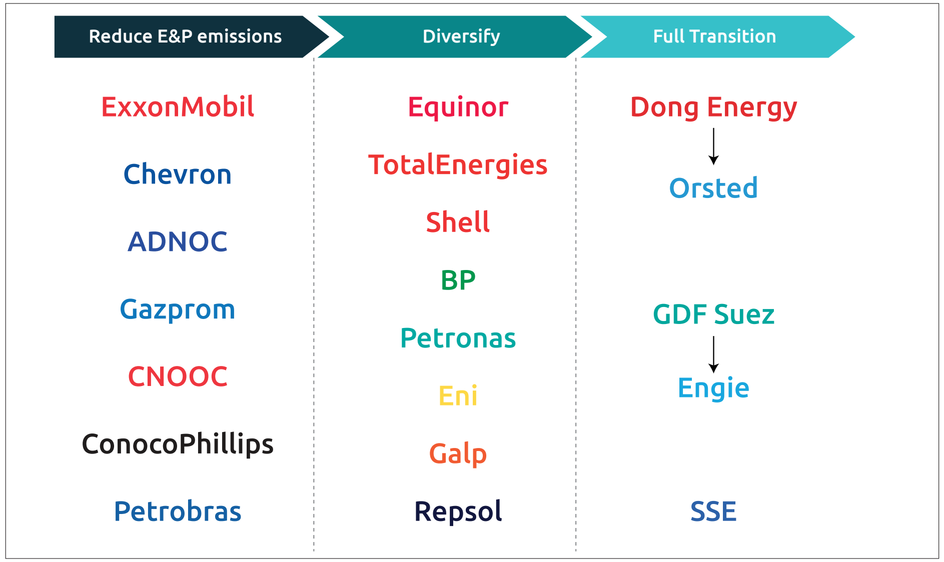
- In any case, the next few years will reveal decisive milestones for the ramping up sustainability investments. While he future of the Oil & Gas industry will be linked to the capacity of the sector to reduce scope 1 and 2 emissions, the future of current key players will be linked to their capacity to develop new (low-carbon) businesses.

Faced with the inexorable pressure for transition, the industry has no choice but moving toward a cleaner business. Still three tendencies can be observed:

- *companies focusing on the core business while optimizing their emissions*
- *companies diversifying their portfolio by entering new business*
- *companies operating a full transition and moving away from hydrocarbons*

FIGURE 2

Positioning of Oil & Gas companies towards Energy Transition



Securing the license to operate

Focusing on GHG emissions related to their own activity

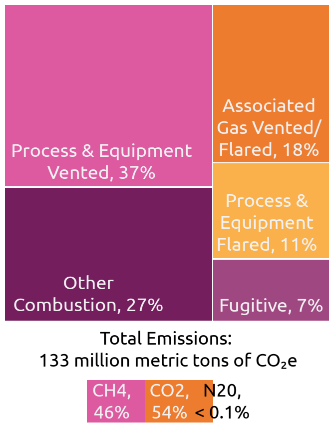
Despite a remaining risk inherent to the oil price fluctuation, the recent oil price recovery has shifted the focus toward more pressing requirement: reducing emissions from direct and indirect operations. Representing roughly 10% of the global emissions, industry activities are pressed to show concrete actions in this direction. Therefore, the sector has started to communicate its performance and improvement. For example, the American Petroleum Institute (API) is currently releasing its first template to report GHG emissions. Even though it is based on voluntary reporting, it shows the importance of communicating its scope 1 and 2 emission reductions, as well as mitigating actions taken.

CO2 release and methane leakage are, at first order of magnitude, the two elements to manage when dealing with scope 1 emissions. As an example, the 2021 GHG Reporting Program from figure 3, shows that in 2019, CH4 and CO2 contribution to onshore United States GHG emissions were similar. To address these challenges, the operators are focusing on two main aspects: reducing GHG emissions related to their own energy consumption and minimizing methane leakages.

Following cost and portfolio optimization driven by low prices, the sector is now focusing on GHG emissions. Transparency is becoming a standard, imposing more reporting and follow up. As a matter of fact, this will imply an optimization of the GHG emissions related to energy consumption, as well as minimizing methane leakages.

FIGURE 3

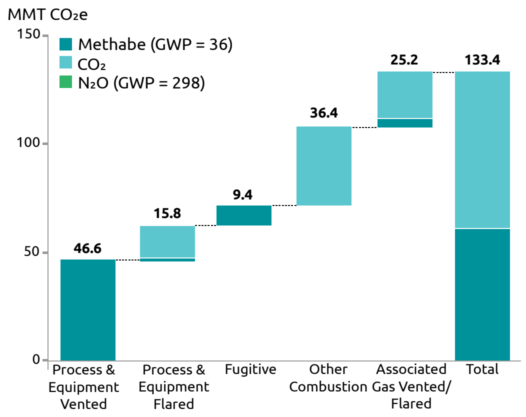
2019 GHGP Reported Emissions by source category



Sources: Clean Air Task Force, M.J. Bradley & Associates 2021
World Energy Markets Observatory 2021

FIGURE 4

2019 Reported Production Emissions, by Source Category



Sources: Clean Air Task Force, M.J. Bradley & Associates 2021
World Energy Markets Observatory 2021

Securing the license to operate

Reducing GHG emissions related to their own energy consumption

Electrification: Even though electrification is seen as a major opportunity to lower GHG emissions, connecting to the local grid does not guarantee the target will be met. In fact, as shown in figure 5, the associated benefit will depend on electricity generation. For example, Chinese CO2 emission intensity in 2020 was three times higher than European emissions.

In Norway, where hydroelectricity generates less than 40gCO2/kWh, the electrification of the platforms from shore is very common. As an example, Equinor’s Johan Sverdrup is producing oil at less than 1kgCO2/bbl compared to the world average of 18kg/bbl due to the use of onshore power.

In the United States, where the benefit of connecting to the grid is less advantageous (380gCO2/kWh in 2020), some companies are implementing their own solution. Chevron, in collaboration with Algonquin, will co-develop a 500MW renewables capacity to power its own assets.

Electrification is also an opportunity to optimize costs by replacing high operating expenses equipment or providing decentralized energy sources for decentralized unconventional wells:

- To replace gas turbines offshore, Abu Dhabi National Oil Company (ADNOC) is developing a 3.2 GW subsea power transmission network, which is expected to be operational in 2025.
- Saudi Aramco commissioned their first solar-powered unconventional gas well (50 MW) in 2019 and plans to scale to 11 wells in a near future.

Energy efficiency: In addition to a net reduction of GHG emissions from electrification, the Oil & Gas industry is expected to track and improve the energy used for hydrocarbon extraction and transformation.

For its assets, energy management systems and digital twins are becoming a standard. They play a key role in monitoring GHG emissions and environmental impact, enabling scope 1 optimization:

- Shell is a founding member of Open Footprint Forum, an open-source data platform to define, store, and exchange scope 1 and 2 emissions. As scope 3 emissions make up most of their total emissions, Shell aims to expand the project to include all GHG emissions in the near future.
- Petrobras plans to invest $1.5 billion in digital transformation and innovation in the next five years, according to its 2021-2025 strategic plan. Petrobras also implemented the digital twins technology at its refineries.

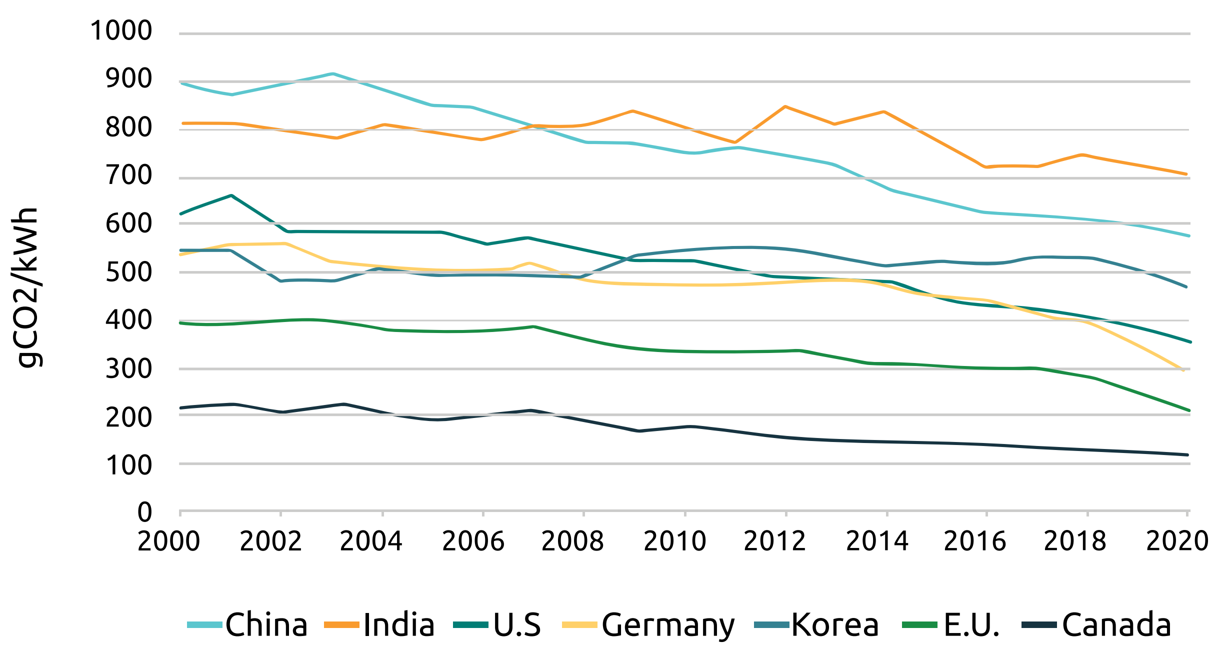
For its products, the industry is implementing solutions to follow up on the related environmental impact. Clients are expecting cleaner products and thus need to access more sustainability information from the suppliers. As an example, the two biggest IOC LNG players, Shell and TotalEnergies, announced carbon neutral LNG cargos.

In both cases, data and digitalization are playing a central role to access and share trusted information.

Digitalization itself will have a limited impact on GHG emissions. Still, by bringing reliable and transparent information, it will enable a better portfolio management.

FIGURE 5

Development of CO2 emission intensity of electricity generation in selected countries, 2000-2020



Sources: IEA - Electricity Market Report - December 2020
World Energy Markets Observatory 2021

Securing the license to operate

Minimizing methane leakages

Methane emissions are mainly related to processes and equipment. According to the IEA, conventional onshore (oil or gas fields) operations remain the main source of methane emissions (see figures). Compared to 2019 figures, normalized downstream and unconventional gas emissions of 2020 have increased.

Despite a relatively low emission intensity, the United States and Russia remain the two main contributors of overall methane emissions. This is mainly due to their position as major gas producers. The IEA estimates an abatement potential of up to 70% of methane leakages, at the low or no net cost of 11% (graph 7). Furthermore, the IEA illustrates that the main abatement factor is the replacement of equipment.

Today, we see an acceleration of the movement of minimizing methane leakages, driven by regulation as well as an industry consortium:

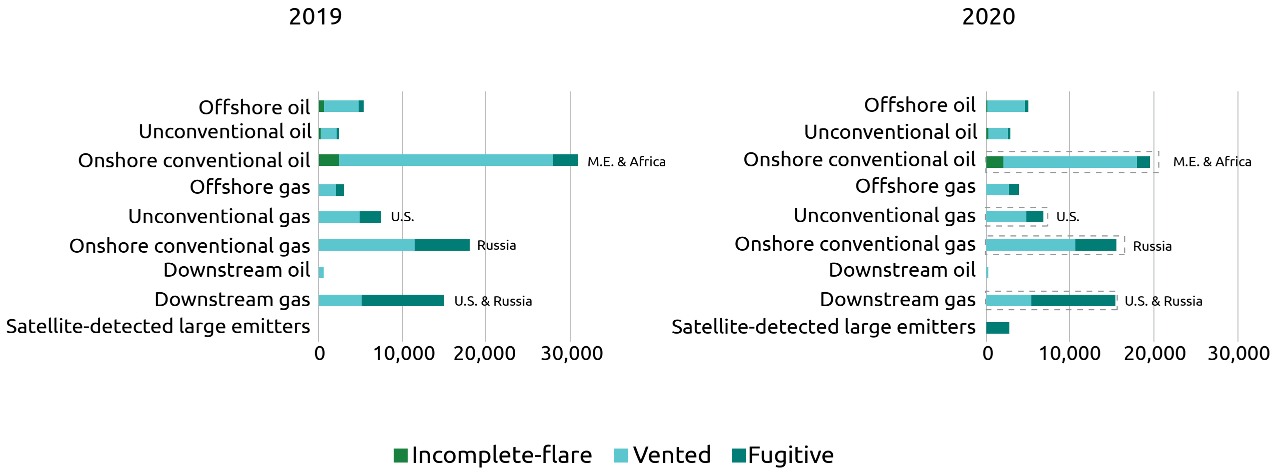
- Supported by the API and key players such as BP, Shell, and Exxon, the United States Senate voted in 2021 to restore stricter methane regulations. Regulating methane gas is a priority for President Biden to reduce emissions.
- Initiatives on methane management include the Oil and Gas Climate Initiative (OGCI), comprised of 12 large oil companies, of which five are NOCs: CNPC, Equinor, Pemex, Petrobras, and Saudi Aramco. The members have set a target to collectively reduce their average methane intensity at upstream gas and oil operations to 0.25% by 2025.

Despite current efforts, fugitive emissions remain difficult to track and quantify. Satellite technology is starting to play a key role. As shown in figure 6, the 2020 "satellite detected emitters" category is showing significant numbers, as compared to zero in 2019. Today, data remains scarce and relatively uncertain. Companies are putting their efforts into accessing better and more representative data to optimize the mitigation measures:

- Since July 2021, Shell, Chevron, and TotalEnergies are collaborating with GHGSat to assess the feasibility of its high resolution, space-based methane monitoring technology.
- ExxonMobil is testing satellite detection as well as aerial drones, helicopters, and planes to achieve its goal of a 40-50% decrease in absolute flaring and methane emissions.

FIGURE 6

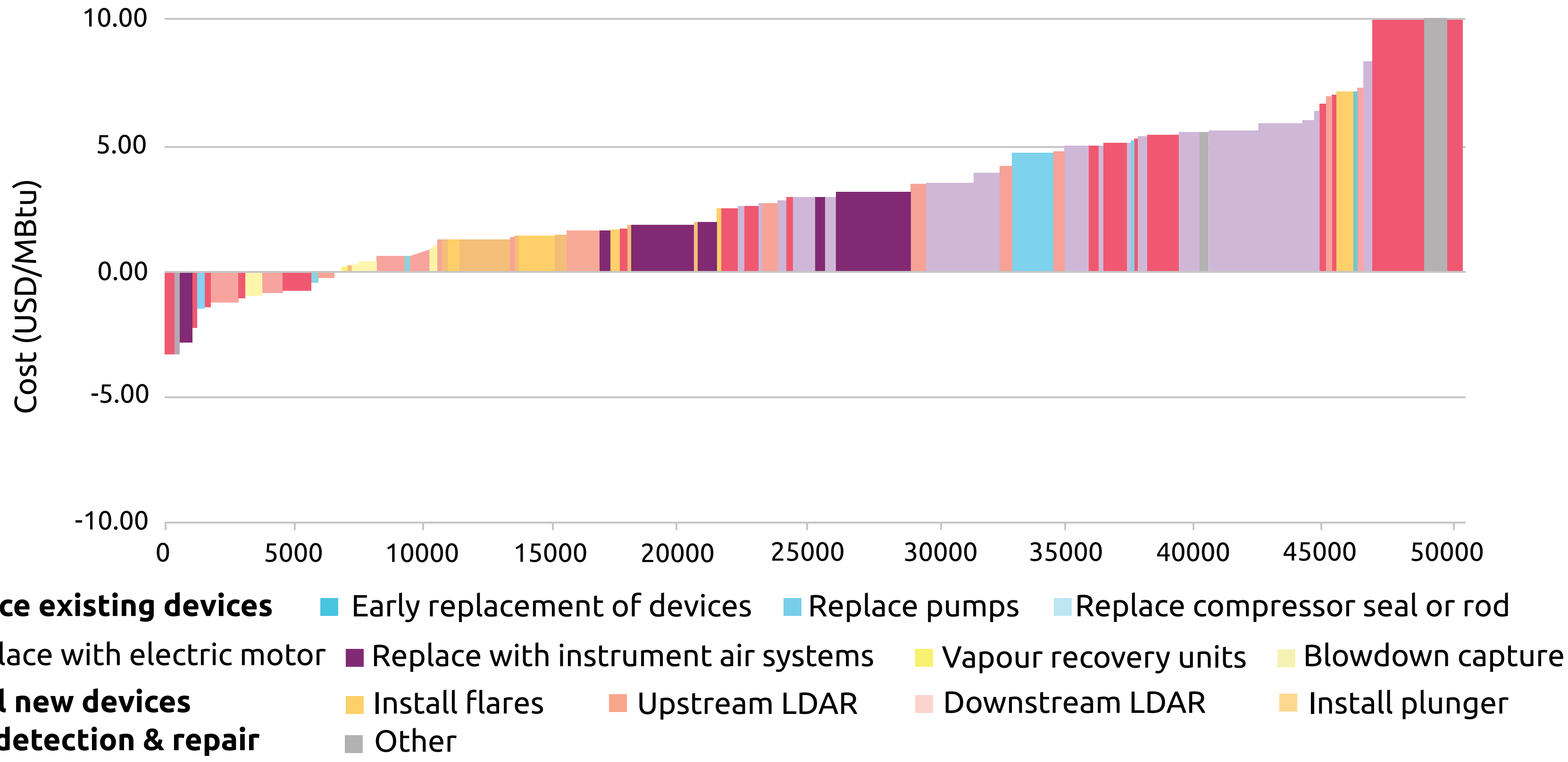
World emission sources



Sources: IEA
World Energy Markets Observatory 2021

FIGURE 7

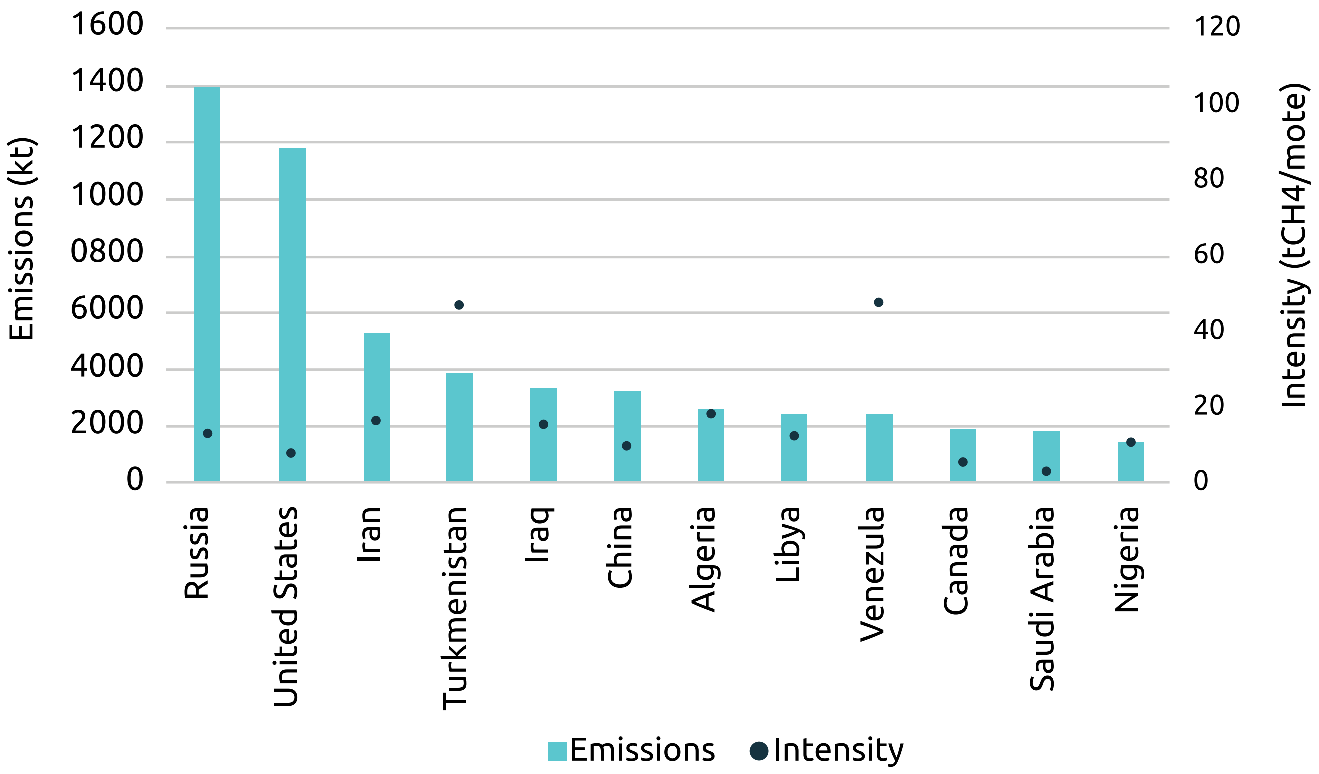
Estimated abatement potential



Sources: IEA
World Energy Markets Observatory 2021

FIGURE 8

Total methane emissions and methane intensity of production in selected oil and gas producers in 2020



Sources: IEA – Methane Tracker 2021
World Energy Markets Observatory 2021

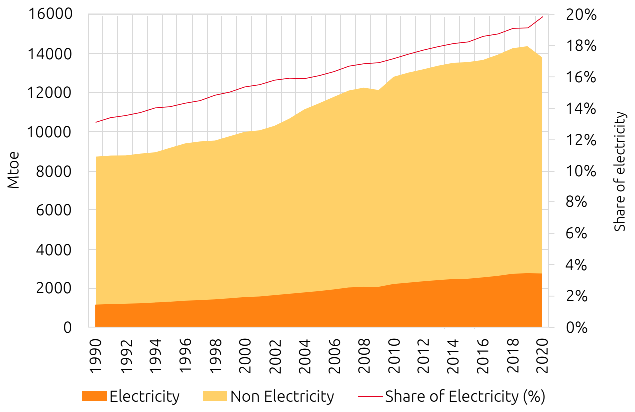
Entering new businesses

Accelerating the maturation of carbon offsetting projects and the growth in renewable energies

In a $50/bbl oil price environment, investment in renewables represents an opportunity for companies with strong balance sheets that are in position to think strategically and long-term. Diversification into clean energies could ensure their long-term survival, especially since the power sector shows relentless growth. Globally increasing carbon prices make it more attractive to move towards a lower emission portfolio. Companies can shift from oil towards gas and investing more into renewables.

FIGURE 9

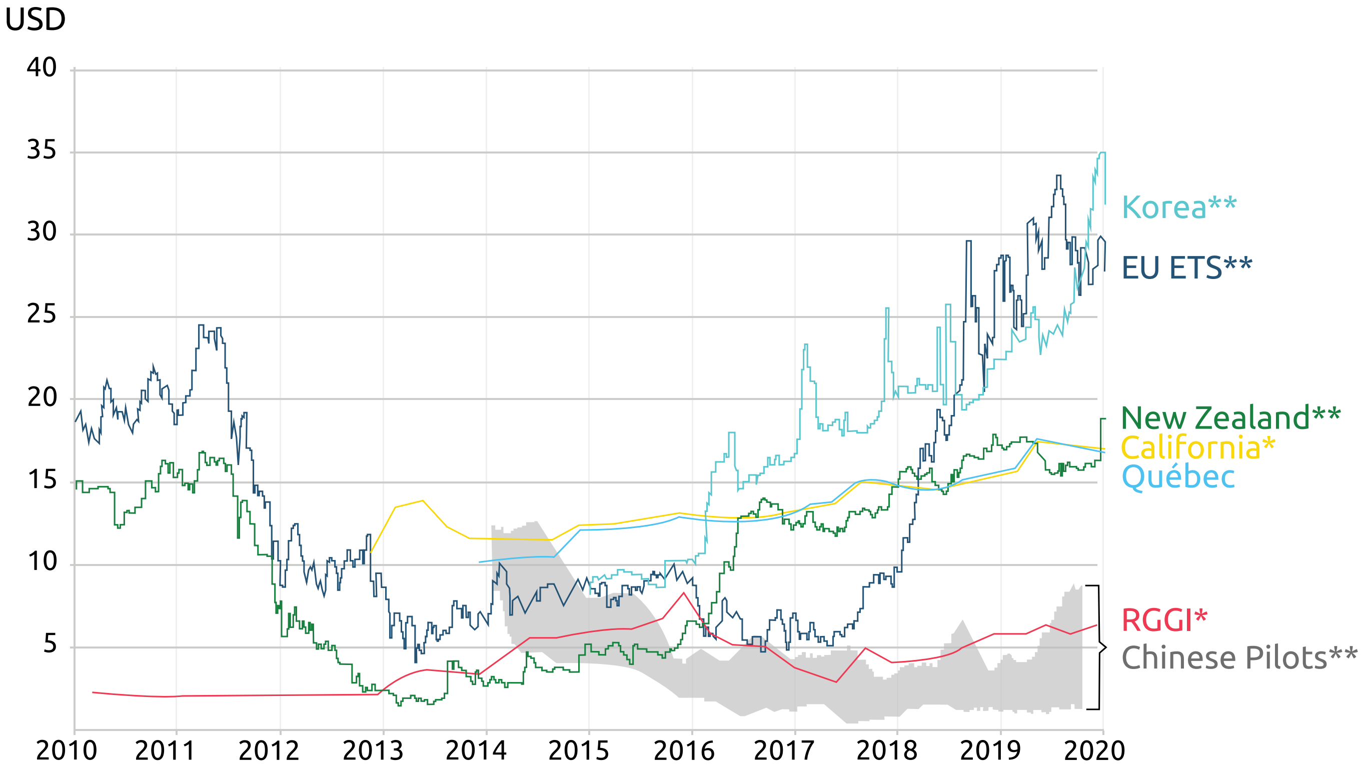
Evolution of global total energy consumption and growth of the power sector



Source: Enerdata (2021)

FIGURE 10

Carbon allowance prices



*primary market data
*secondary market data

Sources: International Carbon Action Partnership (2020)
World Energy Markets Observatory 2021

Entering new businesses

Maturating carbon offsetting projects

Two main means of carbon offsetting are considered by the sector: nature-based solutions (NBS) and carbon capture, utilization, and storage (CCUS).

Still in development, NBS have not been deployed yet, but ambitious targets have been expressed by some of the actors:

- Eni is aiming for forestry to absorb 20 mt p.a. in 2030 and approximately 40 mt p.a. in 2050[1].
- Shell is planning to offset 120 mt p.a. CO2 by 2030 using NBS. In 2020, the company signed a five-year contract to supply PetroChina with carbon-neutral LNG thanks to a 1.9 mt CO2eq reforestation project in China.

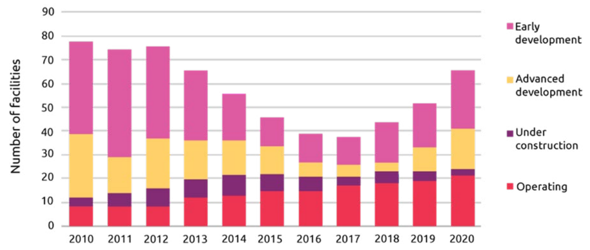
As of 2020, Oil & Gas relies on CCUS exclusively[2], leveraging existing capabilities. Carbon capture is a well-known technology to improve recovery mechanisms and has been implemented over the last decades. Despite recent significant cuts on CCUS in the United States, low CO2 prices and COVID have led to a halt in operations at the Petra Nova coal power plant in Texas; the IEA reports an increase of 250% of the planned investment in CCUS projects between 2017 and 2020[3]. These projects are mainly located in Europe and the United States, but also in Australia, China, Korea, and the Middle East.

- In Europe, Eni, BP, Equinor, Shell, and TotalEnergies are partnering in the Net Zero Teesside CCUS project in Northern United Kingdom. The project, at early stages of development, targets 6mt/y.
- At a company level, ExxonMobil is shifting from enhanced oil recovery (EOR) to non-EOR projects with more than 20 CCUS projects to be launched. In 2020, its carbon capture capacity amounted to more than 9mt/y, with half of it being dedicated to EOR.

The sector is at the forefront of carbon offsetting technologies thanks to several decades' of experience in enhanced recovery method for oil and gas production. Oil & Gas companies are currently massively investing in this area to control their scope 3 emissions.

FIGURE 11

Global large-scale CCUS facilities operating and in development



Notes: Includes the Petra Nova coal-fired power plant, which temporarily suspended CO_2 capture operations in May 2020 in response to low oil prices.
Source: IEA analysis based on GCCSI (2020), Facilities Database, https://co2re.co/FacilityData

FIGURE 12

Portfolios of carbon capture in large oil & gas companies (in operation in 2021)

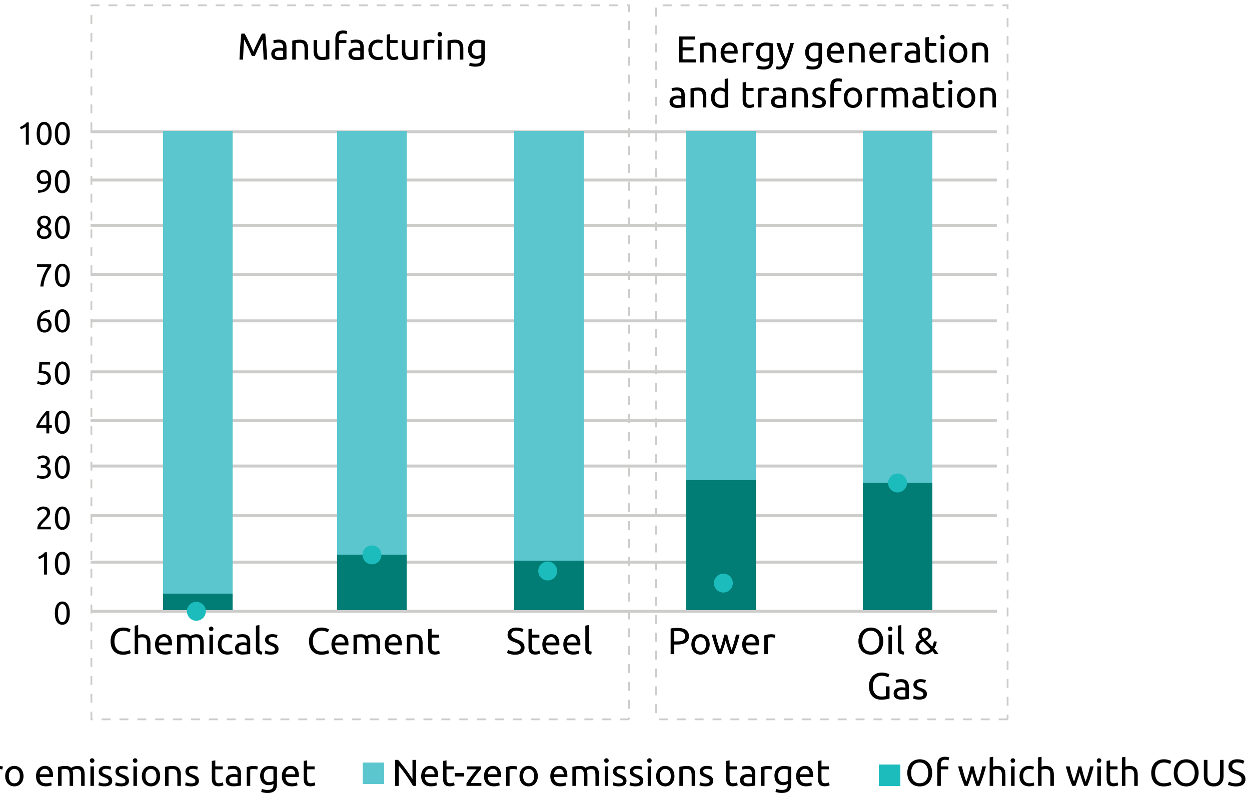
Segment (sum for O&G companies / total worldwide capacity)	BP	Chevron	Total Energies	Exxon Mobil	Petrobras
Carbon capture - EOR* (14 MtCO2/year / 32)	•	•	•	●	●
Carbon Capture - non EOR* (6.7 MtCO2/year / 8)		●	●	●	•

Source: IEA, Capgemini analysis
*EOR=Enhanced Oil Recovery

1 https://carbontracker.org/shell-and-eni-revise-emissions-plans-into-the-weeds-or-into-the-forest/
2 IEA, Share of activity covered by corporate carbon-neutral targets in select sectors, with an identified role for CCUS, IEA, Paris https://www.iea.org/data-and-statistics/charts/share-of-activity-covered-by-corporate-carbon-neutral-targets-in-select-sectors-with-an-identified-role-for-ccus
3 IEA, World large-scale CCUS facilities operating and in development, 2010-2020, IEA, Paris https://www.iea.org/data-and-statistics/charts/world-large-scale-ccus-facilities-operating-and-in-development-2010-2020

FIGURE 13

Share of activity covered by corporate carbon-neutral targets in select sectors



Sources: IEA
World Energy Markets Observatory 2021

Entering new businesses

Accelerating growth within renewables

To secure their revenues and level of activity, Oil & Gas companies are now entering the electricity value chain and accelerating their investments within low-carbon energies. Companies have two options: 1. growing organically through investments; or 2. growing through acquisitions of renewable energy providers. Even though NOCs are accelerating their activities, European IOCs remain the front runners: some companies even went through a rebranding to communicate their transformation, such as Ørsted (formerly Dong), Equinor (formerly Statoil), and, more recently, TotalEnergies (formerly Total).

Regarding acquisitions, the majors are making material moves not only in upstream electricity generation, but also in electricity storage:

- In 2019, Shell acquired Greenlots, a provider for electric vehicle charging, underscoring their move from a traditional oil company to an energy company.

- Equinor is a partner in H21, a suite of projects aiming to supply households with hydrogen beginning in 2028. This includes a 12.15 GW hydrogen production facility and associated carbon capture able to store up to 20 mt p.a.

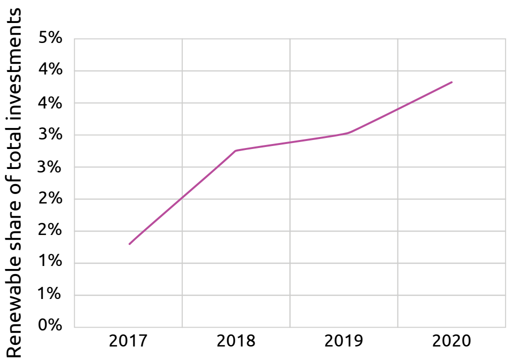
Overall, the ratio of investments within proven renewables technologies (e.g. wind and solar PV) are increasing, despite the COVID-related slowdown observed in 2020. Proven renewable technology investments nearly tripled between 2017 and 2020 to reach 3.8% of overall investments. Still, the production capacity of Oil & Gas historical players in these domains remain marginal compared to historical players (see figure 15) with less than 2%.

In addition to mature segments, the sector is also playing a key role within emerging technologies such as battery storage and hydrogen.

Following cost savings and portfolio optimization, the sector is moving towards renewables with many majors repositioning as energy players rather than oil companies.

FIGURE 15

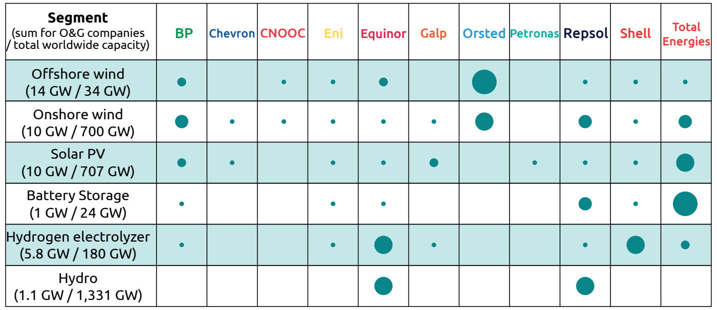
Investment in renewables as share of total investment



Sources: IEA – World Energy Investment 2020
World Energy Markets Observatory 2021

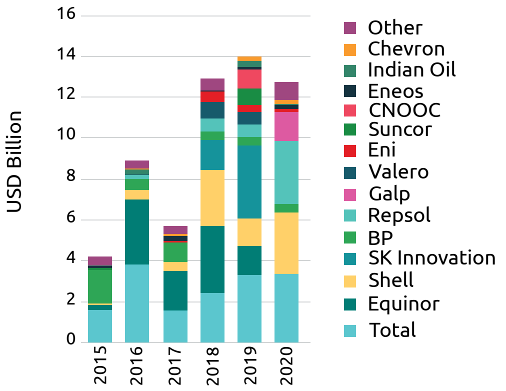
FIGURE 14

Portfolios of renewables in large oil & gas companies (in operation in 2021)



Sources: Rystad Energy, IRENA, annual reports of companies, IEA, Capgemini analysis

Clean energy investment by oil and gas companies, 2015-2020



Sources: BNEF Energy Transition Trends 2021
World Energy Markets Observatory 2021

04 Climate Change & Energy Transition

04

04 Climate Change & Energy Transition

Corporate Power Purchase Agreements (PPA)

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Corporate Power Purchase Agreements (PPA)

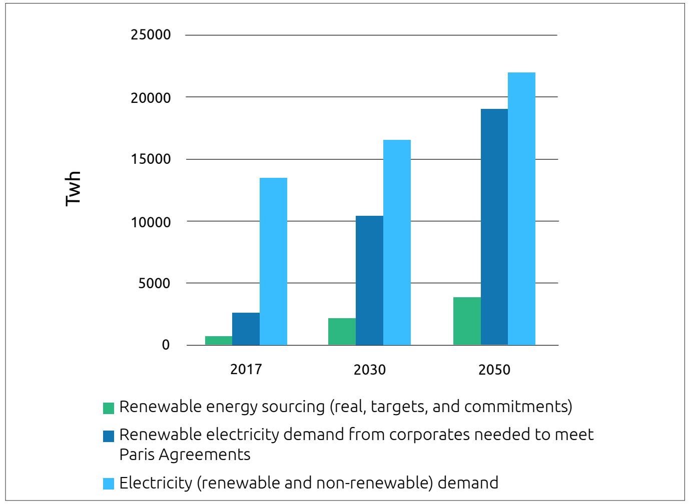
Increasingly challenged by climate change and customer preferences, many corporates have committed to renewable energy sourcing through various mechanisms

Many corporates have committed to renewable energy sourcing, acting through various mechanisms.

- In 2018, the International Renewable Energy Agency (IRENA) estimated that 85% of total commercial and industrial electricity demand should be covered by renewable energy by 2050 to meet Paris Agreement objectives.
- Yet the renewable energy sourcing represented in 2018 is only 20% of the 2050 total electricity estimation (from target commitments reported by companies).
- In 2019, more than 400 companies worldwide committed to setting a science-based target, a two-fold increase compared to previous years. Meanwhile, 300 have set a RE100 target (100% green electricity consumption).
- To achieve such targets, a wide variety of renewable energy sourcing solutions are available, such as: unbundled Energy Attributes Certificates (EAC) purchase, contract with suppliers, PPAs, onsite PPAs, and self-generation.[1]
- The winning renewable energy sourcing strategy is never a single-choice approach. Consequently, corporates must find the right mix of solutions, each one providing different benefits and drawbacks in terms of costs, green quality, availability, and the company's level of involvement in the energy transition.

FIGURE 1

Renewable energy sourcing projection for C&I sector

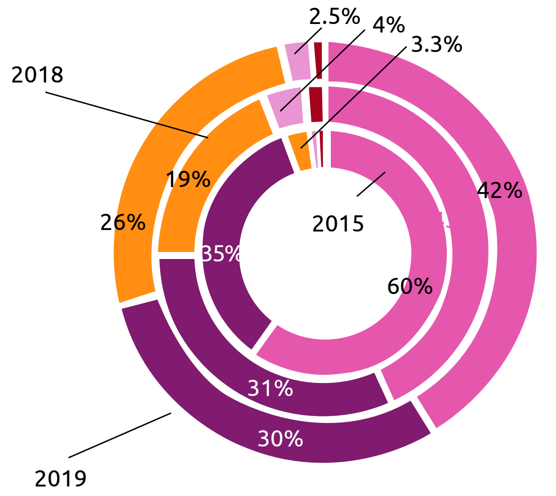


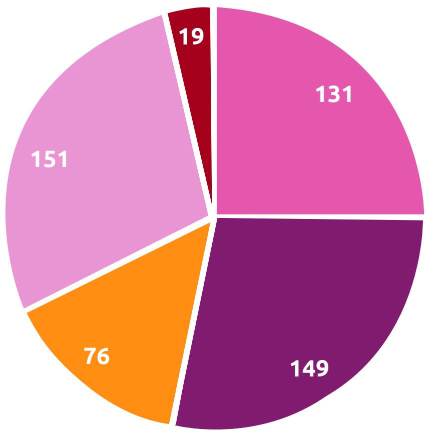
Source: Corporate Sourcing of Renewable Energy: Market and Industry Trends, IRENA, 2018

1 For more information about renewable energy sourcing solutions, see WEMO 2020, page 149

FIGURE 2

Sourcing methods used by RE100 members & 2019 RE100 members by sourcing method





Unbundled EAC purchase | Contract with suppliers | PPAs | Self-generation | Supplier owned on-site installations

Source: RE100 (2021)

Although certificates and contracts are the levers currently preferred, in 2019, corporate PPAs accounted for 26% of renewable electricity sourcing for RE100 companies.

- The share of corporate PPAs in the renewable electricity sourcing of RE100 companies has increased eight-fold between 2015 and 2019; 76 members have chosen corporate PPAs.
- As renewable costs are dropping and state support mechanisms might disappear, renewable energy developers need to find new ways of financing their new assets. Thus, the number of corporate PPAs is expected to rise in the next coming years.

What is a corporate power purchase agreement (PPA)?

SA corporate PPA is a contract between a renewable energy producer and an offtaker (corporate) to buy and consume the electricity produced by a renewable asset at pre-agreed prices and periods.[1]

- The offtaker buys all the electricity produced by (a) renewable producer(s) and has the electricity delivered by a supplier, which is also managing the intermittency of PPA assets and supplying complementary electricity to fit the offtaker's demand.

- Corporate PPAs are often long-term contracts lasting between 10 and 25 years. However, short-term contracts, usually lasting from 3 to 5 years, can be set up in case of existing and financed assets.

- The coal fleet in Vietnam has grown faster than in almost any other country. The country has 20.3 MW of operating coal plants.

Beyond this general definition, different types of corporate PPA exist:

- Physical (Sleeved) corporate PPA: This type of PPA relies on physical electricity flow between the producer and the offtaker. In most of these contracts, the offtaker and producer are in a pay-as-produced scheme, i.e., the offtaker buys all the electricity produced by the asset during the contract period. In this scheme, the offtaker and producer are supposed to be connected to the same network provider. Such PPAs can mobilize new assets (greenfield) or existing ones (brownfield) that are exiting support schemes.

- Virtual corporate PPA: In this type of PPA, the physical flow between offtaker and producer is replaced by a financial structure (e.g., connection to the same network provider). This type of PPA offers more flexibility. It is the most common in the U.S..[2]

Corporate PPAs have many benefits for both contract parties.

- Benefits for offtakers (corporates) are both financial and CSR-related:

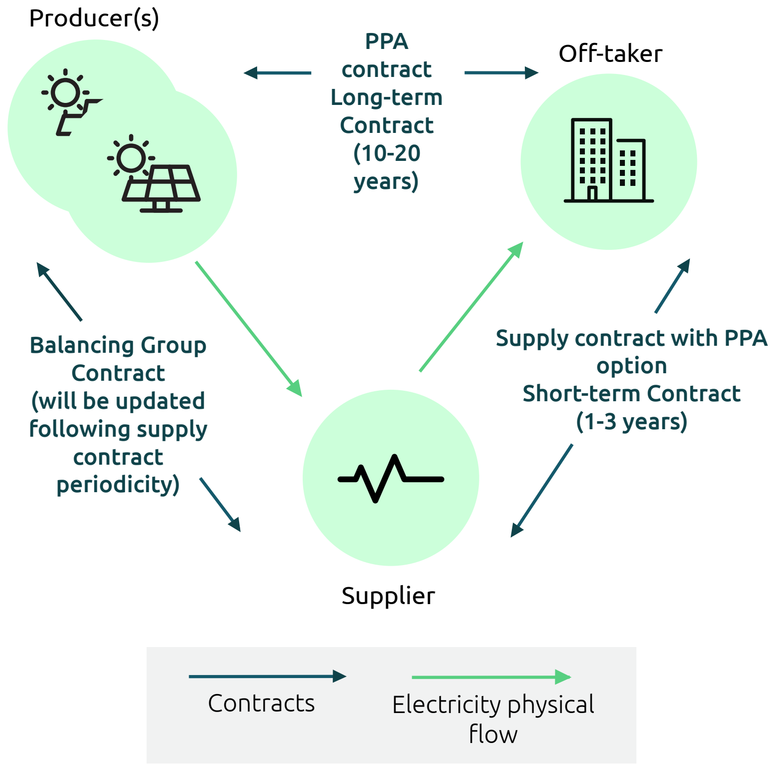
  - A competitive fixed price for the electricity from the PPAs is set in advance and decorrelated from the market prices (based on the production costs of renewable technologies), offering clear visibility on future costs for the buyer.
  - Another benefit is the contribution to renewable energy development through additionality, which is often aligned with the offtaker's CSR and sustain-ability objectives in its procurement strategy.

- Corporate PPAs grant the producer more visibility, thus improving access to financing or to revenue streams other than the market, which is particularly helpful for assets exiting State support schemes.

1 WBCSD, https://www.wbcsd.org/
2 Innovation in Power Purchase Agreement Structures, WBCSD, 2018

FIGURE 3

Physical (Sleeved) Corporate PPA description scheme



Source: Capgemini analysis

Corporate PPA volume continues its growth worldwide, reaching 23.7 GW in 2020, although the American market has begun to decline for the first time

The new corporate PPA market showed an 18% volume increase between 2019 and 2020.[1]

- The geographical footprint is still driven by the U.S. market, despite that market being in decline for the first time; it dropped 16% compared to the previous year.
- The market has been dynamized by innovative contract structures, such as cross-border PPAs for solar projects in Spain.

The European market is booming, almost tripling additional PPA capacity in one year.

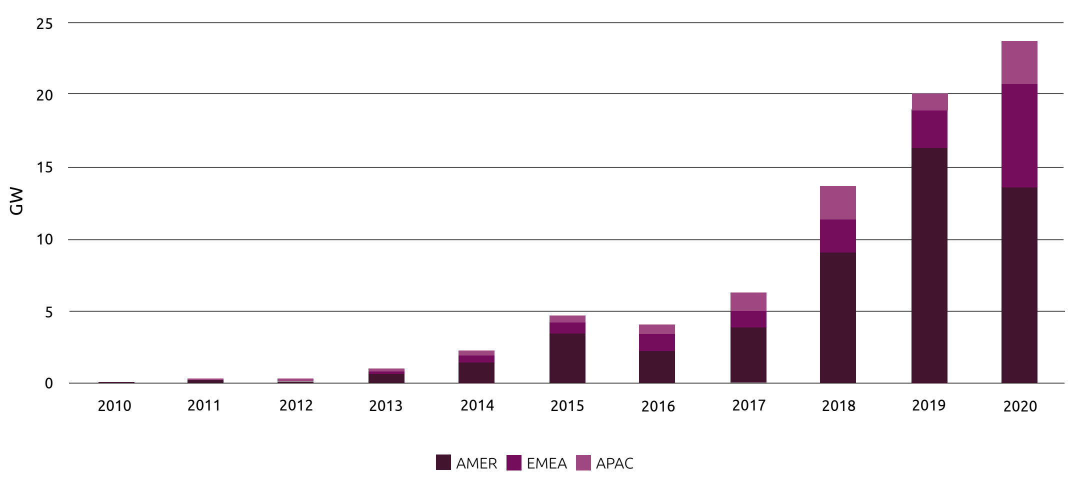
- Europe represented 13.8 GW of corporate PPAs by the end of 2020, dominated by wind technology. However, solar has shown a dramatic rise in terms of additional capacity from less than 10% of contracted PPAs in 2018 to almost 50% in 2020. Technology diversification seems to be increasing with contracts leveraging on a portfolio of technologies (often wind and solar).
- Historically, the Nordic countries were the most important corporate PPA buyers, with Sweden and Norway being the top two and three European markets respectively. However, today the major market (19% of total) is led by Spain, with 2.9 GW contracted, 62% of which are solar projects.

Corporate PPAs are now targeted by all sectors.

- The main buyers are still technology companies such as Amazon, Verizon, or Facebook. Other sectors are increasingly represented in top buyers, like Oil & Gas, with Total contracting 3 GW of solar energy or manufacturers like TSMC (1,2 GW).[2]
- ICT sector is the main corporate PPA contractor in Europe with 5.4 GW contracted, followed by heavy industry and transport with 3.8 GW and 1.2 GW contracted, respectively.

FIGURE 4

Evolution of PPA volumes by region

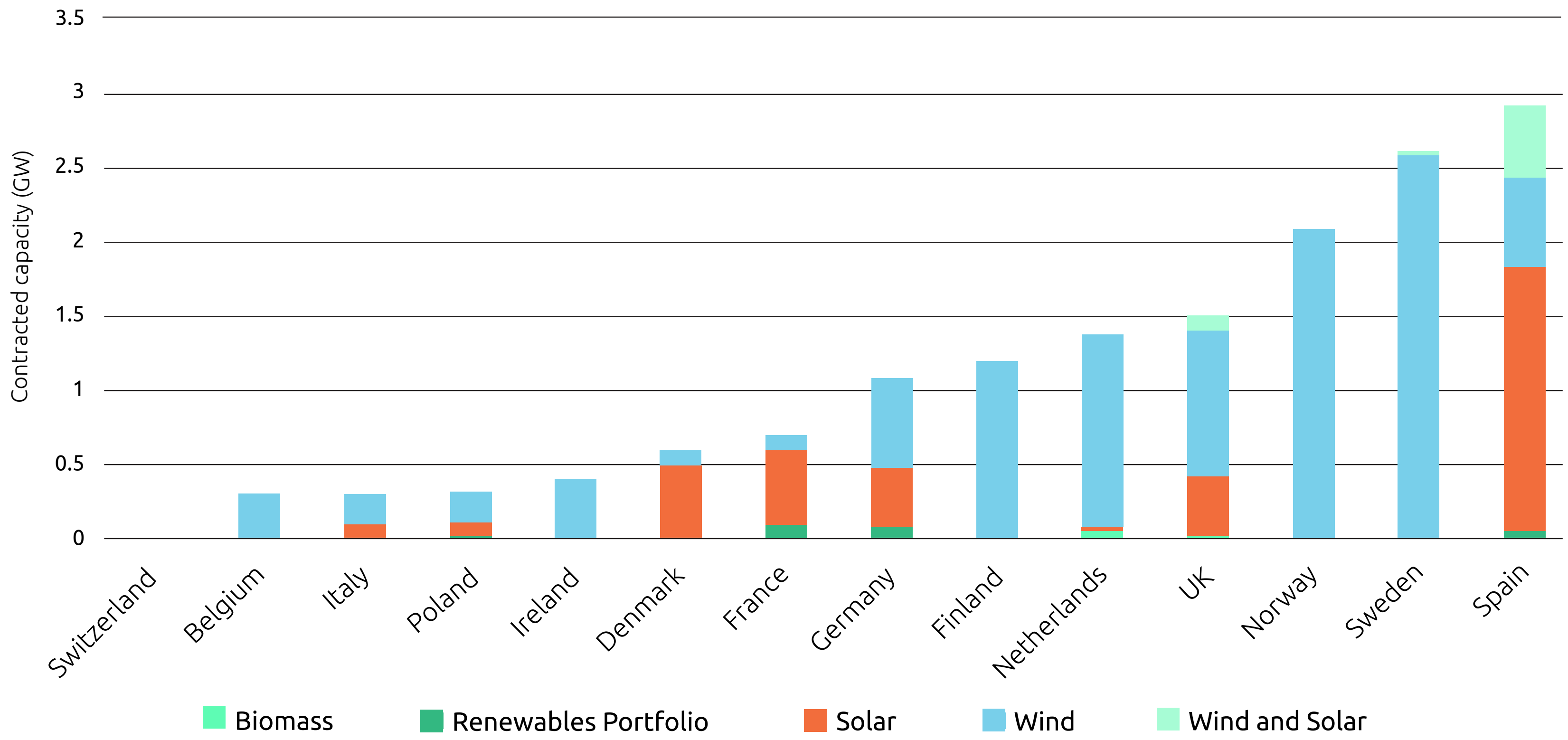


Source: BNEF (2021)

1 BNEF, 2021
2 Renewable Energy Buyers Toolkit, RE-Source, 2021

FIGURE 5

Evolution of PPA volumes by region



Source: Renewable Energy Buyers Toolkit, RE-Source, 2021

U.S. market: Corporate PPAs declined in 2020 as companies tightened their budgets in response to due to COVID-19

Corporate power purchase agreements (PPAs) for clean energy totaled 12 GW in 2020; this is down from 14 GW in 2019, and is the first drop in annual corporate PPA volumes since 2016.

- COVID-19 was the biggest factor in the drop. Few deals were announced in the first half of 2020, as companies tightened budgets and shifted priorities internally in response to the pandemic.

- There was a revival in the number of deals announced in the second half of 2020, which signals that companies will be better prepared to carry on sustainability initiatives during any future disruptions.

- Solar has become the dominant clean energy technology sought by corporations. This reflects growing expertise in power markets among buyers who are trying to capture peak power pricing, in which solar tends to fare better than wind.

- Additionally, many wind projects in popular markets like ERCOT and SPP have seen their revenues erode as more zero marginal cost clean energy is built, which depresses prices. This has prompted companies to seek solar contracts in these markets instead.

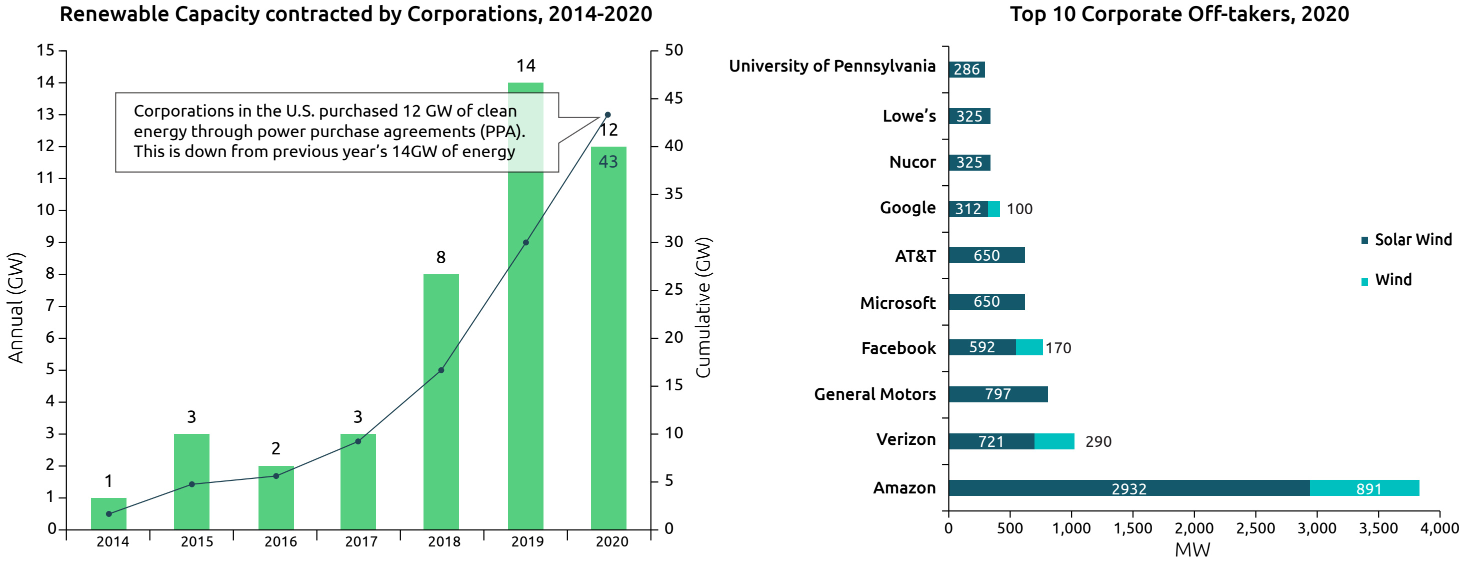
Amazon was by far the largest corporate buyer of clean energy in 2020, at 3.8GW.

- The company announced 21 individual clean energy PPAs in the U.S., with most projects located in Virginia and Ohio. Verizon (1GW) and General Motors (797MW) were the next largest buyers.

- A slew of first-time buyers also entered the market in 2020, including Applied Materials, Henkel, and Nucor.

FIGURE 6

Corporate Procurement of Clean Energy, 2020 (GW)



Source: BNEF ~ Sustainable Energy in America Factbook, 2021 ;
Link: http://www.bcse.org/factbook/#

Country snapshot: The French market faces a growing demand but is challenged by the volume availability of renewables and competition with state tenders

Total contracted corporate PPA volume in France reached ~1 TWh in mid-2021.

- In 2019, the French corporate PPA market started leveraging both existing projects that were exiting support schemes, such as the Metro PPA with Eurowatt, as well as additional new projects, such as Groupe ADP's PPA with Urbasolar.
- This market is very dynamic; it started at 45 GWh in 2019 but reached more than 680 GWh by the end of 2020. It also posted +200 GWh of additional renewable generation in the first semester of 2021.
- The French market is not diversified in terms of technologies: the additional projects are only solar-based, while the projects that are exiting support schemes are almost exclusively wind-based.

All sectors are interested in contracting corporate PPAs

- Contrary to the global market, the French PPA market is not dominated by ICT; the French market is rather diversified, and is comprised primarily of transport or retail companies, as well as banks.
- Generally, corporates cover up to 20% of their total annual consumption at the national level (due to intermittency, aggregation, and load curve adequation concerns).

Although growth is dynamic, corporates may compete with CRE auctions, limiting the number of available projects in the future.

This trend has been observed since the last PPA was publicly announced and should be followed carefully.

*For quarterly information about the Corporate PPA market and expert interviews (by corporates and renewable energy producers), subscribe to **Capgemini's Baromètre des achats d'énergie verte en France***

FIGURE 7

Overview of signed Corporate PPA in France in June 2021

New plants (additional) — 12 PPAs, ~760 GWh

Offtaker	Producer	Volume/ Time	% Conso
Groupe ADP	Urbasolar	47 GWh / 21 yrs	10%
SNCF	Voltalia	143 MW / 25 yrs	3,6%
Crédit Mutuel	Voltalia	10 MW / 25 yrs	5%
Boulanger	Voltalia	5 MW / 25 yrs	10%
Auchan	Voltalia	61 MW / 20 yrs	NC
SNCF	RES group	40 MW / 15-20 yrs	~2%
LCL + 15 other offtakers	Voltalia	55 MW / NC	~2%
Decathlon	Voltalia	16 MW / NC	15%
Amazon	Engie	15 MW / NC	NC
Orange S.A.	Engie	51 MW / 15 yrs	4%
Orange S.A.	TotalEnergies	80 MW / 15 yrs	5%
SNCF	EDF Renouvelables	20 MW / 20 yrs	NC

Existing plants exiting support schemes — 10 PPAs, ~450 GWh

Offtaker	Producer	Volume/ Time	% Conso
Société Générale	Eurowatt	27 GWh / 3 yrs	10%
Maïsadour	EDF Renouvelables	20 GWh / 3 yrs	15%
METRO	Eurowatt	25 GWh / 3 yrs	16%
Auchan	Eurowatt | Boralex	NC / ~3 yrs	NC
Orange S.A. (France)	Boralex	67 GWh / 5 yrs	3%
FNAC DARTY	Groupe VALECO | Solvay S.A.	16 GWh / NC	14%
RATP	EDF Renouvelables	60 GWh / 3 yrs	4%
IBM (France)	Boralex	1NC / 5 yrs	55%
Bouygues	EDF Renouvelables	203 GWh / 5 yrs	55%
Eureden	Primeo Energie	9,7 MW / 3 yrs	NC

Source: Capgemini Analysis from press releases, Capgemini Baromètre des achats d'énergie verte en France, July 2021

In Europe, innovative corporate PPA models such as cross-border PPAs are emerging[1], demonstrating the appetite of offtakers to leverage this type of contract as a pillar of global energy procurement strategy

Cross-border PPAs are PPAs signed between an offtaker and a renewable energy producer in two different energy markets. They can be either virtual or physical.

- ***A virtual PPA is "similar" in terms of contract structure:*** The offtaker pays a difference to the producer in relation to a contractually agreed-upon price and recovers the Guarantees of Origin. The two actors are not linked by a physical flow of electrons.
- ***A physical PPA is more complex:*** A physical flow of electrons must be established between the offtaker and the generator by passing through two interconnected networks at the "market border," requiring a secure capacity authorization to pass from one market (network) to another.

This type of contract has several advantages for the offtaker:

- The economic optimum from low LCOEs in some geographies can be more attractive in terms of price, renewable technology, and efficiency.
- International corporates can aggregate several sites and countries' load curves without multiplying the need for local management of PPA subjects.
- Finally, the valuation of the carbon benefit in CSR reporting would be higher if the financed project is in a carbon-based electricity production location.

In terms of practicality, physical cross-border PPAs are very complex to implement and do not exist in Europe.

- This is largely due to the constraints and regulations of the electricity markets.
- The allocation of capacity rights to guarantee physical electricity flows are negotiated on an annual basis, so flows are not guaranteed over the whole duration of the PPA.

Only virtual cross-border PPAs, which do not have this constraint, are observed in Europe although the risk is increased.

- It remains a virtual PPA, so having to treat the contract as a financial derivative is then maintained,
- Price risk depends on which market (the producer's or the offtaker's) is used as a reference in the PPA contract.
- Corporates may not be able to account for carbon benefits if the guarantees of origin issued by the producer are issued in a non-AIB country.
- Regarding the last two points, levers can be used to limit these risks, such as integrating a "cap and floor" on prices as well as integrating the choice of electricity production geography into the corporate PPA strategy.

More than ever, this new contract structure presents a strategic question for corporates, who must mobilize and align numerous players throughout their organizations. It is also essential that the contract terms are examined in detail, in order to ensure a good distribution of risk between the offtaker and the producer.[2]

1 Cross-border PPAs: New opportunities for business to decarbonize their electricity supply across Europe, WBCSD, 2021
2 Baromètre des achats d'énergie verte en France, Capgemini Invent, Avril 2021

FIGURE 8

Examples of cross-border PPAs in Europe

130 MW
Tenor: 10 yrs

Power producer: Neoen
Offtaker: ABInBev
Generation market: Spain

Offtake markets: Belgium, Germany, the Netherlands, the Canary Islands and Luxemburg

78.5 MW
Tenor: 10 yrs

Power producer: Enel
Offtaker: Novartis
Generation market: Spain

Offtake markets: : Austria, Germany, Spain, France, UK, Italy, Sweden, Romania, Switzerland, Belgium, Slovenia, Poland, Czech Republic, Ireland

76 MW
Tenor: 15 yrs

Power producer: EDP
Offtaker: DSM

Generation market: Spain
Offtake markets: 9 European countries

126 MW
Tenor: 10 yrs

Power producer: Neoen
Offtaker: Heineken, Nouryon, Philips, Signify

Generation market: Finland
Offtake markets: Not specified

Capgemini Analysis from WBCSD, 2021

What is at stake for corporate PPAs to sustain their growth in the future?

In some companies and finance institutions, corporate PPAs are still perceived as more of a risk than an opportunity.

- A survey conducted in Germany with 138 industry experts[1] highlighted than the top five barriers to PPA adoption are: lack of experience (51%), contract structure complexity (47%), uncertainty about regulation (42%), risk of loss due to unilateral contractual relationship (26%), and long-term contract duration (23%).

- From the perspective of renewable developers and producers, corporate PPAs are indisputably a concrete way to expand their portfolio. However, they can be a barrier for project financing from banks that fear uncertainty concerning the corporate/offtaker's financial long-term solidity. This position may set a floor in PPA prices decline.

1 dena-Marktmonitor 2030 "Corporate Green PPAs", Deutsche Energie-Agentur GmbH (dena), July 2019

The financing of renewable projects faces competition with state support tenders.

- Even if state support may decrease in the coming years, it remains the most compelling way to finance projects from the point of view of developers and financing entities, due to its low risk and uncertainty.
- However, as state tenders put more pressure on the environmental quality of projects, such as PV modules sourcing or land use constraints, the land available for such projects might decrease. In this case, corporate PPAs could be the only way to develop some renewable projects and maintain an ambitious renewable share in national electricity production targets.

Digital and platforms could be corporate PPAs accelerators.[1]

- The digitalization of the PPA market, as observed in Germany, is a trend to be followed. Platforms allow interested companies to identify existing PPAs and to compare offers from producers with the history of the projects on the platform.
- Access to such information improves the understanding of offtakers about corporate PPAs while the transparency improves the competitiveness of the market.
- Moreover, as the sustainable nature of this market is attracting strong interest from banks, insurance companies, and venture capitalists, the necessary funding for the development of such initiatives seems accessible.

Setting clear market standards and rules at the national level is key to fostering the growth of corporate PPAs.

- In many countries, corporate PPAs have appeared since 2017-2018, but procedures for establishing market standards are stalling at the state level.
- There are several working groups that are bringing together potential offtakers, renewable developers, and regulation entities in order to provide standard documents (contracts, etc.), such as the FEE (France Energie Eolienne) working group in France.

For the offtaker, the key success factors are the alignment of corporates internal stakeholders and the demonstration of benefits.

Corporate PPAs should be perceived and treated like a transformation project that temporarily disrupts procurement but has a positive effect. Such transformation will impact administrative and operational entities like CSR, finance department, accounting, legal, operations, etc.

Thus, due to the long-term engagement framework, the validation of attributes, principles and contract must be conducted at the highest level and become a strategic orientation of corporate decarbonization.

The renewables sector, corporates and regulation entities must work together at both the national and international level in order to determine clear and transparent standards that reduce uncertainty around PPAs.

This cooperation is required to achieve renewable energy share targets at both corporate and national levels.

1 Baromètre des achats d'énergie verte en France, Capgemini Invent, Avril 2021

04

04 Climate Change & Energy Transition

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Europe
Energy Transition

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Europe Energy Transition

Europe's perspective

The European Union (EU) toughens sustainability targets after enduring the hottest year since records began.

- Greenhouse gas emissions in the EU-28 have decreased year-on-year. In 2020, emissions reduced by 3.7%, while GDP grew by 1.5%. **At present, emissions have been reduced by 24% compared to levels in 1990.**
- This significant reduction in emissions has been **mostly driven by the COVID-19-related restrictions** and subsequent recession. To some degree, it is also a continuation of past trends.
- Regardless, Europe saw its **warmest year on record**; 0.4 °C warmer than 2019 (which was previously the warmest year on record and at least 0.4 °C above the next five warmest years). Emissions are gradually returning to pre-pandemic levels.
- Clearly, the 27 current trends are not enough to prevent the worst effects of the climate crisis. Therefore, Europe has set **new and ambitious sustainability goals,** becoming a global climate leader.
- MEPs reached an interim agreement with the Council, increasing the EU's goal of reducing greenhouse gas emissions by 40% to at least 55% by 2030. This was compared to emission levels in 1990.
- The final agreement was extended to **60%** - an ambitious reduction that will place the EU as the first region with **goals compatible with the Paris agreement.**
- **Between 2021 and 2027, 30% of the budget will be used for climate action.** This will aim to curb the impact of the pandemic and make a sustainable future more viable.

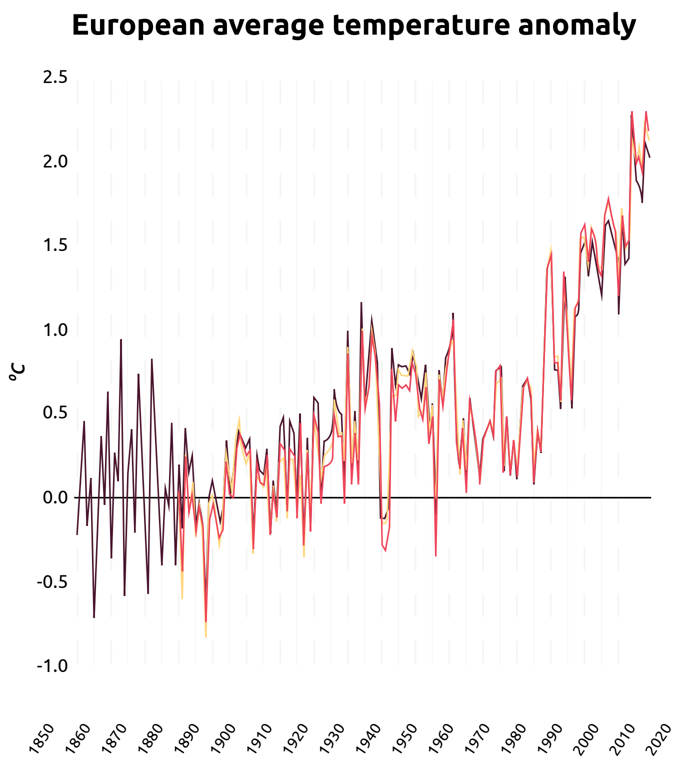
In October 2020, the European Parliament adopted the result of its negotiations on the Climate Law and endorsed the climate neutrality target set for 2050. Therefore, the emission reduction for 2030 was set at 60% compared to 1990 levels, a more ambitious target than the Commission proposal of 55%, and the current provisional target of 40%.

1 https://climate.copernicus.eu/2020-warmest-year-record-europe-globally-2020-ties-2016-warmest-year-recorded
2 https://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-7/assessment
3 https://climateactiontracker.org/countries/eu/
4 https://www.bbc.com/news/world-europe-55273004

The packages, measures and actions put in place during 2021 and 2022 will be critical in setting the path towards neutrality and turning the possibility of a climate disaster into an opportunity to lead the transformation.
100% renewable powered means moving from 300bn pa investments in clean energy today to 2,500bn pa for 30 years.

FIGURE 1

European average temperature anomaly



Source: National Oceanic and Atmospheric Administration (NOAA) (2020)

European countries are mostly complying with primary energy consumption targets, leveraging their ambitions in areas such as energy efficiency and mobility

- **Primary energy consumption targets for 2020 (set by EU Member States) have mostly been met.** Up to 17 countries have exceeded their objectives, although some goals are questionable:
  - **Major economies are meeting considerably unambitious targets.** France, U.K., Italy, and Spain mostly comply, yet have increased their primary consumption by over 10% since 2014.
  - **Germany and Hungary fell short of achieving their goals,** even though they have substantially increased their consumption.
  - **Sweden, Ireland, and Austria are failing to reach their targets,** although their energy consumption has remained largely stable in recent years.

- **When it comes to the EU's target of increasing energy efficiency by 32.5% in 2030, there is still a considerable ambition gap.** Although progress is being made, the gap currently stands at 2.8% of primary consumption[2]:
  - **The building sector must be the primary focus when implementing energy efficiency measures.** Accounting for over a third of EU emissions, building efficiency is a key NECP priority that needs to be thoroughly monitored.
  - **Deep renovation is key, but action is only taken in 1% of EU buildings per year.** About 75% buildings are not energy efficient though 85-95% are expected to be in use until 2050[3].

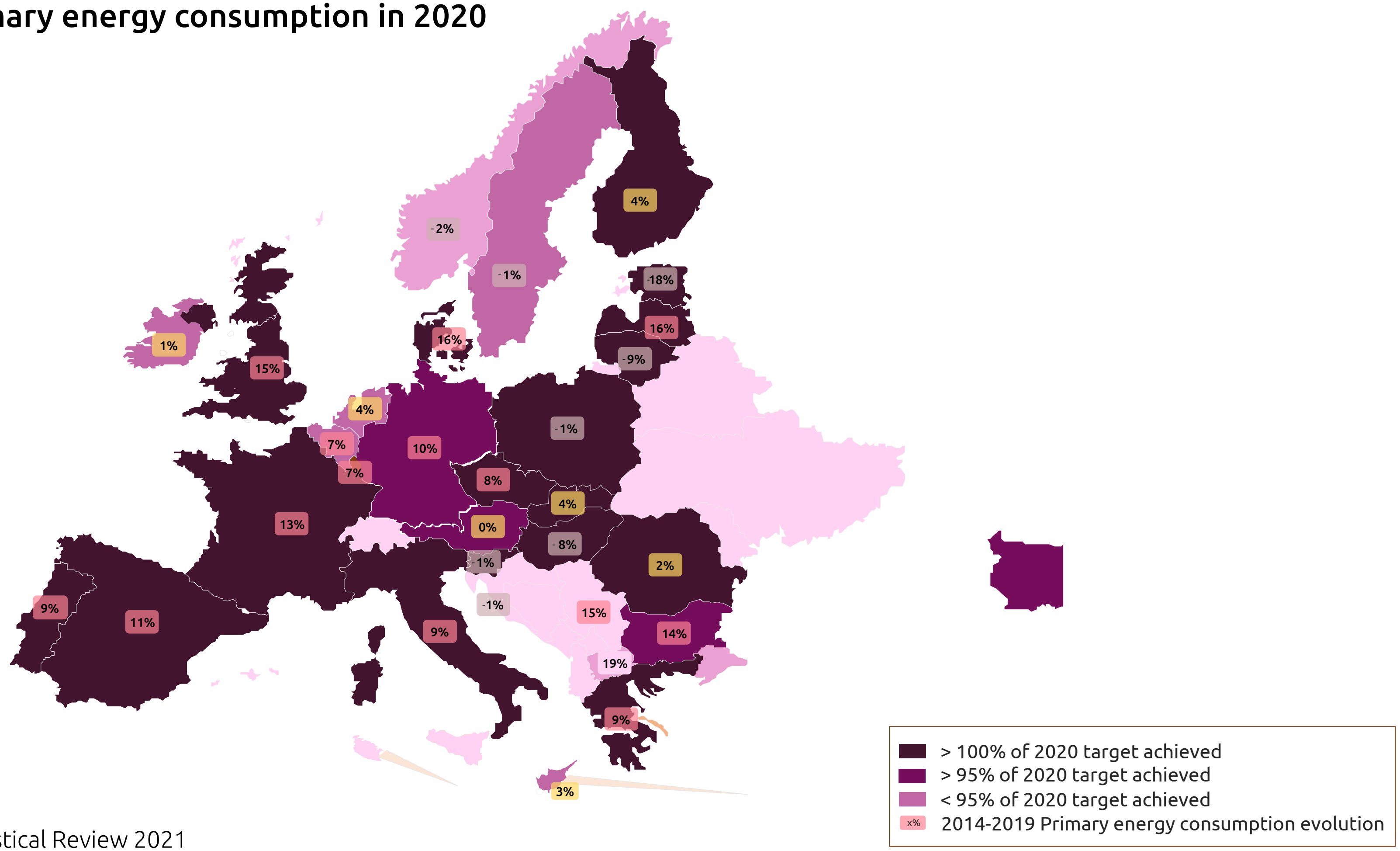
- **Member States' NECPs have set ambitious targets on mobility.** But the path to reaching them is still long and uncertain:
  - **There must be further investments to achieve sustainable mobility.** In order to meet the current EU 2030 GHG targets under existing policies, transport requires the most additional investments (amongst all sectors) between 2021-2030. This is based on commissions calculations[2].
  - **However, many countries have set independent and ambitious strategies to transform the transport industry.** Member States are focusing on promoting the electrification of road mobility, while heavily investing in hydrogen - especially for marine, rail, and airline transports.

National Energy and Climate Plans from European countries can play a major role on powering EU's climate ambition. Monitoring and comparing Member States' NECP performance is key in holding them accountable and fostering long term results

1 https://unify.caneurope.org/policy-areas/necp/
2 https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1600339518571&uri=COM%3A2020%3A564%3AFIN
3 https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en

FIGURE 2

Map of primary energy consumption in 2020



Source: BP Statistical Review 2021

Renewable power generation continues to be a key decarbonisation factor for Europe's energy consumption, steadily increasing its available capacity in 2020

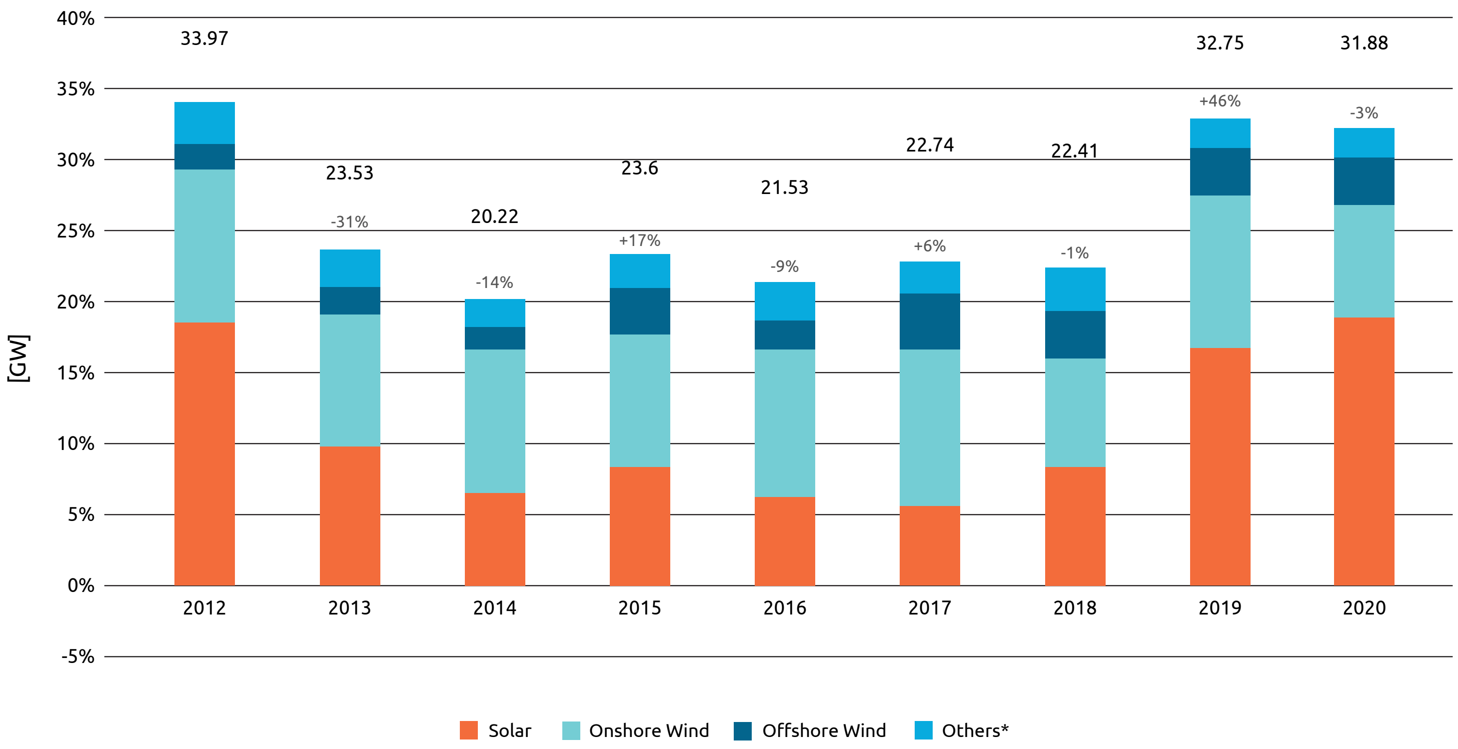
- **Adding new RES power capacity is paramount to achieving Europe's ambitions on reducing GHG emissions.** Data from a 2021 IRENA report[1] shows that, during the last five years, RES power has become increasingly relevant in Europe, playing a major role in decarbonizing the power industry:
  - **COVID undoubtedly had an impact on the installation of new renewable generation capacity. However, optimism persists.** In 2019, newly installed capacity grew by almost 50% and, despite COVID's impact on the construction sector, almost the same amount of new renewable GW were installed in 2020.
  - **The trend of solar power generation growth continues in Europe.** Solar power remains the most installed RES per GW, as driven by the continued drop of both PV panel costs and LCOE. Meanwhile, onshore wind exhibited a substantial decrease of new power capacity in 2020.
- **As a result, the EU is mostly on track to meet 2020 and 2030 NECP commitments to RES shares of final energy consumption.** Existing measures might be enough to surpass 2030's targets of 32% of shares of renewable energy[2]. However, according to Eurostat data (Figure 6) the progress towards 2020's goals remains inconsistent between countries:
  - **As many as 14 member states have surpassed these goals,** while the same number (including the U.K.) have yet to overcome the substantial gap.
  - Countries such as **Croatia, Sweden, Denmark, Estonia, and Bulgaria are leading the way in Europe,** exceeding short term goals by 5% up to 8%.
  - Some major regional economies, including **France, UK, Netherlands, and Spain,** have the worst deficits relative to reaching their targets.
  - **Consequently, EU-28's overall efforts from 2019 were insufficient** in meeting 2020 objectives to increase renewables shares in final energy consumption.

After 2019's historical surge in renewable power capacity, RES growth is still relevant in power generation, although COVID is holding it back from further increasing its YoY growth in 2020.

1 https://www.irena.org/publications/2021/March/Renewable-Capacity-Statistics-2021
2 https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1600339518571&uri=COM%3A2020%3A564%3AFIN

FIGURE 3

Net renewable power capacity added in Europe in 2020 (GW)

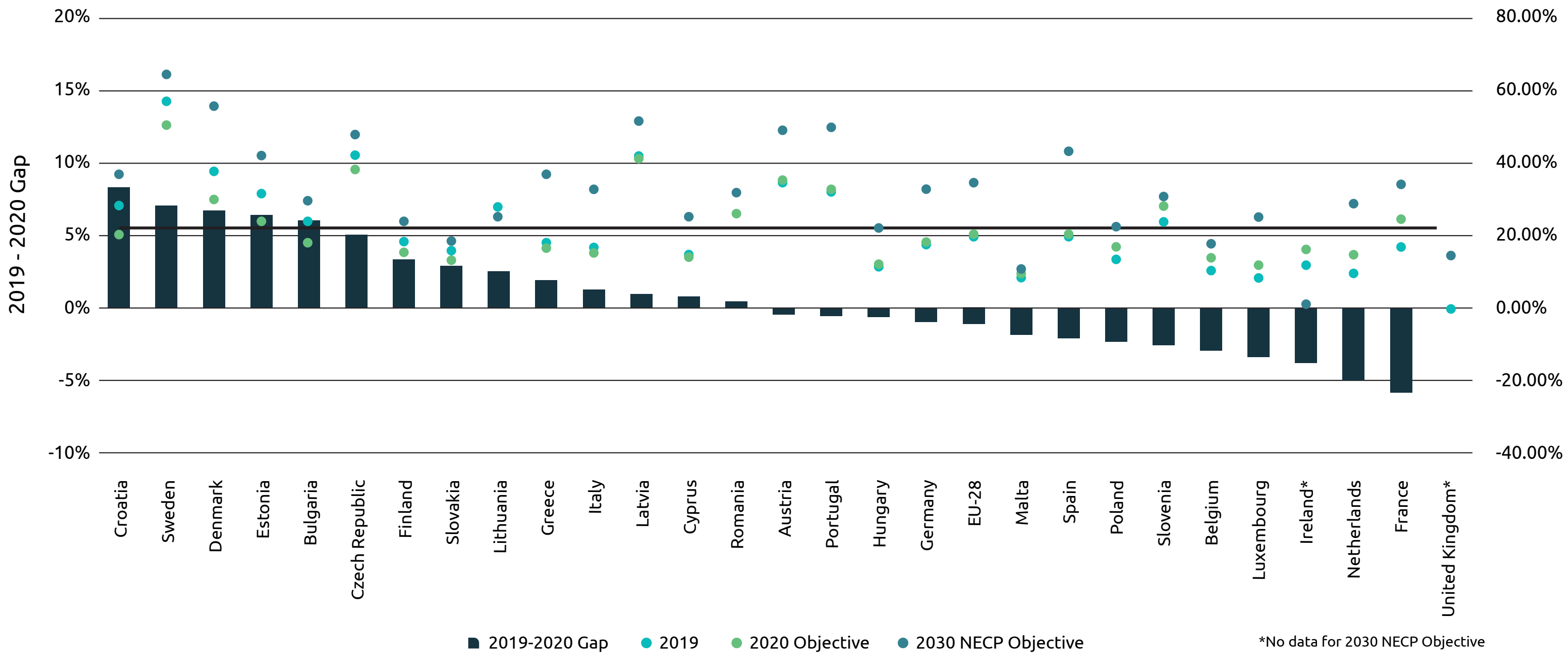


Sources: IRENA 2021

EU Member States show uneven progression in their efforts to meet NECP targets on the share of renewables in final energy consumption

FIGURE 4

Share of Renewables in the Member States' gross final energy consumption in 2019



Sources: Eurostat 2021, European Commission

Compared to last year's progress, current data shows that more countries are reaching their 2020 objectives ahead of schedule. However, the largest economies in Europe (with the exception of Italy) are still lagging behind on their RES commitments.

Despite reaching their target of reducing 20% of CO2 emissions in 2020 (compared to 1990), the EU-27 needs to strengthen their measures in order to reach the goal of net-zero by 2050.

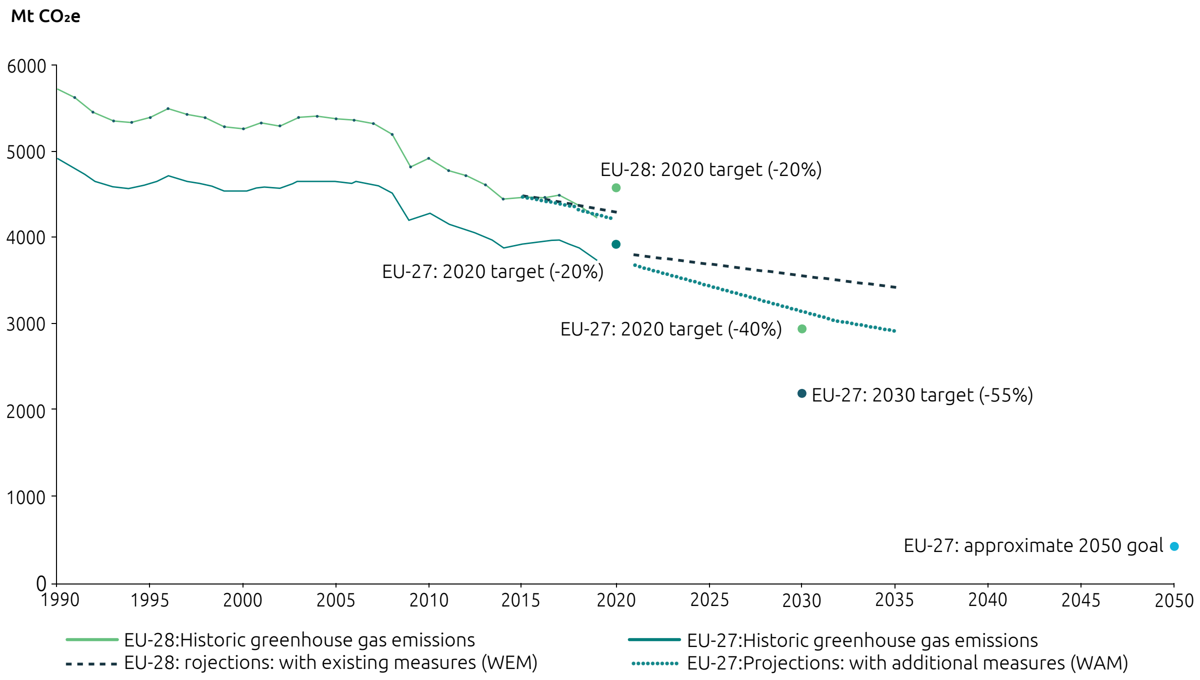
- The EU-28 (including UK) have reached their goal of reducing 20% of CO2 **emissions since 1990. This places Europe as one of the world's leaders in climate action.**

- However, some European countries are **far from achieving the Paris Agreement pathway of a 1.5°C** global temperature rise. Here are the current measures:
  - The Commission has recommended **strengthening the 2030 target of emissions reduction by 55%,** instead of the current (and insufficient) 40%.
  - The current and planned policy projections are estimated to reduce emissions by 35% (compared to 1990 levels).
  - In October 2020, the EP endorsed a new target of reducing emissions by 70% by 2030 (compared to 1990 levels).

- If the goal of reducing **60% of emissions by 2030** is achieved, **Europe will be positioned as the first region** compatible with the Paris Agreement.

FIGURE 5

Greenhouse gas emission targets, trends, and Member States MMR projections in the EU, 1990-2050



Source: European Environment Agency (2021)

The current trends prove to be insufficient in achieving the 2050 net-zero goal. The new goals and measures bring along the necessity to radically change the way we operate, both in our businesses and in our everyday lives. Europe is in a unique position to lead this transformation.

EU institutions are determined to meet climate ambitions by 2030, setting the scene for an unprecedented transformation in EU's economy and society.

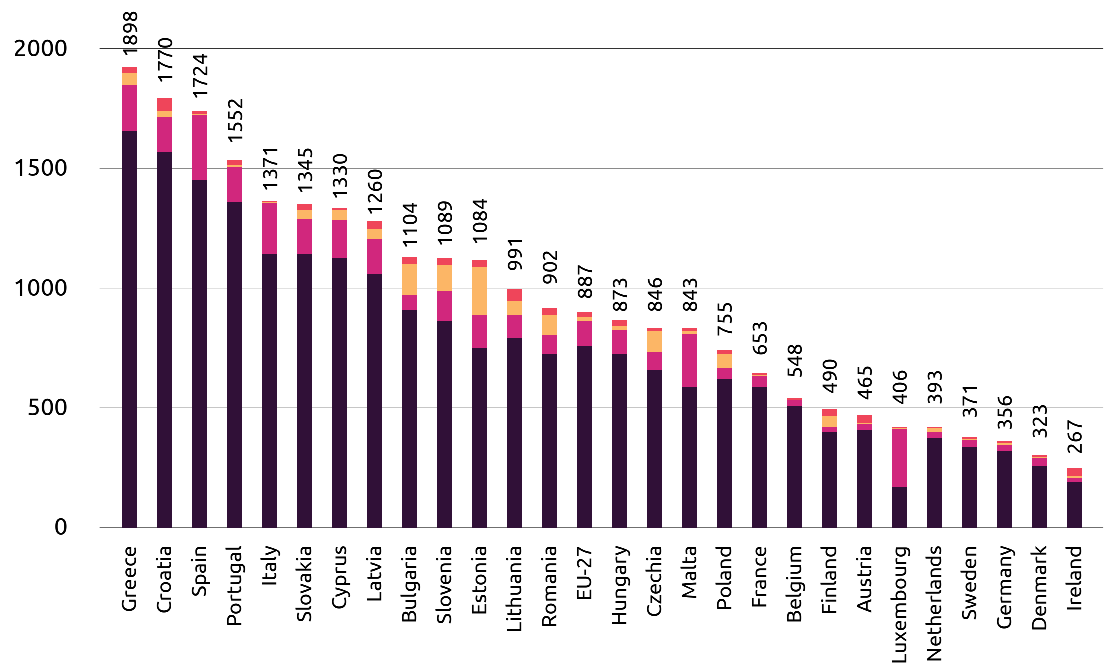
- According to the European Commission, an additional investment of €260 billion per year will be required to achieve the 2030 climate and energy targets.

- The **Fit for 55 package** offers a set of policies and rules for creating a future that is green, sustainable, and inclusive. It is intended to deliver the targets agreed upon in the European Climate Law and to put a **greater price on carbon** via the Emissions Trading System (ETS), as well as a **greater premium on decarbonisation.**
  - The **package builds on policies and legislation** that the EU already has in place. **The European Green Deal** is a growth model powered by **innovation, clean energy,** and the **circular economy.** The **NextGenerationEU's (NGEU) recovery** plan is to make Europe greener, more digital, and more resilient.
  - Environmental considerations set the blueprint for these **transformational changes** and are at the heart of global recovery and resilience programs. As part of the NGEU recovery plan, the EU will safeguard up to **€250 billion** of its €806.9 billion budget for **green investments over the next 5 years.**
  - The long-term focus is to continue to **mobilize all EU policies to support the shift in climate neutrality,** including research, skills, industrial, competition, and trade policies.

- The **package strengthens 8 existing pieces of legislation and presents 5 new initiatives** across a wide range of policy areas and economic sectors: climate, energy and fuels, transport, buildings, land use, and forestry. It strikes a careful balance between pricing, targets, standards, and support measures.
- **Emission-intensive sectors** (e.g., manufacturing, transportation, building operations, etc.) will **require bold environmental commitments and increased financing** in order to meet the EU targets. These targets comprise reducing net GHG emissions by at least 55% in 2030 (compared to 1990) and becoming the world's first climate neutral continent by 2050.
- Reducing carbon emissions across all sectors of the economy will require **accelerating the transition to 100% clean energy,** contemplated within the revisions of the renewable energy rules (RED III) in the Fit for 55 package.
- **New and advanced infrastructure** is a prerequisite for a carbon free energy system. This requires broad investment, advanced research, and the development and deployment of the necessary digital tools and infrastructure. This supports greater precision and efficiency in tracking carbon removal outcomes.
- The l**egislative revisions and new proposals,** including the **expansion of the EU emissions market** or the **introduction of a new mechanism to tax polluting imports,** are just the first steps in maintaining Europe's leadership in green transformation.

FIGURE 6

NGEU resources pre-allocated to Member States (RRF, REACT-EU, JTF and rural development) by Member State and per capita (€, current prices)



Source: European Parliament 2021, EPRS based European Commission and Eurostat 2020 data

1 https://ec.europa.eu/commission/presscorner/detail/en/fs_20_48
2 https://ec.europa.eu/info/strategy/recovery-plan-europe_en
3 Figure. NGEU resources pre-allocated to Member States (RRF, REACT-EU, JTF and rural development) by Member State and per capita (€, current prices) https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690656/EPRS_BRI(2021)690656_EN.pdf

Maintaining Europe's leadership in green transformation

- Climate change has a disproportionately greater impact on some communities than others. Therefore, the climate transition will be accompanied by a **Social Climate Fund**, supporting income and investments to address economic disparity and cut bills in the short-term for vulnerable households, micro-enterprises, and transport users.

- The Social Climate Fund includes investments to support the increase of energy efficiency and renovation of buildings, sustainably reducing both CO2 emissions and energy bills in low, and low-middle-income vulnerable households.

- The fund also finances access to zero- and low-emission mobility, equivalent to 25% of the expected revenues of emissions trading for building and road transport fuels. With a proposal to draw on matching Member States funding, the Social Climate Fund could also mobilize €144.4 billion for a socially fair transition.

- There is, however, a challenge at the heart of Europe's green transition. That is to **make sure the benefits and opportunities that come with the mobilization of €350 billion per year in sustainable investments are available to all as quickly, and as fairly, as possible.**

- However, given that Europe only accounts for 8% of global CO2 emissions, the EU action alone cannot deliver the global emission reduction the world needs.

- Consequently, **the EU is working with the G7, G20 and other international forums** to show that it is possible for increased climate ambition, economic prosperity, and sustainable growth to go hand in hand.

- In that regard, **sustainable finance** is globally on the rise. **The European Commission's package offers investors and companies an opportunity to transform ambitions and commitments into clear, measurable actions across all sectors of the economy.**

- **Reorienting investments towards more sustainable technologies and businesses** will be instrumental in making the world climate neutral.

- Actions concerning progress and policymaking **need to be measured in the same way, to create transparency and accountability.** Data science, AI, and digital technologies will play a vital role in supporting and enabling this progress.

- The EC's recently adopted proposal for a **Corporate Sustainability Reporting Directive** (CSRD) could be a game changer for companies when reporting annually on their social and environmental impacts.

- All large and most listed companies (representing 75% of the turnover of limited liability companies) would be **required to do non-financial reporting and seek assurance for reported information.**

- Given the importance of the European market, other regions would follow the same standards, paving the way for an exponential growth in sustainable investments worldwide.

"For the transformation to be successful, it has to be fair.

- Ursula von der Leyen

The new Corporate Sustainability Reporting Directive that the European Commission is drafting could play a major role in setting high standards for companies to report annually on their social and environmental impacts, making it easier to align private and public efforts to tackle the climate crisis.

1 https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541
2 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0550&from=EN

04

04 Climate Change & Energy Transition

04 Climate Change & Energy Transition

North America (USA, Canada)
Emissions, Carbon Taxes, Renewables and Energy Efficiency Measures

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North America (USA, Canada) Emissions, Carbon Taxes, Renewables and Energy Efficiency Measures

U.S. energy consumption: Petroleum will remain the most-consumed fuel in the U.S. due to its widespread use in vehicles and industrial processes.

According to a projection by the U.S. Energy Information Administration (US EIA), Petroleum and other liquids will remain the most-consumed fuel in the U.S. from 2020-2050.

- For industrial uses, petroleum remains the primary fuel for refining processes.
- The transportation sector is also one of the largest consumers of petroleum and other liquids, particularly motor gasoline and distillate fuel oil.
- Petroleum demand has returned in the U.S. to pre-COVID level as Covid-19 vaccines roll out, governments ease lockdowns, and freight shipments surge. In August 2021, the White House called on OPEC (Organization of the Petroleum Exporting Countries) to boost oil productions so that U.S. gasoline prices do not rise more. The increase in oil production will offset previous production cuts that OPEC imposed during the pandemic.

Coal use will continue to drop from 2020–2050, as solar, wind, and natural gas use increases.

- Policies at the state and federal level have stimulated significant investment in renewable resources for electricity generation and transportation fuels.
- New technologies have driven down the cost to install wind and solar generation, further increasing their competitiveness in the electricity market.

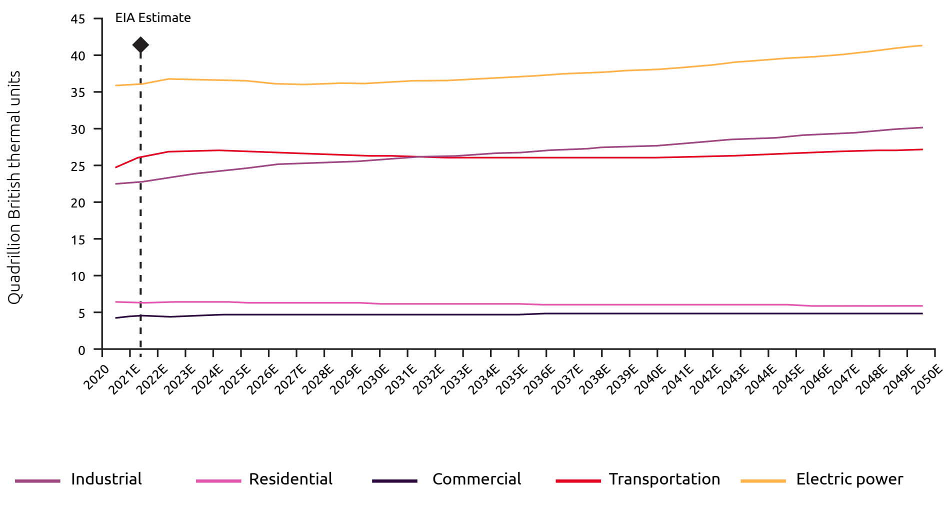
Responses to the COVID-19 pandemic decreased energy consumption in the transportation sector more than in the other sectors.

- Travel greatly declined in 2020 as a result of lockdowns.
- Even after travel resumes, improvements in fuel economy will counterbalance projected energy consumption in the transportation sector.
- Energy consumption within the transportation sector will be further reduced due to energy efficiency technologies in new vehicles, as well as stringent federal fuel economy standards for new light-duty vehicles (through 2026) and heavy-duty vehicles (through 2027).

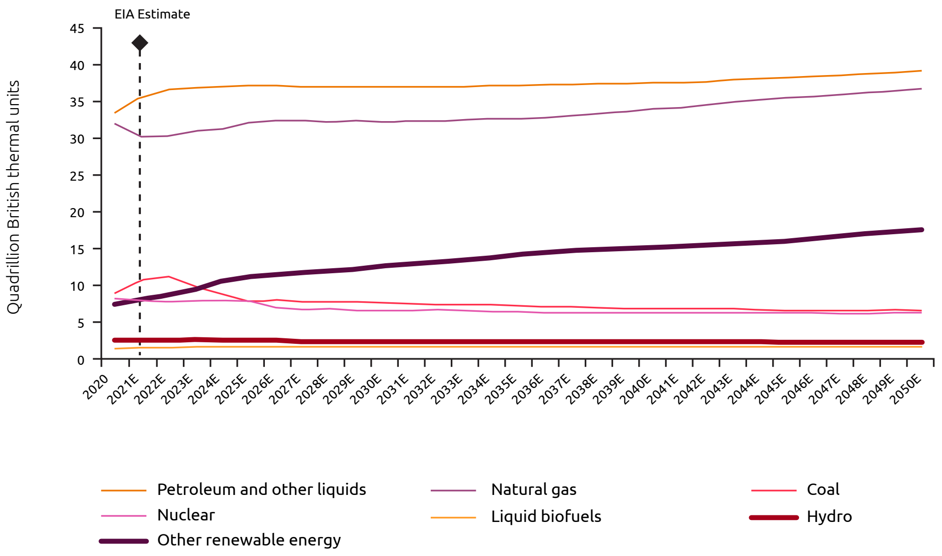
FIGURE 1

US ~ Energy Consumption by Sector, 2020-2050E (quadrillion British thermal units); Energy Consumption by Fuel, 2020-2050E (quadrillion British thermal units)

Energy Consumption By Sector (2020-2050E)



Energy Consumption By Fuel (2020-2050E)



Source: US EIA Annual Energy Outlook, 2021
Link: https://www.eia.gov/outlooks/aeo/

U.S. energy-related emissions: CO2 emissions will begin rising after 2030 due to increasing energy requirements stemming from economic growth.

EIA projects that U.S. energy-related carbon dioxide (CO2) emissions will decrease for most years through the mid-2030s. However, they will begin to rise marginally from the mid-2030s through 2050.

- The decreases in CO2 emissions through the mid-2030s will mostly be a result of changes in the carbon intensity of the fuel mix, especially in the electric power sector.
- The mix of fuels used to generate electricity will continue to transition from relatively carbon-intensive coal to less carbon-intensive sources, such as natural gas and carbon-free renewable energy.
- However, U.S. energy-related CO2 emissions will increase after 2030 due to increasing economic growth, leading to growing industrial energy requirements.
- The energy use in transportation will surge as vehicle fuel efficiency plateaus in the mid-2020s and vehicle travel demand increases.

U.S. energy-related emissions: Texas is the highest emitter of CO2 amongst all the states due to its high industrial share

Texas emits the most CO2 of all the states. It is the leading energy-producing and energy-consuming state in the nation.

- The industrial sector, including its refineries and petrochemical plants, accounts for most of the energy consumed in Texas.
- The 31 petroleum refineries in Texas can process almost 5.9 million barrels of crude oil per calendar day, which was 31% of the nation's refining capacity as of January 2020.
- Texas is also the leading crude oil and natural gas-producing state.
- In 2020, Texas accounted for 43% of the nation's crude oil production and 26% of its marketed natural gas production.

Texas and California are the biggest U.S. State emitters of the past ten years.

- They have been more than 50% higher than the third-largest emitter for more than a decade.
- Both rank in the top two for population and economic size— two important driving forces of emissions.
- Texas has always been the highest emitter in U.S. The state's emission has increased around 1% over the past 20 years.

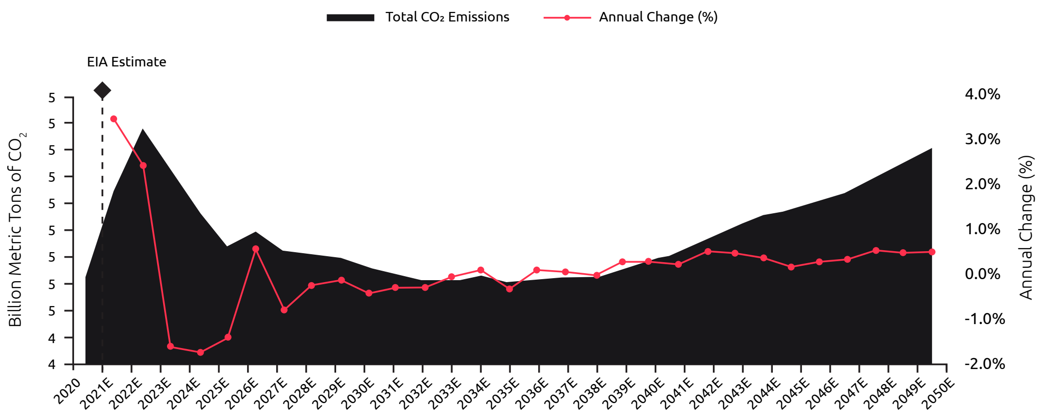
Washington D.C. is the lowest CO2 emitter and has no CO2 emission from coal.

- In 2019, D.C. increased its Renewable Portfolio Standard requiring 100% of the city's electricity come from renewable sources by 2032, including at least 5.5% from solar energy.
- Most of the electricity generated in the District of Columbia comes from small-scale solar photovoltaic panels located on homes and commercial buildings.
- D.C. has more electric vehicle charging stations than motor gasoline stations, and the city's per capita gasoline expenditures are lower than those of any state.

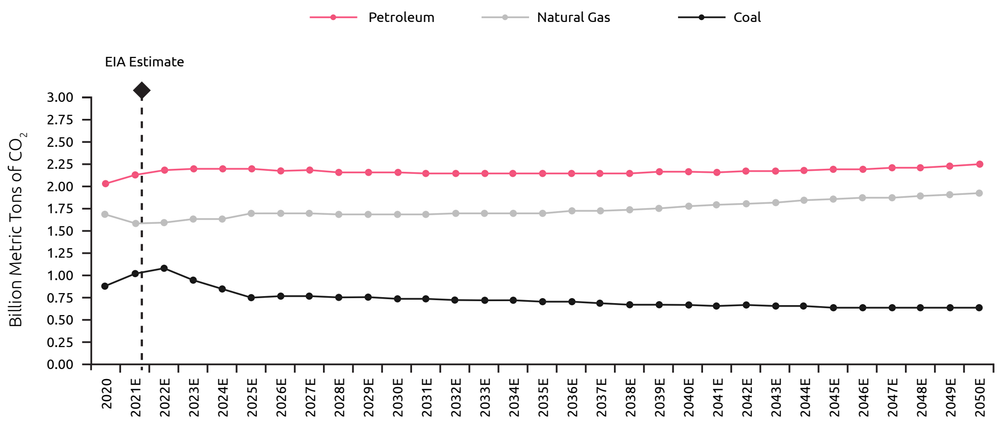
FIGURE 2

US ~ Energy-related CO2 Emissions: Outlook till 2050E, 2020-2050E (Billion metric tons CO2); Energy-related CO2 Emissions by Fuel, 2020-2050E (billion metric tons CO2)

Energy-related CO_2 Emissions (2020-2050E)



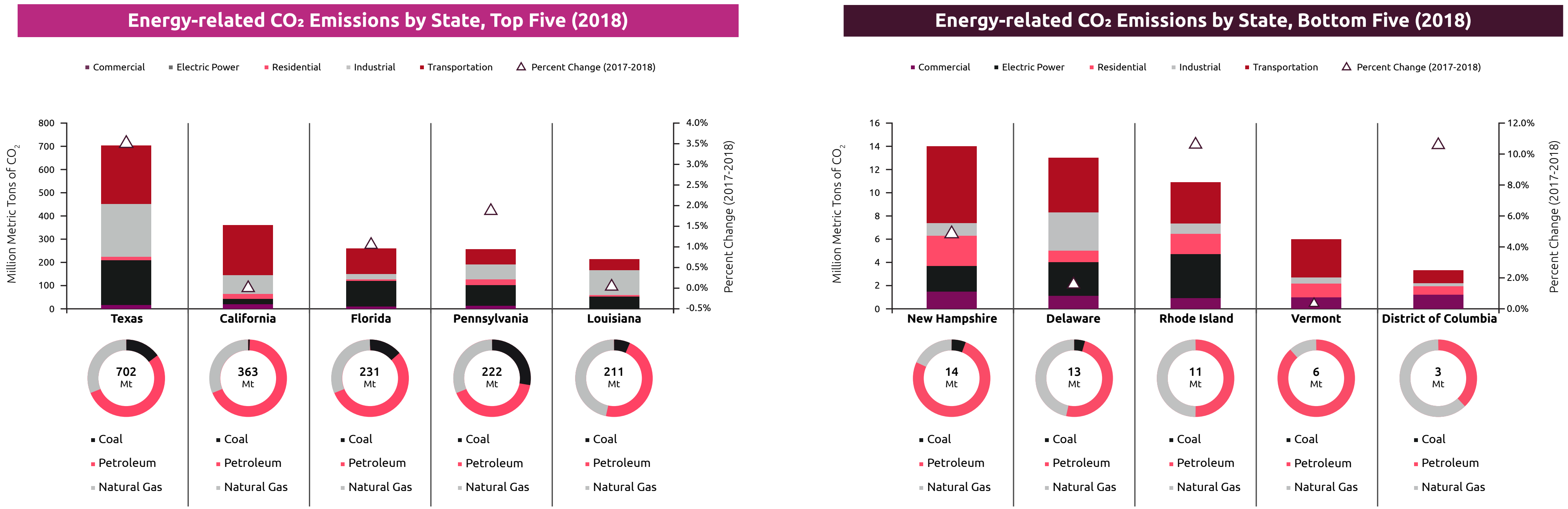
Energy-related CO_2 Emissions by Fuel (2020-2050E)



Source: US EIA Annual Energy Outlook, 2021
Link: https://www.eia.gov/outlooks/aeo/

FIGURE 3

US ~ State Profiles: Energy-related CO2 Emissions: Top Five and Bottom Five States by Sector, 2018 (million metric tons CO2) and Percent Change, 2017-2018 (percent); Share by Fuel Source, 2018 (percent)



Source: EIA Review, March 2021
Link: https://www.eia.gov/environment/emissions/state/

U.S. energy-related emissions: The transition of U.S. states from hydrofluorocarbon (HFC) to safer, climate-friendlier alternatives is on track.

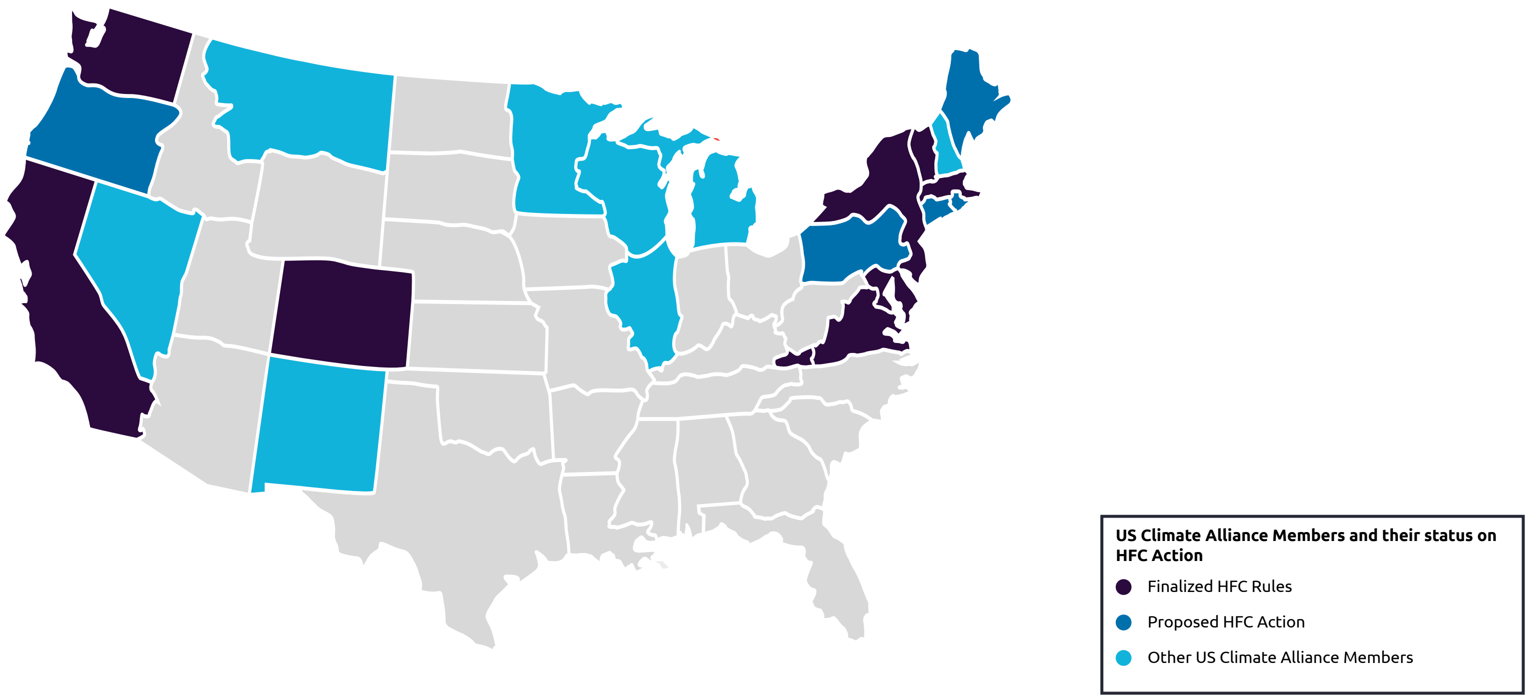
There is an increased Government focus on phasedown of the production and use of HFCs, highly potent greenhouse gases.

- Hydrofluorocarbons are primarily used as replacements for ozone depleting substances but also emitted as a byproduct of the HCFC-22 (chlorodifluoromethane) manufacturing process.
- Currently, they have a small aggregate radiative forcing impact, but it is anticipated that without further controls their contribution to overall radiative forcing will increase (IPCC 2013).
- Despite being emitted in smaller quantities relative to the other principal greenhouse gases, emissions of HFCs are significant because many of them have extremely high global warming potentials (GWPs).
  - 1 kg of a type of HFC gas, Sulfur Hexafluoride, can trap the same amount of heat as 23,500 kg of carbon dioxide (CO2). In other words, 1 kg of Sulfur Hexafluoride has a global warming potential (GWP) of 23,500.

- In 2020, the U.S. Congress passed legislation designed to phase down the production and consumption of HFCs in the U.S., which would lead to lower emissions over time.
- As of April 2021, out of the 16 states taking coordinated action to mitigate HFC emissions, 7 have finalized their prohibitions. On April 26, 2021, Virginia, Massachusetts, and Delaware finalized their HFC rules.
- The regulations prohibit the use of HFCs in several applications, including aerosols, insulation foams, building chillers, and stationary refrigeration (such as supermarkets and home appliances, not refrigerated trucks).
- The prohibitions do not take effect instantly, but rather come into effect gradually over the next four years.
- These rules advance states toward their climate targets by mitigating HFC emissions and reducing reliance on HFCs in regulated applications.

FIGURE 4

US ~ Climate Alliance States and their status on HFC action



Source: NRDC, US Climate Alliance
Link: https://www.nrdc.org/experts/christina-theodoridi/states-keep-steady-course-hfc-regulations

Canada energy-related emissions: In 2020, Canada implemented its strengthened climate plan to ensure that it not only meets, but also exceeds its 2030 emissions reduction goal

In December 2020, Canada released its strengthened federal climate plan—A Healthy Environment and a Healthy Economy. The plan is comprised of 64 new or enhanced federal policies, programs, and investments, to cut pollution and build a stronger, cleaner, more resilient, and inclusive economy.

- In 2030, greenhouse gas (GHG) emissions are projected to be 588 megatons of carbon dioxide equivalent (Mt CO2 eq) under Canada's climate plan (2016) or 227 Mt CO2 eq lower than the 815 Mt CO2 eq projected before the adoption of the Pan-Canadian Framework.
- In 2030, GHG emissions are projected to be 503 Mt CO2 eq under Canada's strengthened climate plan (2020) or about 8 Mt CO2 eq below the 2030 target of 511 Mt CO2 eq.

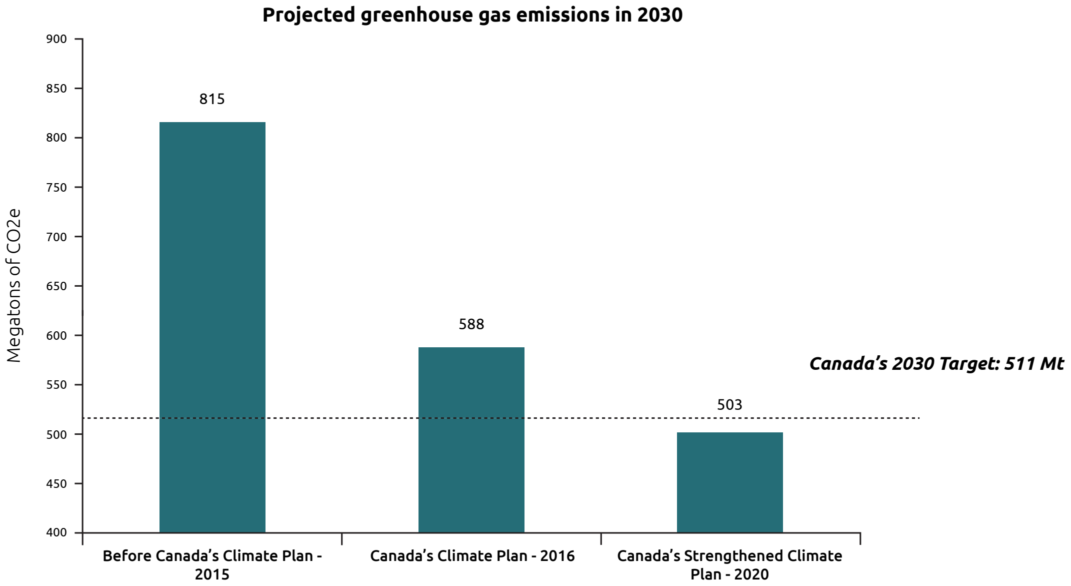
To set Canada on a path to achieve a prosperous net-zero emissions future by 2050, the government introduced the proposed Canadian Net-Zero Emissions Accountability Act in Parliament on November 19, 2020. The Act will formalize Canada's target to achieve net-zero emissions by 2050 and establish a series of interim emissions reduction targets at 5-year milestones towards that goal.

Oil and Gas Emissions are projected to be the largest sources of emissions reduction to reach the 2030 emissions reduction goal.

- Emissions in the oil and gas sector are primarily from the extraction of heavy crudes and bitumen in Western Canada.
- Looking ahead to 2030, there are commitments to reduce the emissions of heavy oil and bitumen extraction, new methane-capture regulations and increasingly stringent output-based pricing systems.
- It also reflects the anticipated leveling off of global demand for crude oil over the next decade and into the 2030s and the difficulty Canadian producers are having in increasing their access to U.S. and overseas markets.

FIGURE 5

Canada ~ Projected greenhouse gas emissions in 2030



Note:: These projections do not include further commitments from provinces and territories.

Sources of Emissions Reductions contributing to reaching the 2030 Target

Sector	Projected emissions reductions in 2030 (megatonnes of carbon dioxide equivalent)
Buildings	44
Oil & Gas	104
Electricity	47
Heavy Industry	46
Transportation	12
Waste & Others	28
Agriculture	2
Nature Based Solutions and Agriculture Measures	10
Land Use, Land Use Change and Forestry	17

Source: Environment and Climate Change Canada (2020) A Healthy Environment and a Healthy Economy. Environment and Climate Change Canada (2021) Canada's Greenhouse Gas and Air Pollutant Emissions Projections 2020
Link: https://www.canada.ca/content/dam/eccc/documents/pdf/cesindicators/progress-towards-canada-greenhouse-gas-reduction-target/2021/progress-ghg-emissions-reduction-target.pdf

FIGURE 6

Canada ~ Historical GHG Emissions and Projections, 2005-2030 (megatons of CO2e)

LULUCF*: Land Use, Land Use Change and Forestry | Note: The Reference Case scenario of 2020 is the "with measures" scenario as defined by the United Nations Framework Convention on Climate Change.

Source: Environment and Climate Change Canada (2020) A Healthy Environment and a Healthy Economy. Environment and Climate Change Canada (2021) Canada's Greenhouse Gas and Air Pollutant Emissions Projections 2020
Link: https://www.canada.ca/content/dam/eccc/documents/pdf/cesindicators/progress-towards-canada-greenhouse-gas-reduction-target/2021/progress-ghg-emissions-reduction-target.pdf

U.S. carbon pricing: Most carbon pricing developments in the U.S. are taking place on the subnational level

Carbon pricing developments are happening in California, Hawaii, Massachusetts, Oregon, Pennsylvania, and Washington through the Regional Greenhouse Gas Initiative (RGGI) and the Transportation and Climate Initiative Program.

Summary of recent developments in key carbon pricing initiatives in various U.S. states

Jurisdiction	Key Developments
California	• Changes to California's Cap-and-Trade Program required by Assembly Bill 398 (Chapter 135, Statutes of 2017) took effect on January 1, 2021. The major changes to the program are: establishment of a price ceiling; changing from a three-tier allowance price containment reserve to a two-tier reserve below the price ceiling; and reductions in the use of offset credits, especially for those generated from projects that do not provide direct environmental benefits in the state. • Under the upcoming 2022 Scoping Plan update, the California Air Resources Board (CARB) will be assessing a suite of climate policies to chart the course to achieving carbon neutrality by 2045. As part of this update, CARB may identify additional opportunities to further strengthen the Cap-and-Trade Program to ensure it continues to help the state meet its GHG reduction targets.
Hawaii	• Hawaii's climate change policies are being coordinated under the state's Climate Change Mitigation and Adaptation Commission as mandated by Act 32, Session Laws of Hawaii 2017. One option being considered is carbon pricing. • Carbon tax bills were introduced in the 2020 and 2021 sessions though they have not passed. • The State Energy Office, a member of the Commission, released a carbon tax study in February 2021. The report modeled different policy packages to assess the impact on emissions; it considered revenue recycling options to address the distributional impacts of carbon price.
Massachusetts	• In 2020, the Massachusetts Limits on Emissions from Electricity Generators system reduced the share of allowances distributed through a free allocation from 75% to 50%. The remainder, after an adjustment to account for banked allowances, were distributed via auctions. The system will assume full auctioning by 2021. • In 2021, Massachusetts finalized a new climate program establishing climate targets for 2030. The Massachusetts Emissions Trading Schemes (ETS) may be revised to align with these targets.
Oregon	• In line with the Executive Order on Climate Action (Executive Order 20-04), the Department of Environmental Quality of Oregon submitted a report in June 2020, which focused on program options to cap and reduce emissions. • However, the details of the program have not yet been determined; it is not clear whether it will be a baseline-and-credit or a cap-and-trade system.

Pennsylvania	• In April 2020, Pennsylvania's Department of Environmental Protection released an update of its earlier proposal for a power sector ETS covering CO2 emissions. The proposed regulation is largely consistent with the system design features of the RGGI Model Rule. A final proposal is expected in 2021, with 2022 being the earliest start date for Pennsylvania's ETS to join RGGI. • It is estimated that Pennsylvania's power sector will emit approximately 40% of emissions covered under RGGI when the state becomes a part of the program. Therefore, Pennsylvania's inclusion would significantly increase the size of RGGI's carbon market.
Washington	• The implementation of Washington's baseline-and-credit system (the Clean Air Rule) was suspended a year after it began due to legal challenges. In January 2020, the Washington Supreme Court ruled that the Department of Ecology could regulate direct sources of emissions (in this case, stationary sources of emissions) but not indirect sources (such as petroleum producers, exporters, and natural gas distributors). • In December 2020, Governor Inslee introduced the Climate Commitment Act for the 2021 legislative session. This proposes an economy-wide ETS for the state's largest emitters based on the Western Climate Initiative's design.

Jurisdiction	Key Developments
Regional Greenhouse Gas Initiative (First multi-state cap-and-trade program for carbon emissions in the U.S.)	• Virginia began participating in RGGI as of January 1, 2021, after the final legislation for establishing an ETS and participating in RGGI was adopted in February 2020. • On February 2, 2021, RGGI states also announced a plan for a third program review.
The Transportation and Climate Initiative Program (a regional collaboration of 13 Northeast and Mid-Atlantic States and the District of Columbia)	• On March 1, 2021, the Transportation Climate Initiative Program (TCI-P) released the Draft Model Rule, which outlines a common framework for participating jurisdictions to use in developing their TCI-P regulations. The program puts a cap on CO2 emissions from gasoline and on-road diesel fuel. It gradually decreases over time to achieve a projected 26% reduction in TCI-P's 2022 CO2 emissions by 2032. • Connecticut, Massachusetts, Rhode Island, and Washington D.C. have announced their participation in the program. It is scheduled to start in 2023 and cover suppliers and distributers of transport fuels.

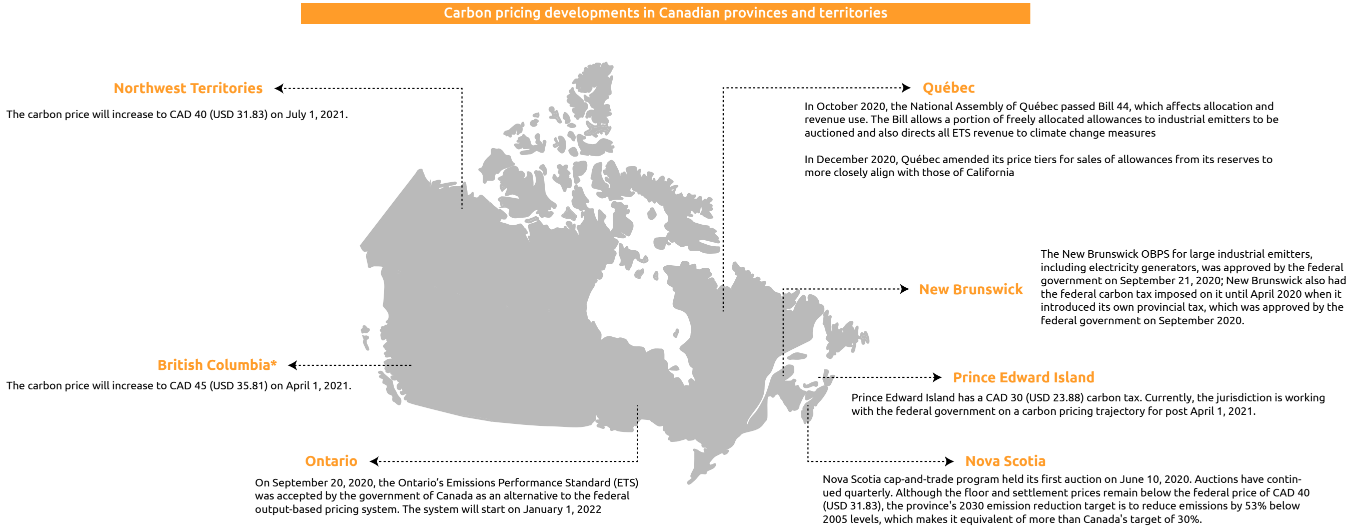
Canada carbon pricing: Canada increased its carbon taxes by 467% through itsEnvironment and Healthy Economy Plan

In December 2020, the Canadian government proposed a CAD $15 billion (USD $11.94 billion) climate action investment plan as part of its economic recovery package. It outlines several programs that include affordable, energy-efficient housing, clean public transport, and zero-emission vehicle programs.

- The plan also recommends increasing the federal carbon price from CAD $30/tCO2e to CAD $170/tCO2e by 2030, with proceeds going back to provinces and territories. That is a 467% increase over 10 years.
- In addition, the revenue raised from the federal ETS (the backstop Output-Based Pricing System) will back projects in the industrial sector that decrease emissions and use cleaner technologies or processes.
- In March 2021, the Supreme Court of Canada gave the federal government constitutional permission to impose a carbon price on the provinces.
- The decision came after years of negotiations between some provinces and the federal government over the Greenhouse Gas Pollution Pricing Act (GGPPA).

FIGURE 7

Canada ~ Carbon pricing developments



Source: State and Trends of Carbon Pricing, 2020, World Bank (May 2020)
Link: https://openknowledge.worldbank.org/bitstream/handle/10986/33809/9781464815867.pdf?sequence=2&isAllowed=y

North America climate performance: In 2021, U.S. and Canada ranked at the very bottom of the Climate Change Performance Index (CCPI)

In the 2021 Climate Change Performance Index (CCPI), the U.S. was ranked 61st among 61 countries.

- The U.S. maintains its spot at the bottom of 2021's CCPI.
- In categories of GHG emissions, energy use, and climate policy, the U.S. ends up at the bottom of the rankings ("very low").
- The U.S. is the only country besides Australia and Algeria to receive the worst rating of "very low" in national and international climate policies.
- The final year under President Trump is the second time in a row the U.S. is ranked last in the CCPI. This is primarily driven by its withdrawal from the Paris Agreement and lack of targets at the national level to either decrease GHG emissions or increase renewable energy deployment.

i. President Trump had relaxed more than 150 climate-friendly regulations over the past four years, including those related to tailpipe emissions, endangered wildlife, and rainforest protection.

ii. On Day One, President Biden fulfilled his promise to rejoin the Paris Agreement and set a course for the United States to tackle the climate crisis, reaching net zero emissions economy-wide by no later than 2050. As part of re-entering the Paris Agreement, he also launched a whole-of-government process, organized through his National Climate Task Force, to establish new 2030 emissions target – known as the "nationally determined contribution" or "NDC," a formal submission to the United Nations Framework Convention on Climate Change (UNFCCC). In April 2021, the U.S., in its updated NDC, pledged to reduce GHG emissions 50-52% below 2005 levels by 2030. This is accompanied by the goal of reaching net zero emissions no later than 2050.

In the 2021 CCPI, Canada was placed near the bottom at 58th place among 61 countries.

- Ranked among the worst-performing countries in the 2021 CCPI, Canada fell three places since last year.
- Canada ranked below par in nearly all categories, placing 56th among greenhouse gas emitters, 54th in renewable energy and 61st in overall energy use.
- The prominent disparity between Canada's high ranking on climate policy and low ranking on the other three categories used by the CCPI methodology indicates a disconnect between action and policy.

U.S. utility net-zero commitments: Pressure is rapidly building for utilities and merchant power plant owners to address climate change concerns

U.S. electric power companies express increasing confidence they can eliminate 70% to 80% of their carbon emissions by 2030. However, they say a technology gap will have to be bridged to reach full carbon neutrality by 2050. The earliest pledges made by the companies date back to 2015-2016. The most recent commitments and updates were made in April and May 2021, during first-quarter corporate earnings calls.

Major U.S. utilities net-zero and interim targets

	Share of U.S. Capacity	Net-Zero Year	CO_2 or GHG	Interim Year	Interim Targets from 2005 baseline, unless noted
Vista Energy Corp.	6%	2050	CO_2	2030	60% from 2010
Duke Energy Corp.	5%	2050	CO_2e	2030	50%
Southern Company	5%	2050	All GHGs	2030	50% from 2007
American Electric Power Co.	4%	2050	CO_2e	2030	80%
Xcel Energy Inc.	3%	2050	CO_2	2030	80%
Tennessee Valley Authority	3%	2050	CO_2	2035	80%
NextEra Energy	3%	--	--	2025	67% carbon intensity cut
Exelon Corporation	3%	No commitment, but statement made on issuses			
Dominion Energy	2%	2050	All GHGs	2030	90% CO_2
DTE Energy Co.	2%	2050	CO_2e	2030 2040	50% 80%

Major U.S. utilities net-zero and interim targets

	Share of U.S. Capacity	Net-Zero Year	CO2 or GHG	Interim Year	Interim Targets from 2005 baseline, unless noted
NRG Energy	2%	2050	CO_2e	2025	50% from 2014
PPL Corporation	2%	2050	CO_2e (80%)	2040	70% from 2010
Entergy Corp.	2%	2050	CO_2e	2030	Reduce carbon intensity by 50%, no coal
Evergy Inc.	2%	2045	CO_2e	2030	70%
Ameren Corp.	1%	2050	CO_2e	2030 2045	50% 80%
WEC Energy	1%	2050	CO_2	2025 2030	60% 80%
FirstEnergy Corp.	1%	2050	CO_2e	2030	30% reduction of 2019 baseline for units "under direct operational control"
AES Corp.	1%	2040 - Net-zero electricity sales 2050 - Net-zero full portfolio	CO_2e	2025	<10% power of gen from coal fired power
Alliant Energy Corp.	<1%	2050	CO_2e	2030	50%
Avista Corp.	<1%	2045	CO_2e	2030 2027	30% Carbon neutral supply of enery by 2027
CMS Energy Corp.	<1%	2040	--	2030 2040	Net-zero methane from gas pipelines 90% CO_2
PSEG	<1%	--	--	2050	80% from 2005
OG&E Energy	<1%	--	--	2030	50%
National Grid	<1%	2050	All GHGs	2030 2040	80% from 1990 90% from 1990

Major U.S. utilities net-zero and interim targets					
	Share of U.S. Capacity	Net-Zero Year	CO2 or GHG	Interim Year	Interim Targets from 2005 baseline, unless noted
Sierra Pacific Power	--	2050	CO_2e	--	--
PacificCorp	--	--	--	2050	90% from 2005
NV Energy	--	2050	CO_2e	--	--
Eversource Energy	--	2030	CO_2e		100% (Scope 1, company operations only)
MidAmerican Energy Co.	--	--	--	2021	100% for "retail load" only

U.S. levelized cost of energy: The cost-reduction for renewables continues, but at a lower rate, especially for onshore wind

According to Lazard's Levelized Cost of Energy Analysis (LCOE) (Version 14.0) released in October 2020, solar and wind are the most affordable sources of electricity.

- In a base comparison, without taking into account subsidies, fuel prices or carbon pricing, utility-scale solar (thin-film and crystalline silicon), and wind, have the lowest LCOE of all sources considered.

- Utility-scale crystalline silicon photovoltaic (PV) comes in anywhere from $31 to $42/MWh. Utility-scale thin-film PV ranges from $29 to $38. Utility-scale wind registers the lowest possible LCOE over the largest range, from $26 to $54/MWh.

- Gas peaking comes in at $151-$198/MWh. Nuclear is $129-$198/MWh. Coal is $65-$159/MWh. Gas combined cycle is $44-$73/MWh.

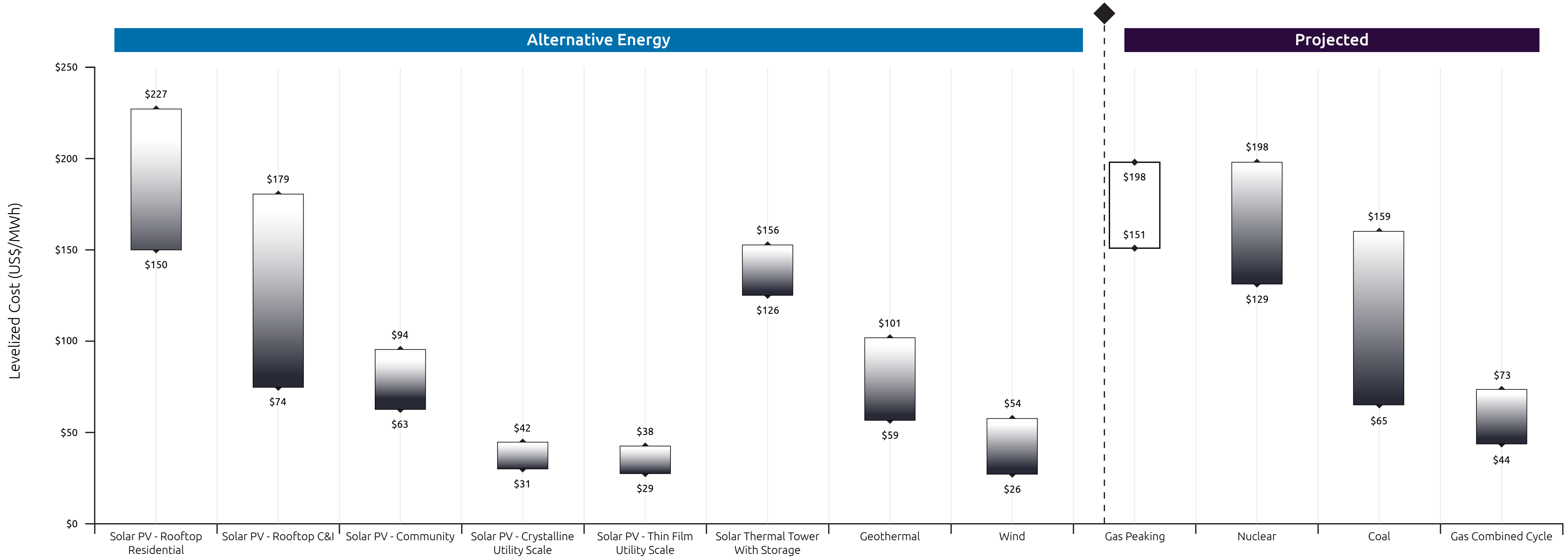
While the reduction in costs continues for renewable energy sources, their rate of decline has slowed, especially for onshore wind.

- The LCOE in the U.S. of generating energy from onshore wind and utility-scale solar projects fell by 2% and 9%, respectively, over the past year.

- Costs for utility-scale solar have been falling more rapidly (about 11% per year) compared to onshore wind (about 5% per year) over the past five years.

FIGURE 8

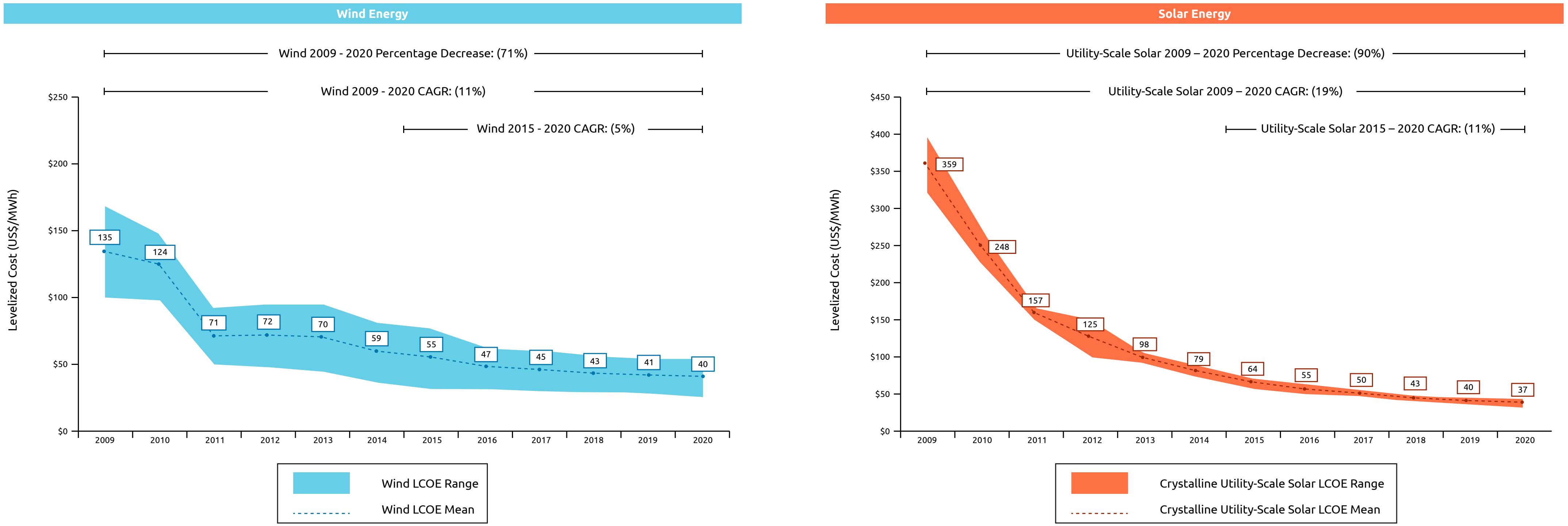
US ~ Unsubsidized Levelized Cost of Energy (LCOE), 2020 (US$/MWh)



Source: Lazard - Levelized Cost of Energy, Version 14.0 (October 2020)
Link: https://www.lazard.com/media/451419/lazards-levelized-cost-of-energy-version-140.pdf

FIGURE 9

US ~ Historical Alternative Energy LCOE Declines, 2009-2020 (US$/MWh)



Source: Lazard - Levelized Cost of Energy, Version 14.0 (October 2020)
Link: https://www.lazard.com/media/451419/lazards-levelized-cost-of-energy-version-140.pdf

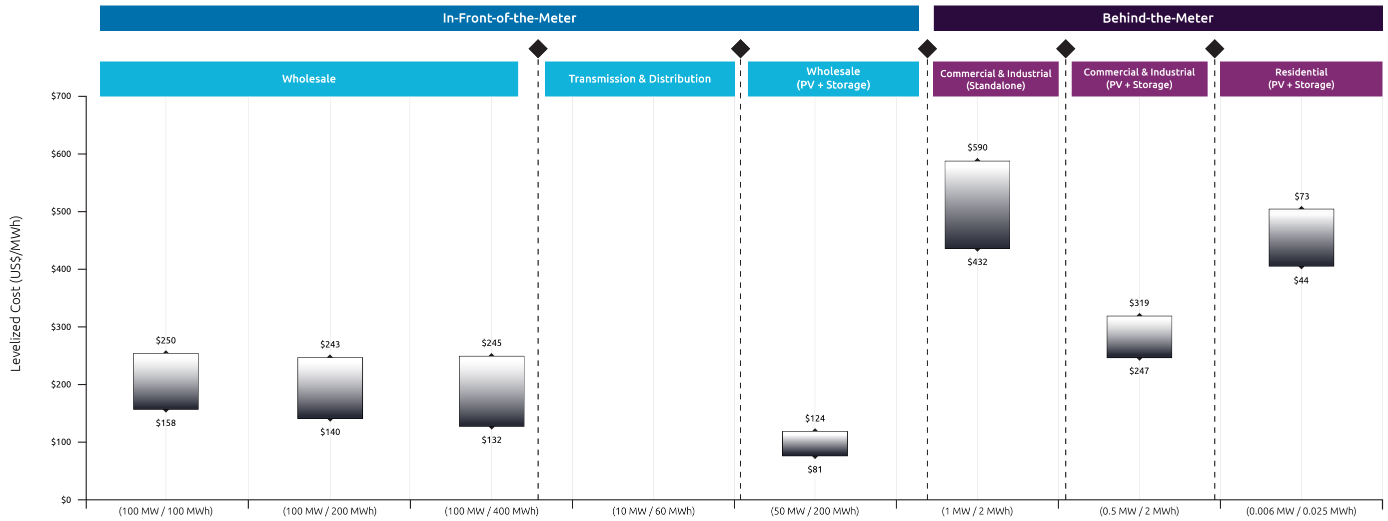
U.S. levelized cost of storage: Storage costs have gone down, especially for shorter-duration applications, mainly driven by evolving preferences in the industry regarding battery chemistry

According to Lazard's Levelized Cost of Storage (LCOS) (Version 6.0) released in October 2020, storage costs have declined across most use cases and technologies, particularly for shorter-duration applications.

- Project economics analyzed for standalone, behind-the-meter applications remain relatively expensive without subsidies. However, utility-scale solar PV+ storage systems are becoming increasingly attractive.
- Long-duration storage is gaining traction as a commercially viable solution to challenges created by intermittent energy resources like solar or wind.

FIGURE 10

US ~ Unsubsidized Levelized Cost of Storage (LCOS), 2020 (US$/MWh)



Note: Lazard's LCOS analysis evaluates storage systems on a levelized basis to derive cost metrics based on annual energy output

Source: Lazard - Levelized Cost of Storage Analysis, Version 6.0 (2020)
Link: https://www.lazard.com/media/451087/lazards-levelized-cost-of-storage-version-50-vf.pdf

U.S. battery storage: U.S. battery storage installations topped 1 GW for the first time in 2020

There is a significant expansion in power sector applications of battery storage in the U.S.

- The Standard & Poor's forecast (in January 2021) projects that 15,000MW of utility-scale energy storage will be put into service by the end of 2023. In Q4 2020, the Energy Storage Association (ESA) in the U.S. is similarly bullish. It estimates that annual energy storage additions will jump to more than 4,000MW in 2021 from 1,464MW in 2020 and climb steadily to 7,830MW in 2025. Of those totals, ESA said, roughly three-quarters are expected to be utility-scale installations.

- These numbers point to two key developments:

  i. Rapidly falling costs are quickly making energy storage economically competitive across a range of applications.
  ii. Utility executives from across the industry are increasingly comfortable with the technical capabilities of energy storage, using it as a capacity resource, a peak reduction tool, and a transition tool away from gas.

- A few years ago, battery storage was a niche product with limited applications, either as a standalone unit or linked with solar or wind. Today, rapidly falling costs and expectations of continued declines have changed the discussion, opening markets for storage across the board.

- NextEra, the leading renewable energy developer in the country, uses the term near-firm renewables because of its ability to pair battery storage with its conventional wind and solar projects and still compete on price with existing coal and new gas.

- NextEra expects to compete on price even without the extension of the existing production tax or investment tax credits, or the creation of a storage tax credit, which is currently being discussed in Congress. Indeed, the economics are so compelling that NextEra estimated in its year-end 2020 financial presentation that it would install between 4,350 and 6,300MW of battery storage capacity through 2024.

There is an increase in current applications for battery storage and its adoption by utilities and other companies of all sizes.

- **Plus Power and ISO-New England's Capacity Market:** Plus Power's win in ISO-New England's latest forward capacity auction is one of the most telling developments for energy storage 2020. The California company was successful with two bids in the auction. One was a 150MW/300MWh storage facility built south of Boston. The second was a 175MW/350MWh project to be built in Maine. The auction was for capacity beginning in 2024. The prices bid by Plus Power almost certainly undercut those of a conventional fossil fuel option and did so without subsidy support.
- **Green Mountain Power's Peak Reduction Program:** In Vermont, Green Mountain Power has been running a successful effort to cut its power demand during ISO-New England's peak load periods, saving ratepayers more than US$ 5 million in the past three years. The program began in 2016 and now has about 2,700 participants. Customers can participate by bringing their battery storage device into the program in exchange for a credit from the utility or having GMP install two Tesla Powerwalls at their home.
- **Battery storage in small co-op:** In 2020, The Northeastern Rural Electric Membership Corporation (NREMC) in Indiana announced it was teaming up with FlexGen to deploy 108MWh of battery storage across its territory over the next five years. The co-op plans to install batteries at each of its five substations, with a total capacity of 31MW.
- **Florida Power and Light's Manatee battery storage project:** Florida Power and Light's Manatee battery storage project is designed to replace the power provided by the utility's aging gas-fired facility at the same location.
- **Vistra's battery storage capacity:** Vistra said it had begun commercial operations at its Moss Landing Energy Storage Facility in California in January, 2021. The facility, now sized at 300MW/1200MWh, is currently the largest operating battery storage facility globally, and expansion plans are already in process.

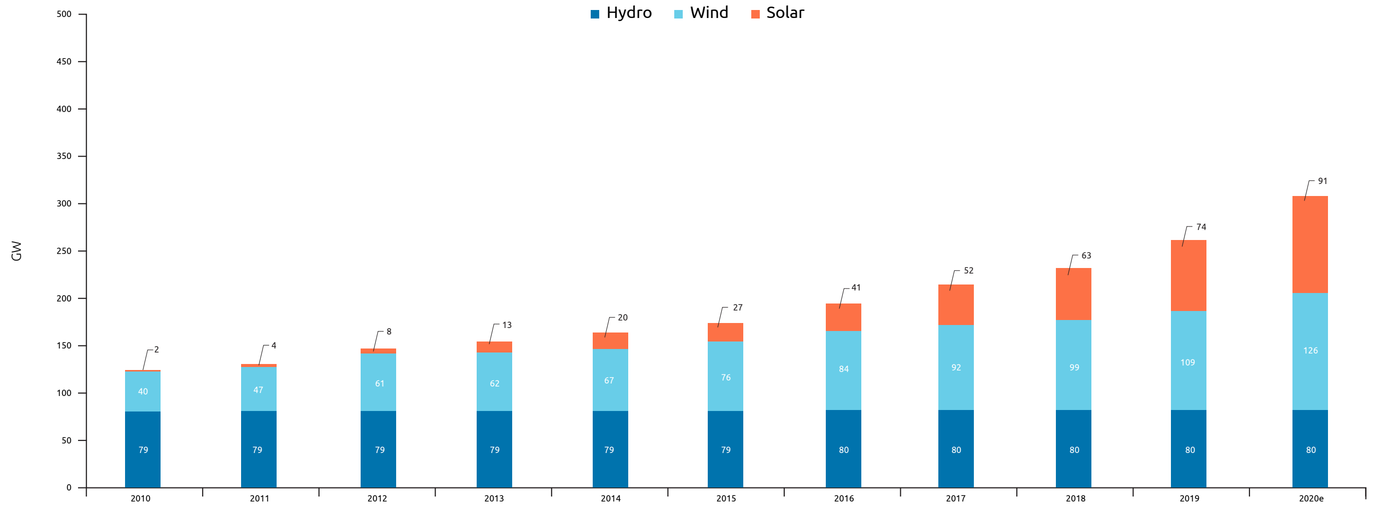
U.S. renewable energy capacity: Wind and solar have accounted for most of the new additions in renewable energy capacity in the past decade

Total renewable energy capacity has more than doubled in the past decade.

- Wind and solar have accounted for nearly all new additions, aided by policy support and rapidly falling equipment costs.
- Wind and solar capacity more than quintupled during the decade, rising from 42GW to 216GW
- U.S. wind capacity reached 126GW in 2020 and continued to be the largest source of U.S. zero-carbon power generation for the second year in a row, at 335TWh.
- Solar power-generating capacity rose to 91GW from less than 5GW at the start of the decade.

FIGURE 11

US ~ Cumulative Renewable energy capacity, 2010-2020E (GW)



Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#

Due to strong wind and solar additions, the generation of renewables rose 10% in 2020 to 829TWh.

- Solar saw the largest year-on-year growth on a percentage basis, expanding by an estimated 25TWh, or 23%.
- Wind output jumped 12% year-over-year and accounted for 40% of all renewable output.
- Hydro generation rose 14TWh, or 5%, and accounted for 35% of total renewable output.

U.S. renewable energy capacity: The energy transformation in Texas is indicative of the changes across the electric sector in the U.S.

The transition in the Electric Reliability Council of Texas, or ERCOT (the grid operator responsible for distributing most of the electricity consumed in the state) is indicative of the changes underway across the electric sector in the U.S.

- At the end of 2011, installed wind capacity in ERCOT was 9,603MW. That capacity generated 28.3 million megawatt-hours (MWh) during the year, accounting for 8.5% percent of ERCOT's electricity demand. By contrast, natural gas and coal both generated more than 130 million MWh that year, supplying 40.4% and 39% of ERCOT's electricity needs, respectively. Even nuclear outperformed wind, producing 39.6 million MWh and meeting 11.9% of the market.

- The Texas electricity generation from wind changed dramatically at the end of 2020.

  i. In 2020, the total installed wind capacity in ERCOT climbed to 25,121MW, more than two times higher than in 2011. That capacity generated 87.1 million MWh during the year, making wind, with a 22.8% market share, the second largest electricity resource behind gas, which supplied 45.5%.

  ii. In contrast, coal generation dropped to 68.5 million MWh in 2020, accounting for 17.9% of the generation in ERCOT.

- Solar is still a small factor in ERCOT, but it is growing exponentially.

  i. Installed capacity rose to almost 4,000MW by the end of 2020, with generation climbing to 8.7 million MWh and accounting for 2.3% of ERCOT demand.

  ii. This amounted to a doubling in market share in a year—a growth rate likely to continue in the near term.

- ERCOT's forecasts show continued growth in wind and solar capacity over the next three years.

  i. Another 13,554MW of wind capacity is in its near-term development pipeline.

  ii. Almost half of that total is already built but not yet cleared for full commercial operation. Much of the remainder is in advanced development, meaning most of it will be online by 2023. This means that by the end of 2023, wind generation can be expected to climb by approximately 47.5 million megawatt-hours (MWh).

  iii. Current ERCOT estimates show that 12,259MW of solar capacity is expected online by the end of 2021, and anywhere from roughly 18,000MW to 25,500MW could be in service by the end of 2023.

The potential growth in solar and wind generation poses a serious threat for ERCOT's fossil fuel generators. If the projected growth in these two resources continues as projected, even after accounting for system wide demand increases, there will be roughly 60 million MWh of additional, zero-fuel-cost electricity available in the ERCOT market in 2023. In addition, the expected increase in wind and particularly solar generation is likely to keep the ERCOT energy market prices under control during the high-demand summer months, cutting into the profits previously earned by coal and gas generators during these peak periods.

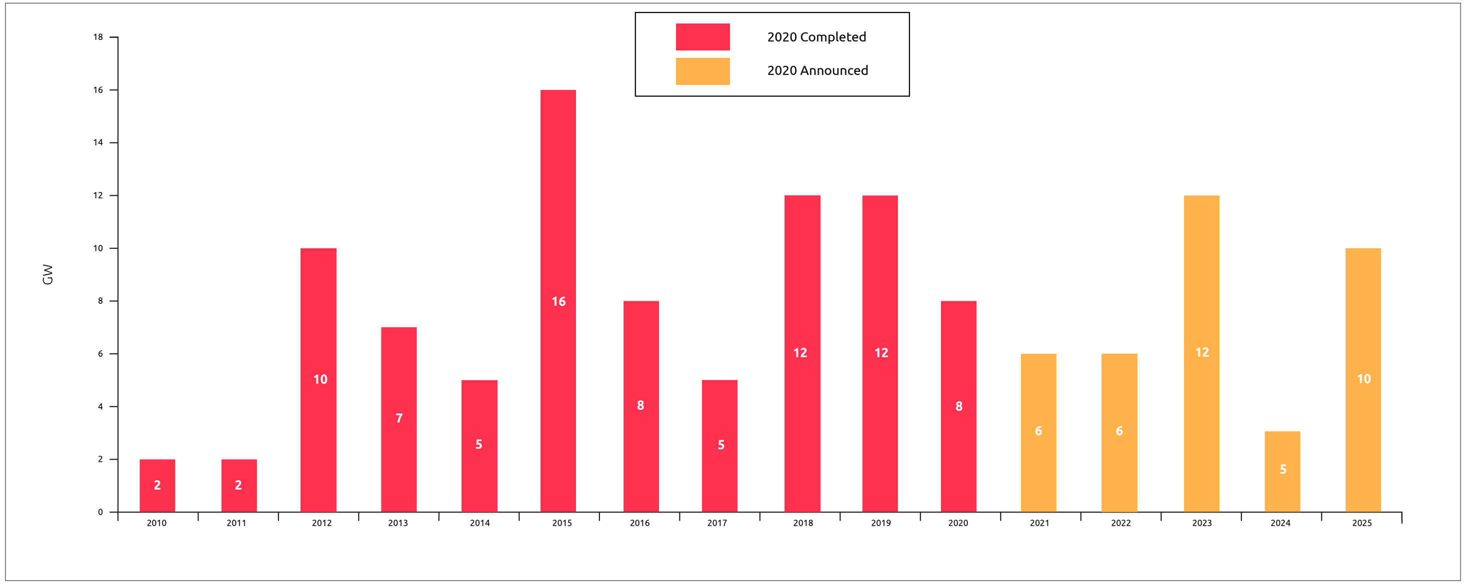
U.S. coal-fired plant retirements: Coal-fired power plant retirements continued in 2020, albeit at a slightly slower pace than the previous years

Coal-fired power plant retirements continued in 2020, albeit at a slightly slower pace than in previous years.

- Plants totaling 8GW of capacity came offline, compared to 12GW in 2019.
- As of 2020, the U.S. coal fleet is 25% smaller than a decade ago.
- Renewable penetration, low natural gas prices, and a slight dip in load have compressed coal's margins.
- State-level support for ailing nuclear plants has also played a role in some regions.
- However, even in states where these factors are less prevalent, utilities are announcing plans to retire coal in favor of lower-cost natural gas, renewables, and energy storage.

FIGURE 12

US ~ Completed and announced coal-fired plant retirements (GW)



Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#

The pipeline of plants that have announced they will close in the future has continued to grow.

- As of year-end 2019, the outlook was for 20GW to retire from 2021-2025.
- In 2020, that number rose to 37GW for the same period.

U.S. coal-fired plant retirements: There is a continuous decline of the U.S. coal industry, placing even the best performing coal plants at risk

In the U.S., five of the 16 coal units with the highest average annual capacity factors between 2016-2020 are scheduled to be retired by their owners by 2025. These include Coal Creek Units 1 and 2 and AES Hawaii, which are planned to close in 2022. In addition, PacifiCorp plans to retire Naughton Unit 1 and 2 in 2025.

- Great River Energy, the owner of Coal Creek, noted that the decision to retire the plant "was based on economics and done in the best interests of our member-owner cooperatives."
- Another of the top performers is Longview Power, which emerged in August 2020 from its second trip into bankruptcy.
- Finally, Bonanza Unit 1 and Rawhide Unit 1, both top performers, are now slated for closure in 2030.
- However, from experience, announced plant retirements are frequently accelerated.

In 2020, there were 455 operating coal-fired units in the U.S. larger than 50MW. Of that total, only 13 posted a capacity factor above 80%. 60 had capacity factors below 10%, 103 had capacity factors below 20%, and 233 had capacity factors below 40%.

- The nation's largest coal-fired power plant, the four-unit, 3,440MW Scherer station in Georgia, posted a 2020 capacity factor of just 18.6%—a stunning drop from the already low 40% capacity factor recorded by the plant in 2019.
- This declining performance is important as it increases the cost of a unit's output by requiring it to spread fixed costs over a smaller number of kilowatt-hours of production. Given that coal is increasingly competing against resources with zero fuel costs, any price increase further widens the competitive gap between the two, to coal's detriment.
- Some plants (albeit a steadily shrinking number) will probably be able to maintain a high level of performance. Still, most will continue to see their generation decline, lowering their capacity factors and undercutting their economic viability.
- This will be driven by several interrelated factors: The continued surge in wind and solar capacity coming on to the grid in the next two to three years; the rapid rise in battery storage installation; continued price drops in both sectors; flat demand growth; and expectations of relatively low natural gas prices.

04 Climate Change & Energy Transition

04

04 Climate Change & Energy Transition

China Emissions, Carbon Taxes, Renewables and Energy Efficiency Measures

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China Emissions, Carbon Taxes, Renewables and Energy Efficiency Measures

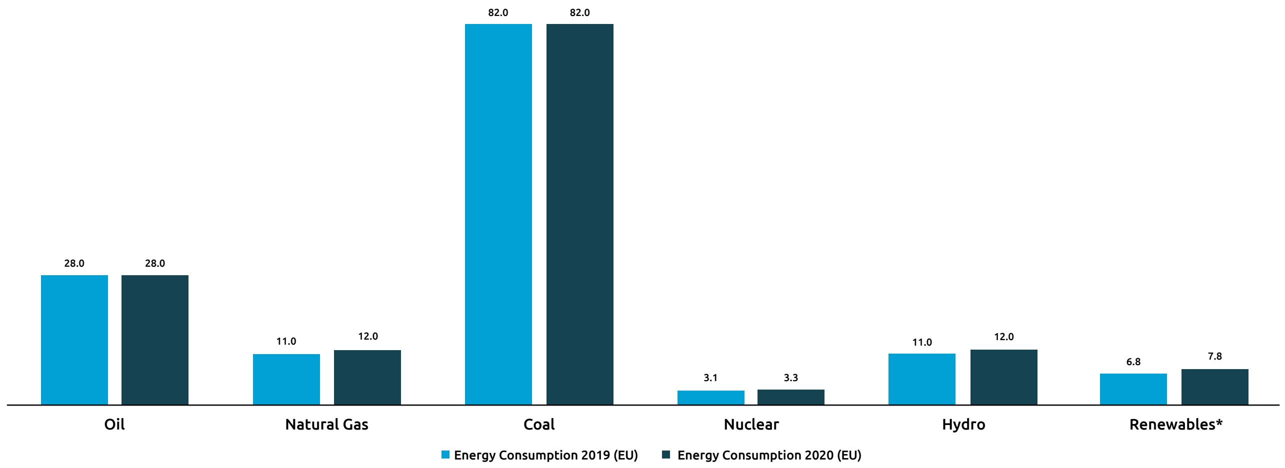
China: Energy Development

China's primary energy demand rose 2.1% in 2020, driven by a rapid economic recovery from the pandemic. China was one of the few countries to grow its energy demand in 2020 and saw the largest absolute rise globally.

- Energy consumption increased by 2.1%, down from the 10-year average of 3.8%.
- China's energy mix continues to shift to a greener one, with coal's share decreasing to 57% in 2020, compared to 58% in 2019.
- Among non-fossil fuels, other renewables like biomass and biofuels grew the fastest (+16.2%), followed by solar (+15.8%), and wind (+14%). Hydro grew by 3.2%, less than half the 10-year average growth of 6.9%.
- Despite the shock of COVID-19, natural gas consumption grew by 6.9%, against a 2.3% decline in gas consumption globally.
- China's renewables consumption grew by 15% in 2020, accounting for 25% of global renewables demand and 36% of global growth.
- China's renewables consumption growth accounted for more than a third of global growth in renewable energy consumption in 2020.
- Nuclear power generation increased by 4.7% in 2020, in contrast to a 3.7% decline globally.
- The output of fossil fuels continued to edge up. Oil (+1.7%), gas (+9.0%) and coal (+1.2%) production increased in 2020.
- China's wind power capacity additions reached 72 GW in 2020, more than the total number of additions in the previous three years combined.

FIGURE 1

Total primary energy consumption, China 2019-2020 (EJ)



Source: BPstats
*Note: Renewable energy include wind, solar, biomass, geothermal and biofuels
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-china-insights.pdf

China: Electricity Mix

As per the China Electricity Council in 2020:

- Total power production in 2020 stood at 7623.6 TWh compared to 7326.9 TWh in 2019, representing a 4.0% year-over-year (YOY) change.
- In 2020, the thermal sector (including coal, gas, oil, and biomass) accounted for 68% of power generation, contributing around 5,174 TWh.
- Renewables (including solar, wind, and hydro power) accounted for 27% and contributed around 2,082.8 TWh in total power generation in 2020.
- Hydro contributed 1,355.2 TWh in total power generation.
- Solar contributed 261.1 TWh in total power generation.
- Wind contributed 466.5 TWh in total power generation.

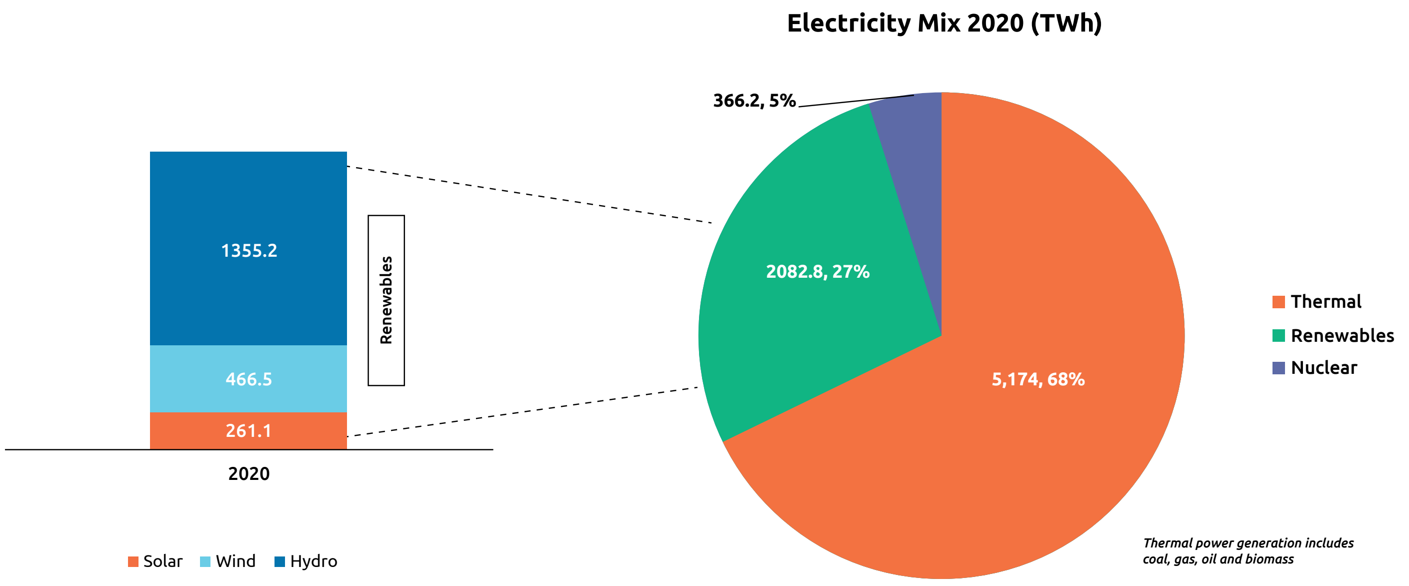
Growth in power generation (TWh) by fuel type for 2020 vs. 2019:

- Thermal accounted for 5,174 TWh in total generation in 2020 vs. 5,047 TWh in 2019, representing YOY growth of 2.5%.

- Nuclear accounted for 366 TWh in total generation in 2020 vs. 349 TWh in 2019, representing YOY growth of 5.0%.
- Hydro accounted for 1,355 TWh in total generation in 2020 vs. 1,302 TWh in 2019, representing YOY growth of 4.1%.
- Nuclear accounted for 467 TWh in total generation in 2020 vs. 405 TWh in 2019, representing YOY growth of 15.1%.
- Solar accounted for 261 TWh in total generation in 2020 vs. 224 TWh in 2019, representing YOY growth of 16.6%.

FIGURE 2

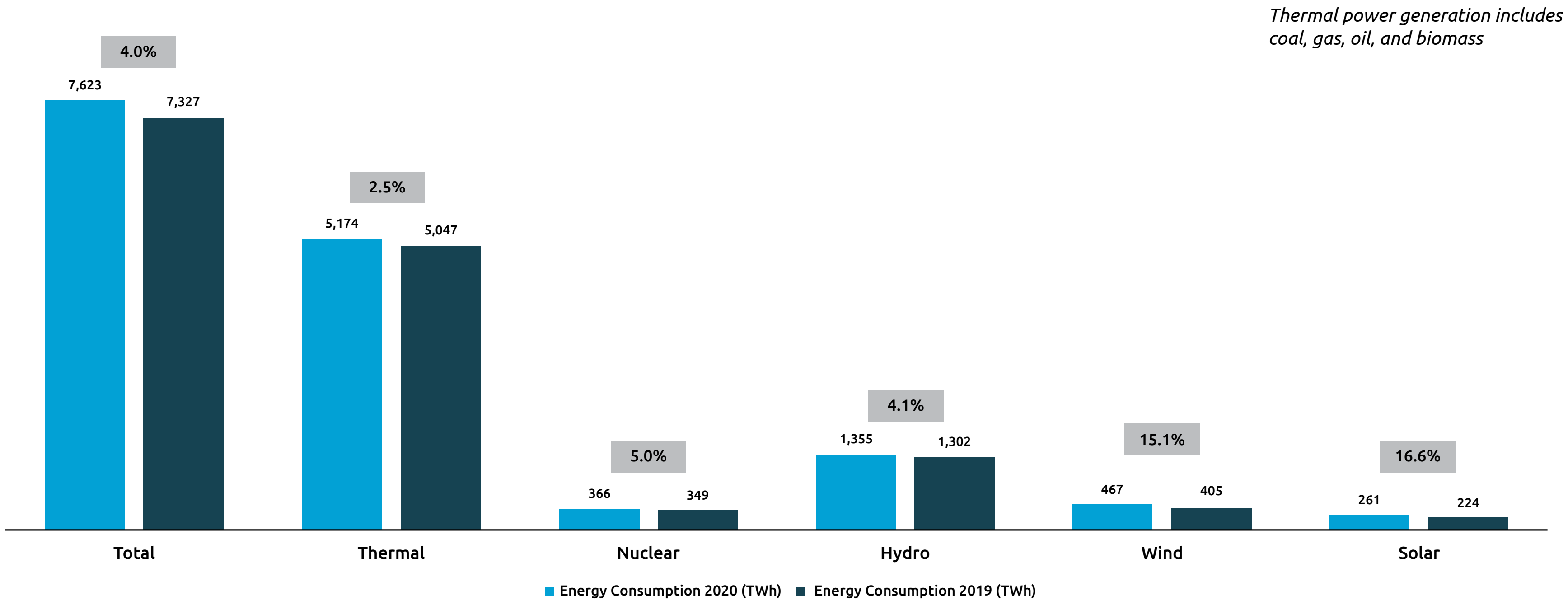
China Electricity Mix CY2020 (TWh)



Source: China Electricity Council
Link: https://www.cec.org.cn/upload/1/editor/1611623903447.pdf

FIGURE 3

China year-on-year growth in power generation (TWh): CY2020 Vs 2019



Source: China Electricity Council
Link: https://www.cec.org.cn/upload/1/editor/1611623903447.pdf

China: Power Consumption And Generation Capacity By Fuel Type

As per the China Electricity Council in 2020:

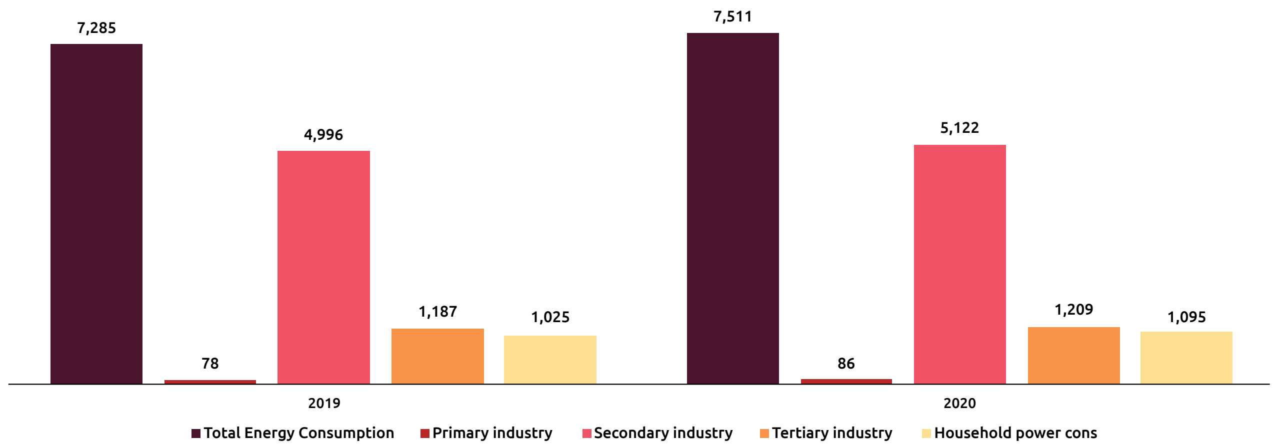
- Total power consumed in China in 2020 was 7,511 TWh compared to 7,285 TWh in 2019, representing a 3.1% of YOY growth.
- Different sets of industries consume power and distribute it further, such as primary, secondary, tertiary and household power consumption.
    - Primary industry consumed 86 TWh of power in 2020 compared to 79 TWh in 2019, representing 10.3% of YOY growth.
    - Secondary industry consumed 5,122 TWh of power in 2020 compared to 4,996 TWh in 2019, representing 2.5% of YOY growth.
    - Tertiary industry consumed 1,209 TWh of power in 2020 compared to 1,187 TWh in 2019, representing 1.9% of YOY growth.
    - Household power consumed 1,095 TWh of power in 2020 as compared to 1,025 TWh in 2019, representing 6.9% of YOY growth.

Growth in installed generation capacity by fuel type (MW):

- The wind power sector witnessed the highest YOY growth in 2020, adding 72,380 MW and reaching a total installed generation capacity of 370,160 MW.
- The solar power sector held second place when it comes to installation of generation capacity. In 2020, it added around 49,250 MW of solar generation capacity reaching 253,430 in total solar, representing 24.1% YOY growth.
- Thermal added another 55,600 MW of generation capacity in 2020, reaching 1,245,170 MW of total thermal capacity.
- Hydro and nuclear sectors added 12,120 MW and 1,150 MW in 2020, representing YOY growth of 3.4% and 2.4%, respectively.

FIGURE 4

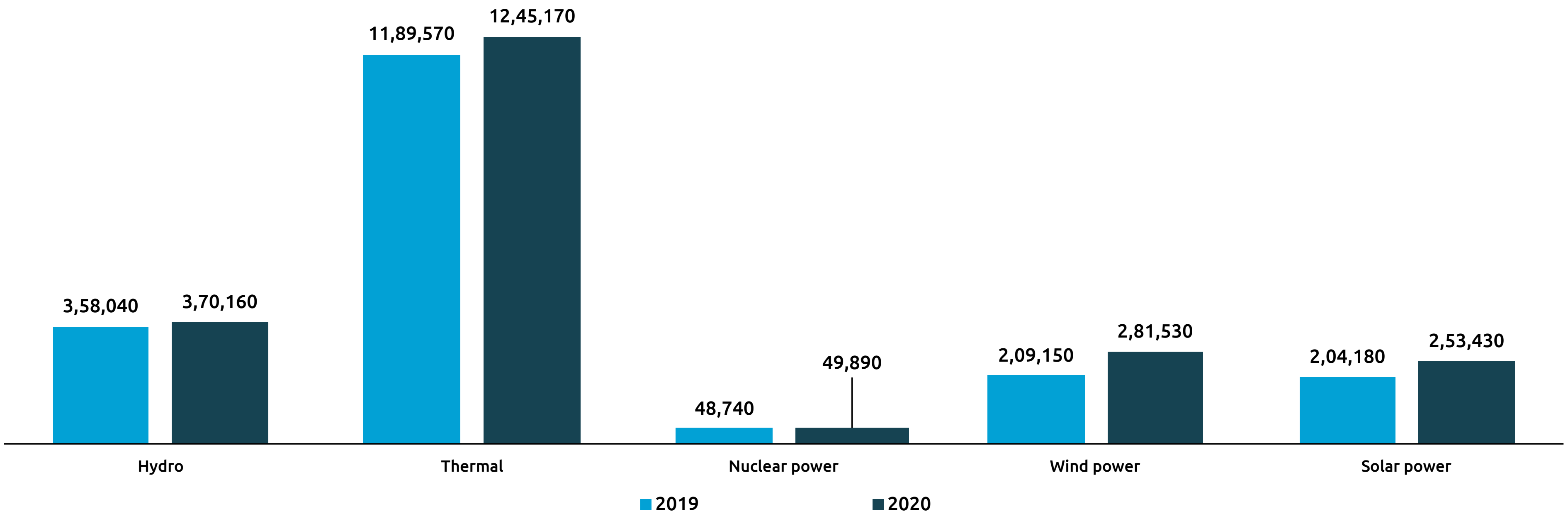
Total power consumption, China 2019 - CY2020 (TWh)



Source: China Electricity Council
Link: https://www.cec.org.cn/upload/1/editor/1611623903447.pdf

FIGURE 5

Installed generation capacity by fuel type (MW), China 2019 – CY2020



Source: China Electricity Council
Link: https://www.cec.org.cn/upload/1/editor/1611623903447.pdf

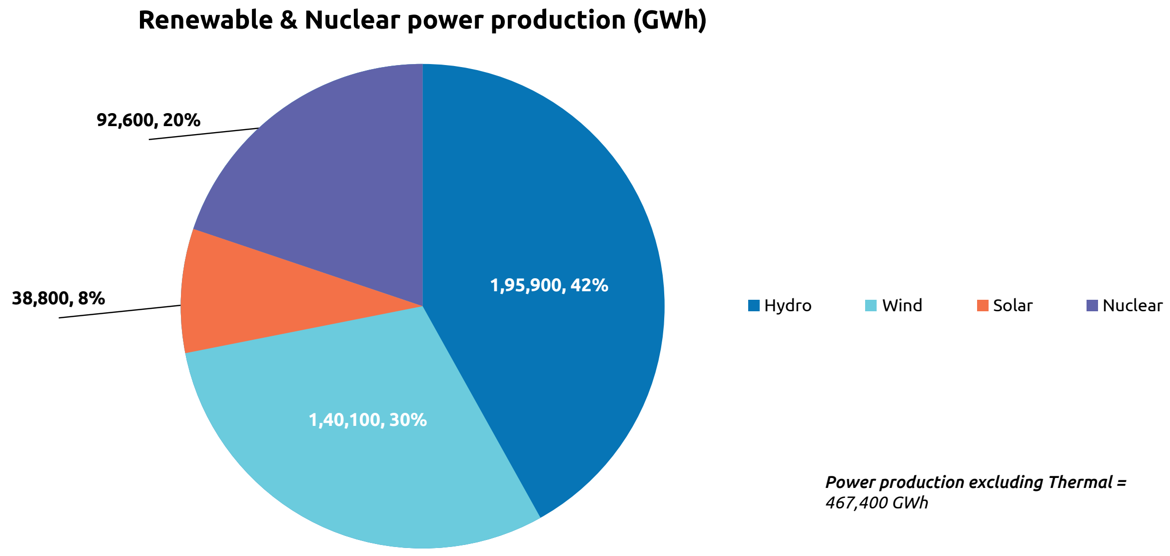
China: Renewable And Nuclear Energy

China produced 2,082.8 TWh of renewable electricity in 2020, according to the China Electricity Council report.

- In Q1 2021, China generated 374,800 GWh of renewable electricity through hydro, solar, and wind sources.
    - Solar contributed around 38,800 GWh in total renewable electricity generation, whereas wind and hydro contributed 140,100 GWh and 195,900 GWh, respectively.
- Nuclear power production stood at 92,600 GWh, contributing around 4.9% of total electricity generation in Q1 2021 (including thermal generation).
- The country consumed 7,511 TWh of power in 2020, which meant that slightly less than 30% was from a renewable output derived from hydropower, wind, solar and biomass.
- According to the country's largest utility, State Grid Corporation of China (SGCC), China consumed 1,570 TWh of electricity in January-March 2020, a decline of 6.5% YOY.
- Hydropower accounts for the bulk of China's renewable energy mix.

FIGURE 6

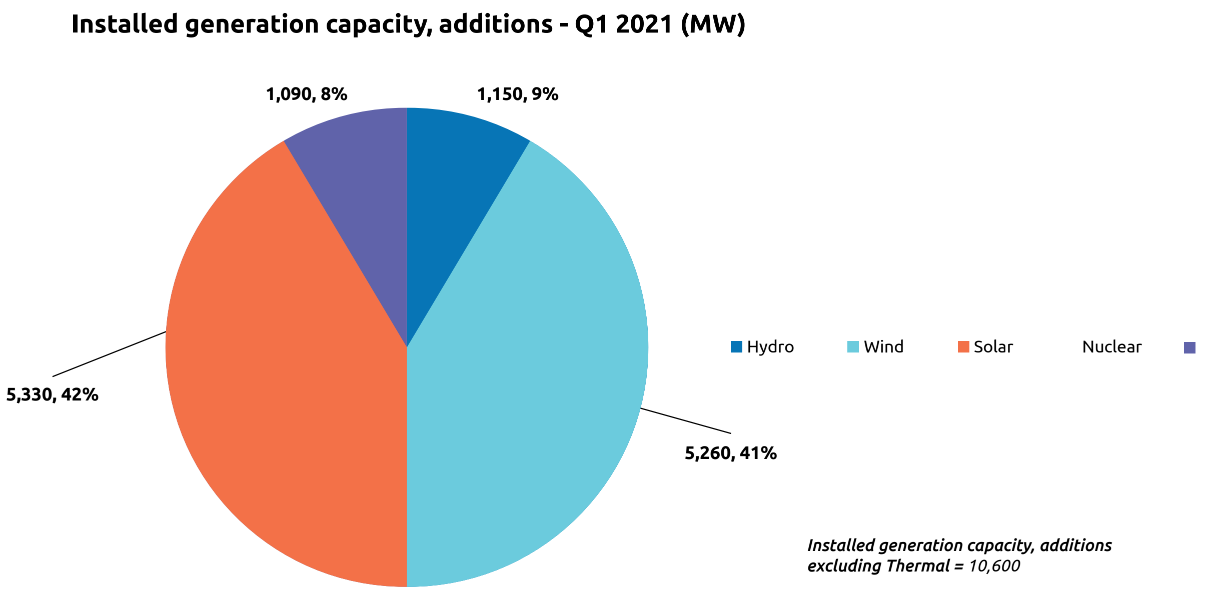
China - National renewable power production - Q1 2021



Source: China Energy Portal
Link: https://chinaenergyportal.org/en/2021-q1-electricity-other-energy-statistics/

FIGURE 7

China - Installed generation capacity, additions - Q1 2021



Source: China Energy Portal
Link: https://chinaenergyportal.org/en/2021-q1-electricity-other-energy-statistics/

Implications:

- As China's economy continues to rebound strongly from the impact of COVID-19, stronger industrial demands for electricity are expected to sustain demand for thermal coal, outpacing growth in renewables.
- Assuming that China's renewable energy output will continue to grow at approximately the same rate this year, it may not be enough to keep pace with its growing electricity demand, sustaining thermal coal as the leading fuel for Chinese utilities.

China – Overview Of Renewable Energy Projects

PROJECT NAME	PROJECT TYPE	COST	CAPACITY	KEY EXCERPTS
Wudongde Hydropower Station, China	Hydroelectric	$15.4 billion	10GW	Wudongde Hydropower has been under construction since 2015 and began producing power from the first batch of generator sets in June 2020. The completed dam is scheduled to be fully operational by December 2021. The dam will offset 12.2 million tons of standard coal, reduce CO2 emissions by 30.5 million tons, and reduce sulfur dioxide emissions by 104,000 tons per year.
Ulanqab Wind Farm, China	Onshore Wind	$6.2 billion	6GW	Known as one of the biggest onshore wind farms, it covers 3,800 square km of North China's Inner Mongolia Autonomous Region. The 6GW Ulanqab wind farm is intended to deliver 18.9 billion kWh a year to the Beijing-Tianjin-Hebei power market and is supposed to help power the 2022 Winter Olympic Games. The project is not subsidized by the government but will take advantage of several measures, including 20-year power purchase agreements, a waiver of local content requirements, and a guaranteed grid connection.
CECEP Wind Park	Wind	$87.5 million	75MW	Recently, CECEP Wind decided to build 75 MW of wind parks in China. The company plans to build a 25 MW wind park in Qinzhou District, Tianshui City, Gansu Province. This project will include 3 MW turbines and four 4 MW machines. They will also construct a 50-MW facility in Pingyuan County, Dezhou City, Shandong Province. The total cost of the two projects is estimated at US$ 87.93 million, comprising US$ 28.17 million investment in the smaller scheme and a US$ 59.76 million investment in the larger one.
Renewable Energy and Battery Storage Promotion Project	Renewable/battery storage	$300 million (commitment)	N/A	The objective of the Renewable Energy and Battery Storage Promotion Project in China is to promote the integration and use of renewable energy through battery storage systems and innovative applications of renewable energy. The proposed project will principally support the installation of battery storage systems and innovative RE applications.
Infrastructure for new energy vehicles (NEVs)	EV/Battery	N/A	N/A	Sinopec and Evergrande Group have agreed to develop infrastructure for new energy vehicles (NEVs). Both companies will construct charging and battery exchange stations for NEVs, lightweight materials for vehicles, and high-performance building chemical materials. Sinopec targets 1,000 hydrogen refueling stations, 5,000 charging and power battery exchange stations, and 7,000 distributed photovoltaic power stations by 2025.

China: Coal (1/2)

China is the world's largest producer and consumer of coal, used for heating, cooking, electricity generation, and steel making

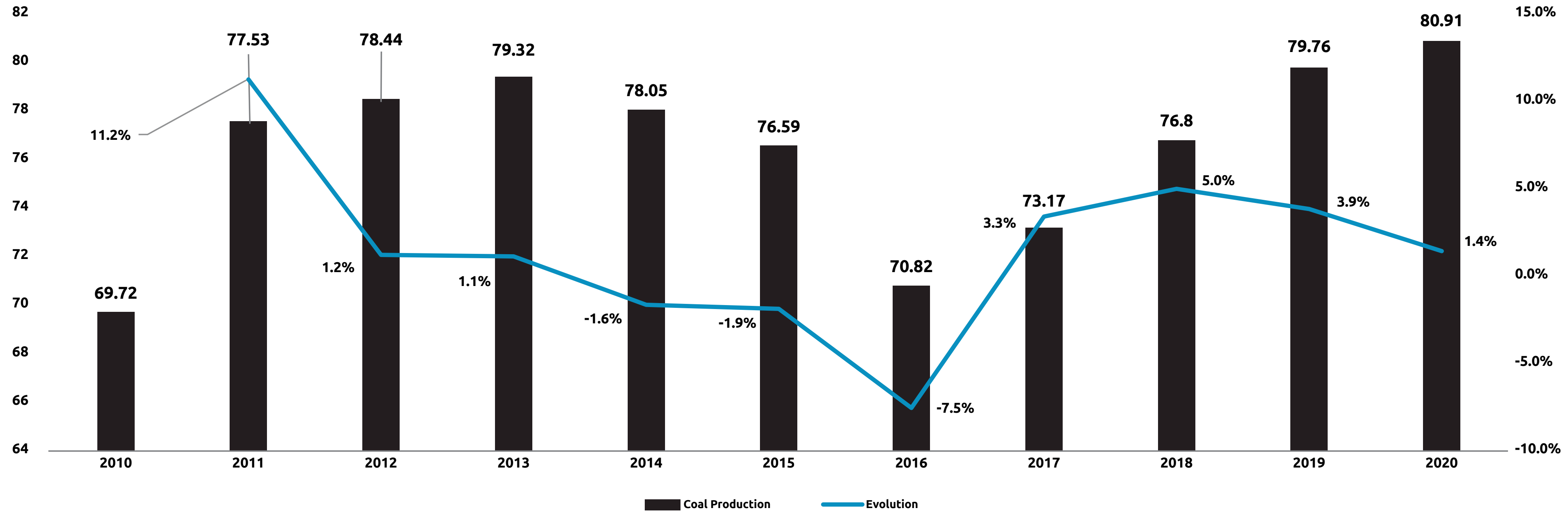
- Coal production in China has been on the rise in the last decade, from 69.7 exajoules in 2010 to 80.9 exajoules in 2020.
  - Thermal coal accounted for 56.8% of the total energy consumption in 2020.
  - Consumption of fossil fuel increased by 0.6% in 2020.
- China can produce a majority of the coal it needs. However, it imports coal to supplement domestic supply and to access higher quality coking coal for steelmaking.
- The country's coal consumption is expected to increase in 2021.
- With the launch of new and advanced coal capacity in major coal mining regions such as Shanxi, Shaanxi, Inner Mongolia, and Xinjiang, the country's coal output will increase in 2021.
  - But central Chinese regions such as Hunan and Jiangxi will continue to shut down their outdated coal mines.

China plans to add 110 million tonnes of coal production capacity in the second half of 2021.

- To meet the rising demand for fossil fuels, China is in talks to add 110 million tonnes of coal production capacity in 2021.
- As of now, 40 million tonnes of coal mining capacity are awaiting government approvals. However, 70 million tonnes are under construction and will be launched subsequently.
- The country has been urging miners to accelerate the construction of advanced mining capacity and ramp up output amid soaring coal prices and robust demand from industrial and residential sectors.
- After multiple mining accidents, coal output fell by 5% in June 2021 due to strict mine safety inspections across China.
- The National Development and Reform Commission (NDRC) is shutting down small and outdated coal capacity. Currently, China has around 4,700 coal mines, down from more than 10,000 in 2015.

FIGURE 8

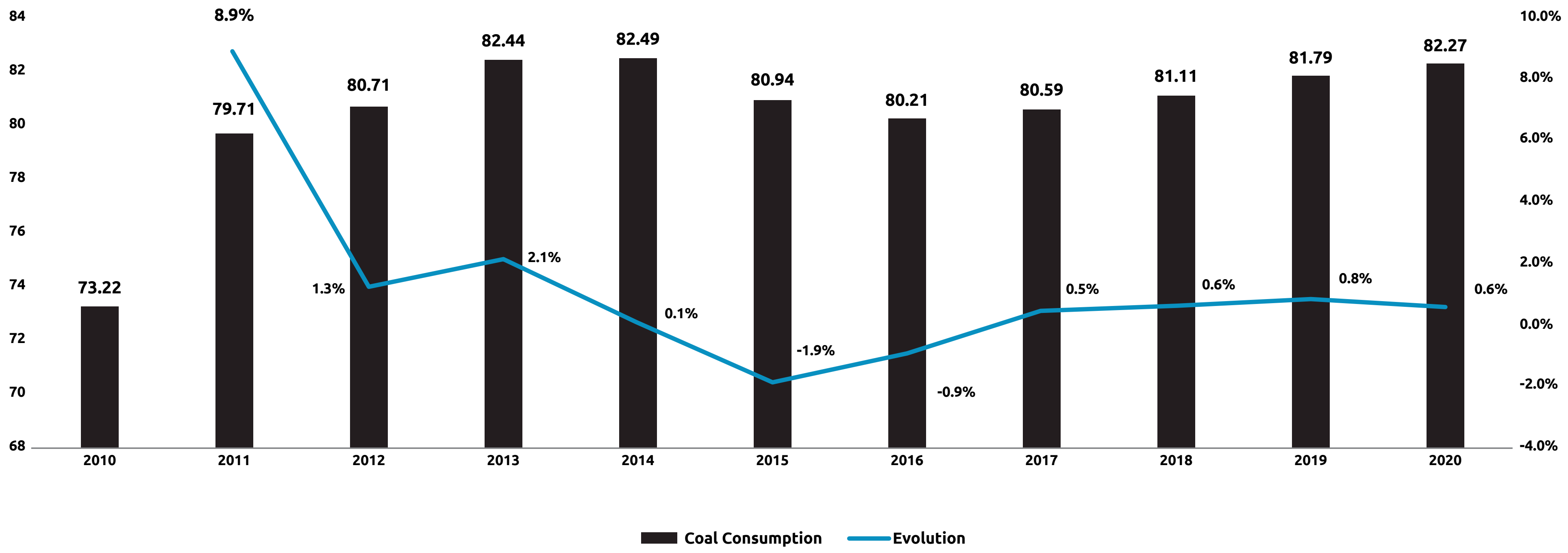
China: Total coal production (Exajoules) (2010-2020)



Source: BPStats
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

FIGURE 9

China: Total coal consumption (Exajoules) (2010-2020)



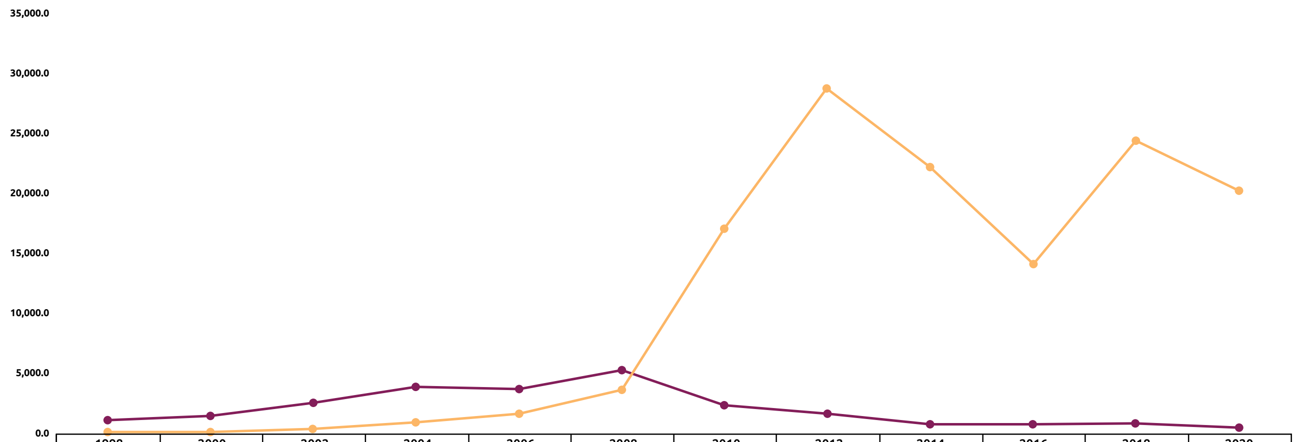
Source: BPStats
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

China: Coal (2/2)

- China imported 304 million tonnes of coal in 2020, up 4 million tonnes a year earlier.
- In 2019, around 57% of China's thermal coal imports and 40% of its coking coal came from Australia. In 2020, imports of Australian thermal coal were about the same scale, but coking coal imports probably rose to 50%.
- In December 2020, South Africa shipped thermal coal to China for the first time since 2014. More is expected, since Beijing is seeking to diversify its coal sources.
- Chinese buyers also imported coal from Colombia, which was not a big seller to China due to long shipping times compared to regional suppliers such as Australia and Indonesia.
- In the past, South African coal was not allowed into China because it contains restricted trace elements like fluorine.
- Most raw coal mined in China is used for power generation, while about 20% creates coking coal for steel mills.
- Indonesia, Australia, and Russia are the three biggest suppliers of thermal coal transported to China via ship. Australia and Mongolia dominate exports of coking coal, which is used in steel furnaces.

FIGURE 10

China's import and export of coal, In millions USD (1998-2020)



	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Export	1067.7	1468.3	2532.9	3814.5	3672.0	5237.8	2241.8	1,586.0	696.0	698.2	787.4	435.7
Import	68.4	68.6	328.4	885.8	1620.8	3543.5	17,016.3	28,728.6	22,167.9	14091.8	24,485.4	20,217.9

Export Import

Source: General Administration of Customs in China
Link: https://www.scmp.com/economy/china-economy/article/3121426/china-coal-why-it-so-important-economy

China: Oil Production

In China's energy mix, coal will continue to account for the highest share. However, oil will account for 20-25% of its overall primary energy consumption.

- China's oil production has declined from 4,077 thousand barrels daily in 2010 to 3,901 thousand barrels in 2020.
    - One of the important reasons is the crash in commodities prices, which led state-owned oil giants to sideline less-productive wells.
    - The decline also comes from a dearth of new discoveries. While the country has continued some exploration, domestic growth is increasingly focused on tapping potentially vast natural-gas reserves, including those from shale.
- In 1993, China became a net importer of oil, According to most estimates, its imports will continue to grow in the decade to come. As a result, oil will be the primary fuel for the Chinese transportation industry.

China's oil projects:

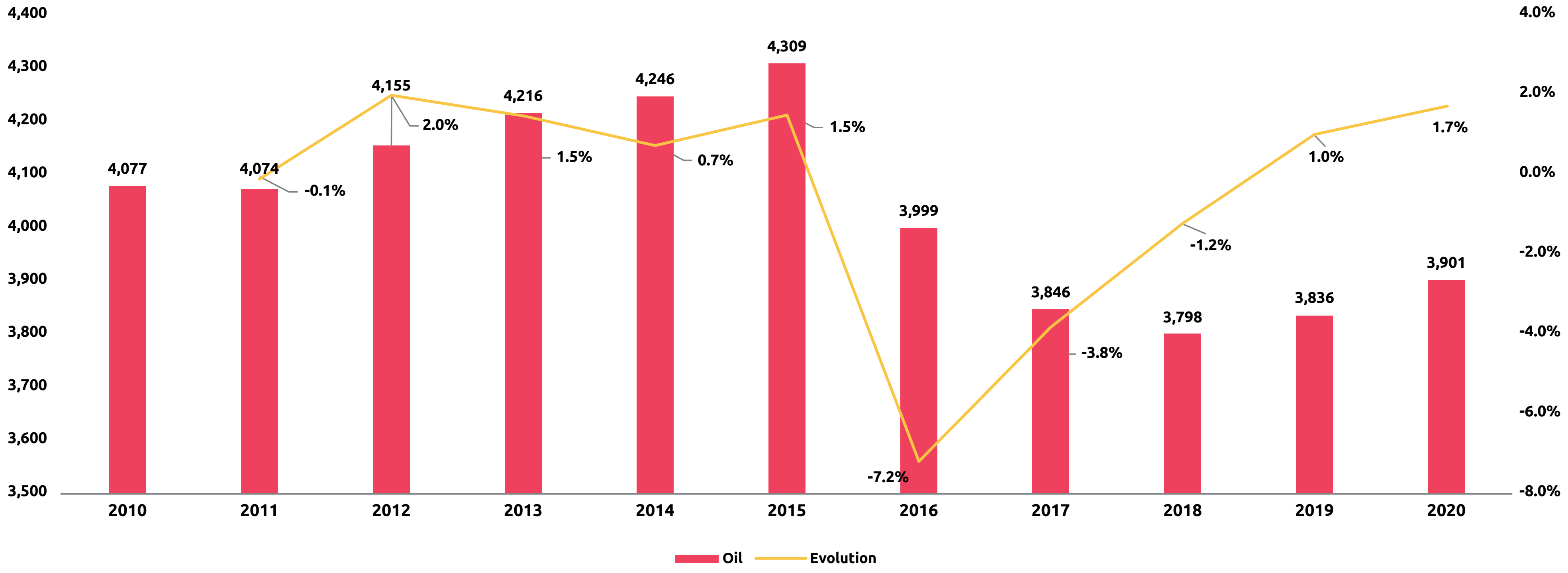
1. China National Offshore Oil Corporation (CNOOC) started its first oil production from the Liuhua 16-2 and 20-1 joint development project in the South China Sea in September 2020.
    - The project is expected to reach its peak production of approximately 72,800 barrels of crude oil per day in 2022.
    - CNOOC is working on ten new projects on stream: Luda 21-2/16-3; Penglai 19-3/Penglai 19-9; Qinhuangdao 33-1 South oil field phase I; Bozhong 19-6 gas field pilot area development project; Nanbao 35-2 oil filed S1 area; Jinzhou 25-1 oil field 6/11 area; Liuhua 29-1 gas field development project; and Liuhua 16-2/20-2 joint development project in offshore China.
2. PipeChina, formally known as China Oil and Gas Pipeline Network, has reportedly commenced construction on the US$1.3 billion natural gas trunk line in north China.
3. China has discovered a new one billion tonne super-deep oil and gas area in the Tarim Basin in Northwest China's Xinjiang Uygur Autonomous Region, the largest discovery in the basin in nearly ten years.

Implications of foreign policy

- Within the general framework of China's growing energy requirements, the oil strategy faces many domestic and external uncertainties.
    - Domestically, these uncertainties are primarily related to China's future economic performance: the real volume of aggregate energy and oil demand; sufficient technological ability to allow for significant shifts in the structure of China's energy mix; the growth of consumerist tendencies that might trigger an increase in individual energy consumption; and developments in the ecological situation.
    - Externally, these uncertainties are influenced by: possible tendencies of the future energy market; the price of oil and gas; the general climate of international relations; the prevailing tendencies for either confrontation or interdependence in the world; and the level of China's integration into the world economy.

FIGURE 11

China Total oil production (Thousand barrels daily) (2010-2020)



Source: BPStats
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

China: Subsidies For Renewables And Electric Vehicles (EVs)

China's solar development is driven by the subsidies from the state and central government:

- In China, solar subsidies are being phased out as solar costs become competitive enough to make unsubsidized projects economically viable.
- In 2020, 33 GW of new unsubsidized projects were approved and nearly 50 GW of unsubsidized solar is under development across 20 provinces.
- In June 2021, China's central government announced a halt to subsidies from their budget for some types of renewables, including new onshore wind projects, concentrated solar photovoltaic power plants, and distributed solar photovoltaic projects for commercial use. These projects have developed rapidly, become more affordable, and can compete head-on with coal-fired electricity.
- In November 2020, China's Ministry of Finance announced that it had set the country's renewable power subsidy for 2021 at US$ 905.7 million, up 4.9% from 2020.
    - Solar power subsidies reached US$ 0.52 billion and wind reached US $ 0.36 billion, up 56.8% from 2020.

Subsidies include:

- Research and development: The central government subsidizes research and development on key renewable energy technologies through the National Development and Reform Commission.
- The former State Economic and Trade Commission's (SETC) Department of Resource Conservation and Utilization (DORCU) provided low-interest loans from the state budget to support industrial development of renewable energy. The Ministry of Water Resources (MWR) provides low-interest loans of about $26 million (CNY 300 million) for small hydropower development.

China announced subsidies from the central government budget in 2021 for new solar power stations, distributed solar projects by commercial users, and onshore wind projects

- Electricity generated from the new projects is to be sold at local benchmark coal-fired power prices or at market prices.
- Electricity prices for offshore wind and concentrated solar power projects that receive approvals in 2021 will be decided by the provincial governments where they are located.

Subsidies to electric vehicles:

- Both Chinese national and local governments provide subsidies for the procurement of EVs and related charging infrastructures.
- EV subsidies do not draw from the Renewable Energy Development Fund but from other dedicated government budgets.
- Ministry of Industry and Information Technology (MIIT) plays a proactive role in EV related policies due to its relevance in cultivating the manufacturing industry.
- During the 13th FYP (Five-Year Plan) from 2016 to 2020, approximately US$ 62 billion was allocated to procure new energy vehicles, including plug-in hybrid and EVs. Subsidies from national and subnational governments have also been used for infrastructure development related to EVs.

Other insights:

- In China, cross-subsidies exist between non-residential power users (typically industrial and commercial consumers) and households, between developed and undeveloped regions, and between high-voltage and low-voltage users.
- Average electricity prices for industrial users across China are US$ 0.098 per kWh, compared with an average of US$ 0.084 for households.

- Provincial governments oversee setting household electricity prices but can only act following orders from Beijing.

- The local governments will hold hearings about planned price adjustments related to so-called "livelihood products," including electricity and water, before making any changes.

Increasing renewable energy projects and the subsidies given by the government have led the government of China to a debt of US $42 billion

- Due to lack of payments, investors are concerned for China's clean power operators and projects. The Chinese government is reducing the subsidies, and the delayed payments are increasing for developers, which in turn is restricting their ability to borrow money to fund new generation.

China: Renewable Tariffs

Feed-in tariffs (FiT):

- Feed-in-tariffs (FIT) is a common subsidy scheme under which solar projects can charge an above-market electricity rate for 20 years if the government approves.

- In 2010, the feed-in-tariffs were 80 cents per kilowatt-hour. In early April 2020, the National Development and Reform Commission further reduced the subsidy to about five cents per kilowatt-hour for a typical solar project.

- The Renewable Energy Fund is the only source of funding for solar feed-in tariffs. The FIT is collected from surcharges imposed on electricity consumers by every kWh they use.

China has reshaped the policies of electricity price to reflect changes in electricity supply and demand.

- The prices are calculated based mainly on fuel price, finance cost, and operation-period of power plants, or the leveled lifecycle cost of energy.

- The on-grid power prices are composed of the government's capacity prices and the electricity prices generated by market bidding.

- The government determines transmission and distribution prices. The retail prices are formed based on the above electricity prices and a mechanism for linkage with the established on-grid power price.

Coal-fired power plant:

Based on the coal and electricity price linkage mechanism, the benchmark on-grid power tariffs of coal-fired power plants nationwide should be adjusted when the average coal price in China increases by 5% within a half year. Still, only 70% of the increase will be passed to the on-grid power tariffs; the coal-fired power plant operators will bear the remaining 30%.

- In 2013, the portion of the tariff managed by the generation companies should carry was reduced from 30% to 10%.

- In 2019, the coal and electricity price linkage mechanism was cancelled, and the benchmark on-grid power tariffs was no longer a fixed number. Rather, it could be adjusted in a range.

- The abolition of the coal and electricity price linkage mechanism is also part of the on-going power market reform.

- The change of the tariff-setting policy gives the whole industry more room for a market-oriented price finding mechanism.

Gas-fired power plants:

Gas-fired power plants are a conventional generation technology and have more individual tariffs than coal-fired power plants.

- There are no general benchmark tariffs for gas-fired power plants; tariffs for newly built assets are determined by the National Development and Reform Commission (NDRC) and based on the function and operation time of the power plants.

- The tariffs for the gas-fired power plants built for peak shaving, are higher than standard gas-fired power plants, which were close to 0.12 US$ /kWh.

Wind power:

NDRC announced a feed-in tariff system for new onshore wind power projects in August 2009.

- The feed-in tariff has a similar function as the benchmark on-grid power tariff. The only difference is that once the renewable energy asset is connected into the grid, the tariff would not be changed for a fixed time.
  - Category I is applied for assets in the region with the most abundant wind resources. Category IV is for assets built areas with relatively fewer wind resources.

- The feed-in tariffs of onshore wind energy were adjusted five times since 2009. The trend is downward, and the goal is that wind power should be sold to the grid with the same benchmark tariffs as coal-fired power.

Hydropower stations:

The on-grid power tariff setting mechanism for hydropower stations is similar to coal-fired power plants, but it has no general benchmark tariffs.

- The reason is that every hydropower investment project has its condition in hydrological and geological areas.

- NDRC approves large hydropower investment project tariffs, and the provincial governments decide tariffs on smaller projects.

- But in general, on-grid power tariffs for hydropower stations are in the range of US$ 0.031/kWh, which is lower than coal-fired power plants in the same region.

FIGURE 12

China: Feed-In Tariffs (FIT) And Feed-In Premiums (FIP) By Type In 2020

POLICIES	RENEWABLE ENERGY TECHNOLOGIES	RATES, in CNY/Kwh			
		Type 1	Type 2	Type 3	Type 4
FiTs	Onshore wind	0.29	0.34	0.38	0.47
	Offshore wind (coastal)	N/A	N/A	N/A	0.75
	Offshore wind (intertidal)	N/A	N/A	N/A	0.47
	Solar photovoltaic (PV) (utility scale, commercial, and industrial projects that 100% feed-in grid)	0.4	0.45	0.55	N/A
	Solar PV (poverty alleviation purpose)	0.65	0.75	0.85	N/A
	Concentrated solar power	1.15			
	Biomass (agro-forestry)	0.75			
	Municipal solid waste (waste incineration)	0.65			
FiPs	Distributed solar PV (self-consumption by industrial and commercial projects)	0.1			
	Distributed solar PV (residential)	0.18			

Source: CNREC, 2019; NDRC, MoF and NEA, 2018.

National Energy Administration (NEA) promulgate FIT policies applicable to onshore and offshore wind, solar PV, concentrating solar power (CSP) as well as biomass for electricity generation.

In China, FITs are classified according to natural resource classification standards for all regions into four types including type 1, 2, 3 and 4, based on their renewable energy potential combined with the comparative plant construction costs.

- **Type 1:** Type 1 has the greatest potential and lowest costs. Regions with greater renewable potential and thus presumed lower cost, receive lower tariffs than regions with less potential.
- **Type 2:** Chongli district has good solar PV and wind power potential. Therefore, it is classified as a type 2 solar resource area, as per the national classification. The district is classified as a type 2 wind resource area, with wind resources of about 200–500 kWh/m2 at a height of 70 meters.
- **Type 3:** Tongli Town, a district of Suzhou, is classified as a solar energy type 3 zone. Suzhou registers an average solar radiation of about 1279 kWh/m2 per year and 3.5 kWh/m2 per day.
- **Type 4:** All offshore wind generation areas are classified as type 4.

China: Investments Across Energy Sector

China's energy transition investment in 2020 slid 12% to $134.8 billion but was still, by far, the largest of any country in the world. Renewable energy capacity investment dropped 12% to $83.6 billion.

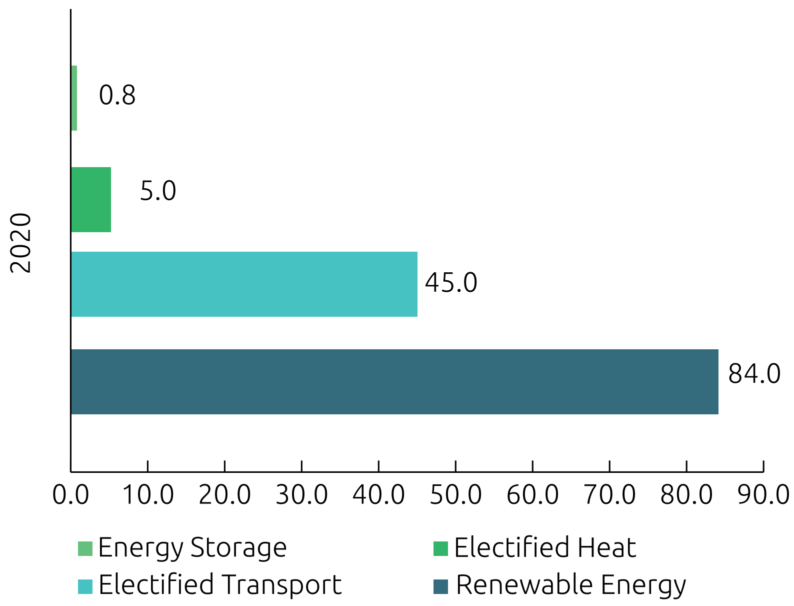
- In May 2021, China confirmed that clean energy is going to be among the first focus topics of a new competitive process for research and development (R&D) funding under the 14th Five-Year Plan.
- China's coal-fired Final Investment Decisions (FIDs) in 2020 were about 25% of their 2010 level.
- China, along with United States, continued to attract about half the global power sector investment. Both showed positive investment growth in 2020 (despite the pandemic), which was driven by a large increase in spending on renewables projects, especially wind.
- Investment in fossil fuel generation declined in 2020 and is expected to do so again in 2021. However, the reduction in 2021 is anticipated to be at a much lower rate than in previous years.
- In grid storage, most of the 2020 decline in investments stemmed from a reduction in China. The majority of the decrease came from the distribution sector. Targets for rural power grid expansion were met and focus was shifted to transmission, which represented a smaller share of grid investments.
- China's spending on energy R&D was nearly US$ 8.3 billion in 2020.

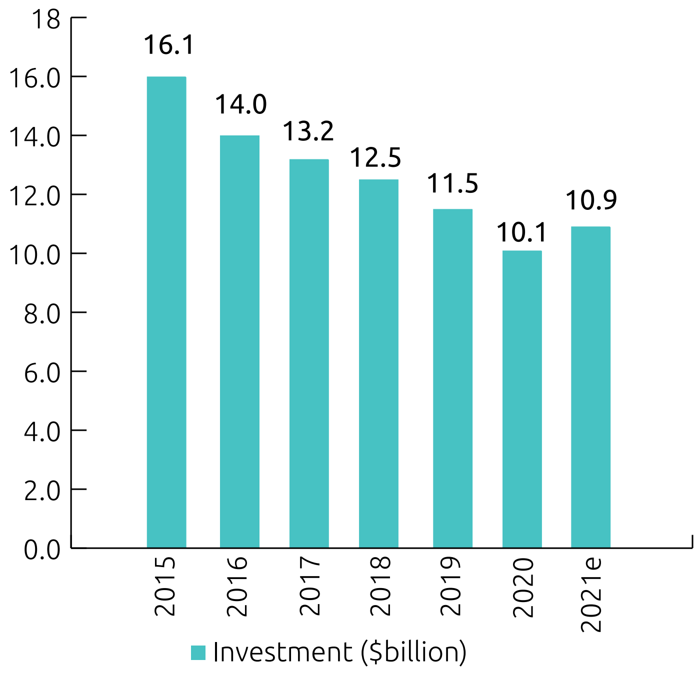
Insights:

- As per Global Transmission Research, China, is expected to invest over CNY 1,148 billion during 2021–2025 in grid projects, including Ultra-High Voltage (UHV) schemes.
- China is developing a green bond market to finance the industry. In the first quarter of 2021, China sold $15.7 billion worth of green bonds, which is the most in the world, despite the market still developing.
- In June 2021, China announced a draft policy to significantly increase its current energy storage capacity in the next five years. The policy plans to accelerate the country's storage capacity, excluding pumped hydro, to 30 GW by 2025.

FIGURE 13

China Investment in energy transition – 2020 (US$ Billion) and Renewables for end-use (US$ Billion) for 2015 – 2021e

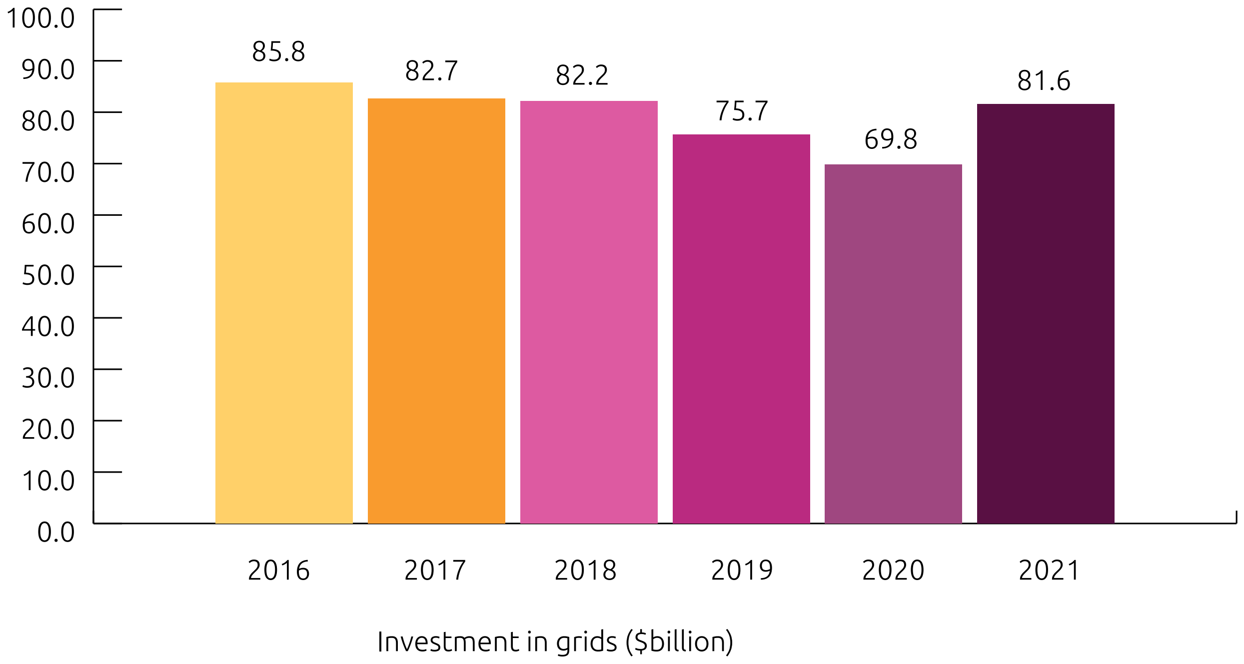




Source: BloombergNEF; IEA - World Energy Investment 2021
Link1: https://www.infrastructureinvestor.com/global-investment-in-the-energy-transition/
Link2: https://iea.blob.core.windows.net/assets/a9da6027-f7c7-4aeb-9710-4f66906c59ab/WEI2021ForWEB.xlsx
World Energy Markets Observatory 2021

FIGURE 14

China's Investment in grids (US$ Billion) for 2016 - 2021e



Source: IEA - World Energy Investment 2021
Link: https://iea.blob.core.windows.net/assets/a9da6027-f7c7-4aeb-9710-4f66906c59ab/WEI2021ForWEB.xlsx
World Energy Markets Observatory 2021

China's CO2 Emissions And Net-zero Target: An Overview

China has committed to achieving net-zero carbon emissions by 2060.

- To achieve the goal, the country is aiming to reduce thermal power capacity by 2030.
- In addition to not building any new coal plants, China needs to implement a range of policies to achieve its target of net-zero by 2060.
- Besides coal investments domestically, China is the largest investor in coal projects internationally. China has spent billions in coal-fired plants, and more are in the pipeline, especially through its Belt and Road Initiative (BRI).

Other goals announced by the country:

- Obtain 20% of its energy from non-fossil fuel sources by 2025, up from 15.9% in 2020.
- Reduce energy use and carbon emissions per unit of GDP by 13.5% and 18%, respectively.
- Boost nuclear power capacity to 70 gigawatts (GW), from nearly 50 GW at the end of last year.

Strategy to achieve the net-zero goals:

- China's stance on carbon emissions puts the country's 14th Five-Year Plan, which starts in 2021, firmly in focus as the main policy tool to pursue its climate goals.
- China's provincial governments are in the process of developing regional Five-Year Plans and, as required by the Ministry of Environment and Ecology (MEE), will also develop action plans to reach peak CO2 emissions.
- China is initially expected to set peak carbon emission targets for cities and highly populated and industrialized coastal regions in the coming years.
- China's state-owned enterprises are shifting towards net-zero. Three of the "big five" energy giants have committed to peak before 2025 or to reduce coal consumption.
- The People's Bank of China (PBOC), China's financial policy regulator, has also made carbon neutrality a priority in 2021.

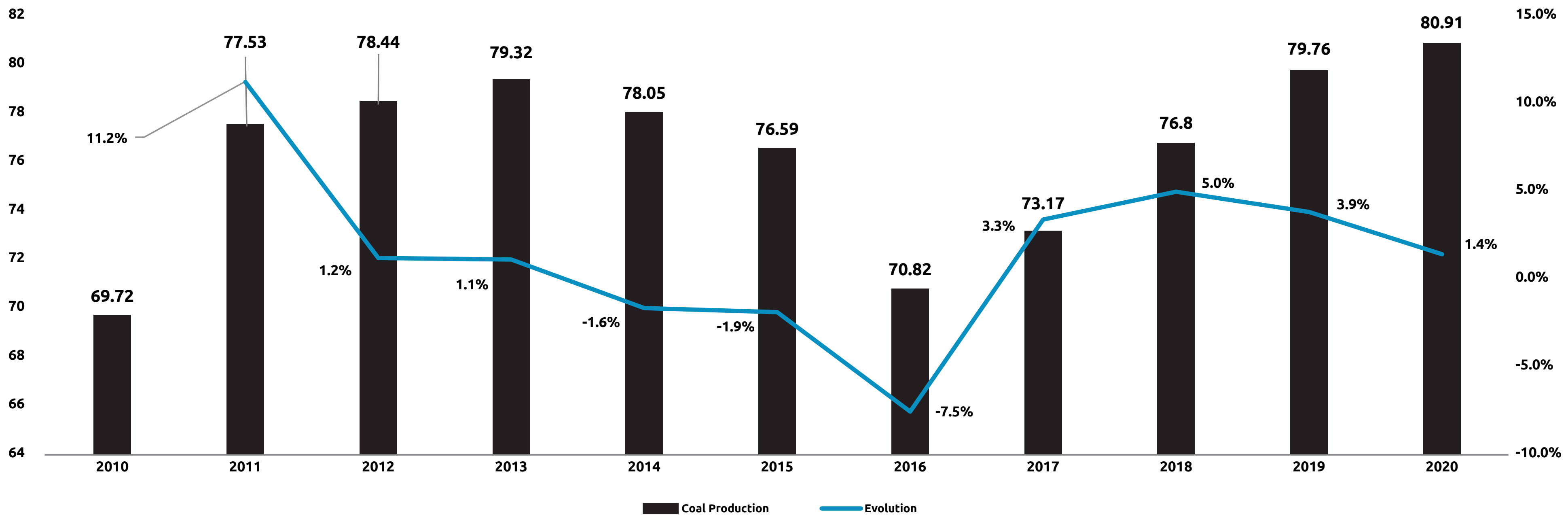
Industrial strategy and policy:

China's State Council issued the guideline to accelerate the development of a green- and low-carbon circular economic development system.

- This policy document describes actions in six areas: industrial production, logistics, infrastructure, consumption, innovation, and enabling policies.
- It states that, "…by 2035, energy and resource utilization efficiency in key industries and for key products is expected to reach an internationally-advanced level".
- With China's industrial sector accounting for over 65% of the total carbon emissions in 2019, more aggressive decarbonization of this sector would help capture a large portion of China's mitigation potential.
- In the transport sector, the Ministry of Industry and Information Technology issued its New-Energy Vehicles Development Roadmap 2021-2035, which aims to improve the NEV share of all sold vehicles to around 50% by 2035 — with the other half being eco-friendly.

FIGURE 15

China: Total coal production (Exajoules) (2010-2020)



Source: BPStats
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

FIGURE 16

China: Net-zero Target In Detail and Commitments Made By State-Owned Generators

OVERVIEW OF CHINA'S NET-ZERO PLANS	
Net-zero target, if any	• Net-zero carbon emissions by 2060
Status of the legislation	• Medium-term targets under the net-zero goal will be formulated in Five-Year Plans, including the 14th Five-Year Plan (2021-2025)
Public investment announced alongside the net-zero target	• No such announcement available yet
Renewable energy targets	• By 2030, lower carbon intensity levels by more than 65% from 2005
Installed wind capacity as of the end of 2020	• Reduce share of non-fossil fuels in primary energy consumption to around 25% by 2030 • Increase installed capacity of wind and solar power to more than 1,200 GW by 2030
Key technology strategy on energy transition	• 272 GW onshore and 9 GW offshore
Nationally determined contributions (NDC) as of February 2021	• Wind and solar power will take a leading role, with nuclear and hydropower as subsidiary elements • Innovative grid system • Storage, hydrogen, and carbon capture and storage (CCS) technologies to scale up
Other drivers of clean energy transition	• National carbon trading market will be established in 2021• Promote industrial restructuring • Improve energy efficiency (industry, building, transportation, public institutions) • Establish market mechanisms (pricing, taxes, financial) for low-carbon development • Increase carbon sequestration capacity

FIGURE 17

CARBON REDUCTION COMMITMENTS MADE BY STATE-OWNED GENERATORS IN CHINA		
Company	**Peaking Target**	**Capacity Target**
SPIC	Emissions peak by 2023	• Clean energy accounts for 60% by 2025 and 75% by 2035
CHN Energy	Emissions peak by 2025	• 70-80 GW renewables added by 2025
Datang	Emissions peak by 2025	• Clean energy accounts for 50% by 2025
Huadian	Emissions peak by 2025	• 75 GW new energy added by 2025, and clean energy accounts for 60% by 2025
Huaneng	Not disclosed yet	• 80 GW new energy added by 2025; clean energy accounts for 50% by 2025 and 75% by 2035
CGN (China General Nuclear)	Not disclosed yet	• 30 GW renewables added by 2025
CTG (China Three Gorges)	Emissions peak by 2023	• New energy reaches 70-80 GW by 2025 and carbon neutrality by 2040

CO_2 Emissions, Net-zero Target: Implications And Measures Taken In Response

The share of coal is still high despite a net-zero target and the measures taken in response:

China remains committed to supporting the coal industry while the rest of the world experiences a decline. It is now home to half of the world's coal capacity.

- The economic downturn from the pandemic has lowered China's emissions trajectory despite its coal consumption.
- China's coal activities remain a large concern and are inconsistent with the Paris Agreement.
- After lifting a previous construction ban on new coal plants in 2018, China has rolled back policies restricting new coal plants permitting them during the last three years.
- By mid-2020 China permitted more new coal plant capacity than in 2018 and 2019 combined, bringing its total coal capacity in the pipeline to 250 GW. 10 GW of new plants were brought online.
- Applications for new coal-fired power plant permits spiked in the following months, leading to over 40 GW of new proposed plants and 17 GW of new plants permitted before July 2020. This is a clear discrepancy with global trends, as coal capacity outside China has been decreasing since 2018.
- Also, China is going against the global shift away from coal and now possesses roughly half of the world's coal power capacity and coal-fired power plants in development.

Implications:

- China needs to phase out coal before 2040 under 1.5˚C compatible pathways, but it appears to be going in the opposite direction.
- China must use further stimulus in Q3 and Q4 to clamp down on what may be the start of a new coal boom and dedicate recovery efforts to low-emissions infrastructure and clean energy projects, particularly ahead of finalizing the 14th Five-Year Plan (FYP) next year.

Measures taken in response and possible measures ahead:

- In September 2020, President Xi made a pledge to the UN General Assembly to have CO2 emissions peak before 2030 and achieve carbon neutrality before 2060. It was an important commitment made from the China government.
- The 14th FYP is expected to carry new caps for coal and benchmarks for renewables. The energy policies it contains could have the largest medium-term implications for the global energy portfolio from any single legislative document.
- The 14th FYP sets legally binding targets to reduce carbon emissions per unit of GDP by 18% in the next five years. It calls for the implementation of supplementary regional absolute carbon caps and locks in efforts to achieve carbon neutrality by 2060. In general, it calls for the adoption of policies and measures with higher impact.
- In 2020, the government issued a draft of its first-ever Energy Law, which highlights the importance of energy efficiency and renewables without making concrete commitments.

State-owned enterprises shifting to net-zero:

- State Grid released its action plan towards carbon neutrality on March 1, the first of its kind among state owned enterprises (SOEs).
- Many other big coal and oil SOEs, including CNE, CNOOC (China National Offshore Oil Corporation), and Sinopec, have kicked off research to develop carbon neutrality action plans.
- However, short-term efforts from all energy giants are still needed to significantly reduce coal use to achieve the long-term net-zero goal.

China: Electric Vehicles (EV) Sales And Market

Nearly 60% of two/three-wheelers sold in 2020 were electric, according to the International Energy Agency (IEA)

- China maintained its lead in the electrification of this transport segment.
- In China, electric car sales reached 1.3 million in 2020, as compared to 1.1 million in 2019, representing a growth rate of 18%.
- Individual EV consumption increased to nearly 70% in 2020 from 20% two years ago.
- China Association of Automobile Manufacturers is expecting sales to reach 1.8 million in 2021.
- For light-duty vehicles (LDVs), China is expected to reach 35% EV sales by 2030. The country is also projected to achieve 43% EV sales by 2030, as outlined in the Sustainable Development Scenario. The China Society of Automotive Engineers set the goal of over 50% EV sales by 2035.
- Electric truck sales share in 2030 is expected to reach 5% in the Stated Policies Scenario and over 15% in the Sustainable Development Scenario.
- In the Stated Policies Scenario, EV sales share across all modes (excluding two/three-wheelers) will surpass 30% in 203 and exceed 40% in the Sustainable Development Scenario.

By 2030, 40% of vehicles sold in China will be electric according to the Massachusetts Institute of Technology (MIT)

- The Chinese government has imposed policies to encourage the adoption of plug-in electric vehicles (EVs).

Major EV policies implemented from January 2020:

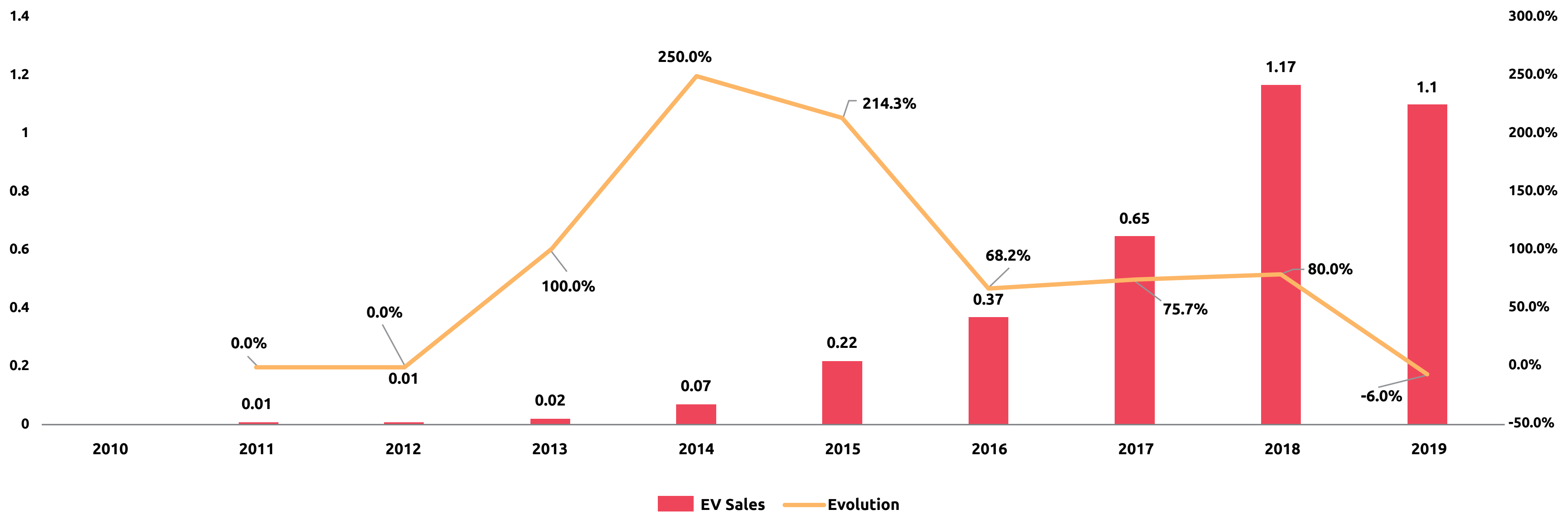
- New energy vehicle (NEV) mandate: 12% credit target (with annual tightening until 2023).

Stimulus policies announced as a response to the COVID-19 crisis:

- Full NEV subsidy program phase-out postponed from the end of 2020 to the end of 2022. (Beginning in April 2020, NEV subsidies will be reduced by 10% from 2019-2020, and an additional 20% in 2021).
- Relaxation of car permit quotas in several cities.

FIGURE 18

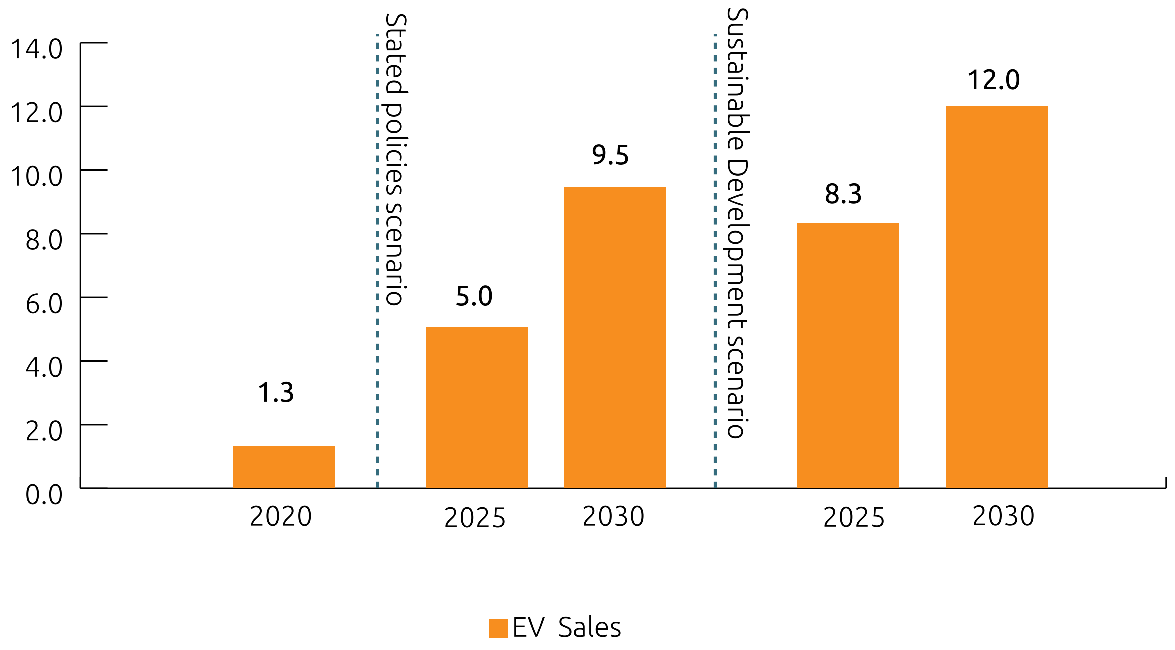
China Electric Vehicle sales (2010-2019) (Millions)



Source: IEA
Link: https://www.iea.org/data-and-statistics/charts/global-electric-car-sales-by-key-markets-2015-2020

FIGURE 19

China EV sales projections by scenario, 2020-2030 (Million)



Source: IEA
Link: https://www.iea.org/reports/global-ev-outlook-2021/prospects-for-electric-vehicle-deployment
World Energy Markets Observatory 2021

China: Green Hydrogen

In China, commercialization of green or renewable-based hydrogen is getting closer to becoming a reality, with a growing number of solar and wind power-to-gas (P2G) projects emerging in the past few months:

- Green hydrogen made with water and renewable power has emerged as a "silver bullet" technology to clean up many CO2-intensive sectors where emission reductions are particularly difficult, such as heavy industry and aviation.
- To date, high costs stood in the way of global deployment in the fight against climate change.
- Green hydrogen remains more expensive than the conventional variety made from fossil fuels because the equipment to make it is costly and because the process requires enormous amounts of power.

As part of its zero-emission pledge, China is increasing its policy focus on green hydrogen to support the decarbonization of hard-to-abate industrial sectors, particularly in heavy transport and industrial processes:

- China aims to increase its use of hydrogen as an energy source.
- Ongoing investment in carbon capture storage and the use of renewable energy to produce green hydrogen should accelerate the adoption of cleaner hydrogen over time.
- However, the pace of adoption will depend on technological progress and cost factors.
- China's supportive policy environment, including access to financing through the expanding green-financing system, will help companies absorb higher capital and operational expenditure requirements and limit any near-term credit impact.

China's emerging hydrogen strategy:

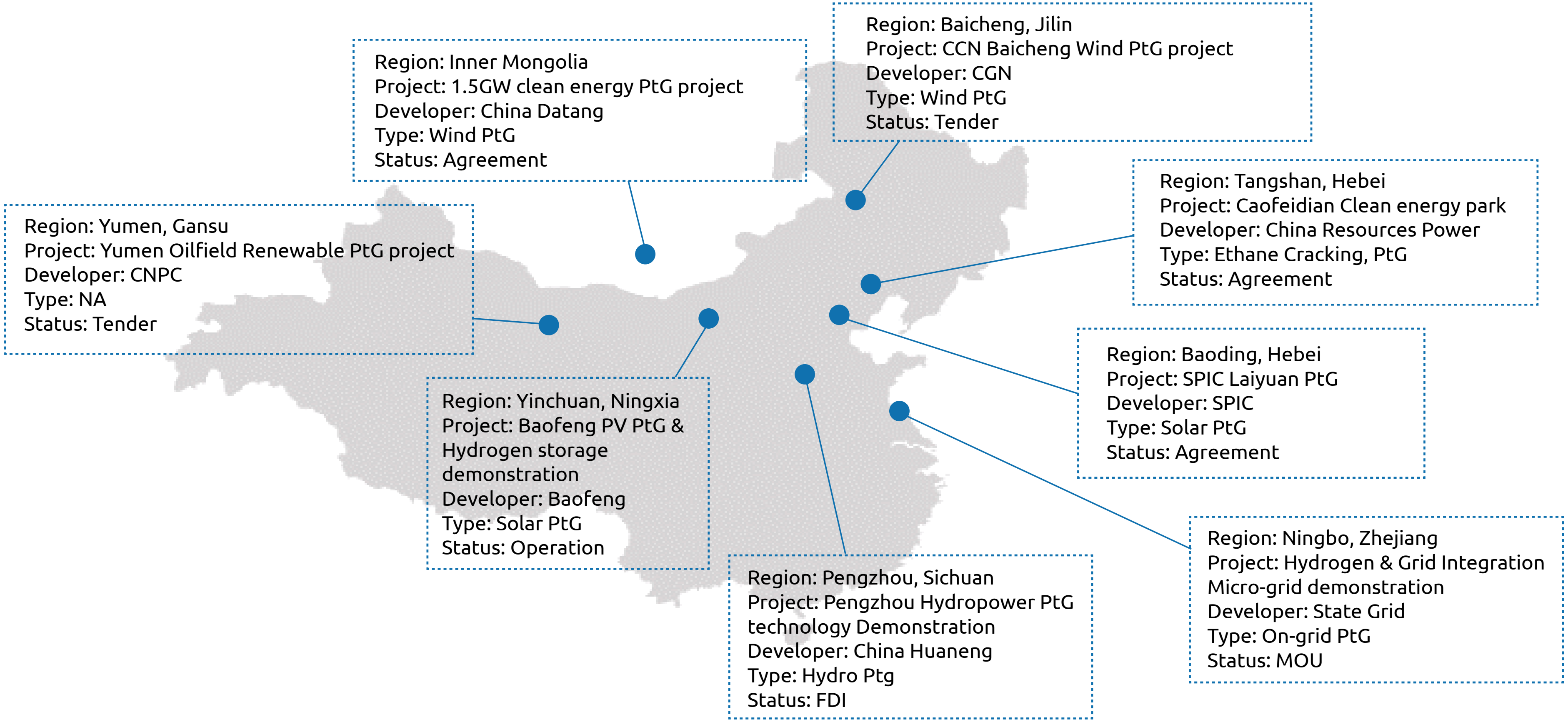
- The country's hydrogen production was estimated at 22 million tonnes (Mt) by the China Hydrogen Alliance in 2019.
- Policies aimed at developing hydrogen date back to the 10th Five-Year Plan (2001-2005) with a focus on the transport sector, as the growth of the Chinese car market and the related oil demand was deemed a source of strategic vulnerability.
- In 2016, China released its first Hydrogen Fuel Cell Vehicle (FCV) Technology Roadmap, aiming for the mass application of hydrogen in the transport sector by 2030.
  - The Roadmap included interim targets to have 5,000 FCVs in demonstration alongside 100 hydrogen refueling stations (HRS) by 2020.
  - The Roadmap also envisioned over 1 million FCVs and over 1,000 stations by 2030, when 50% of hydrogen production is expected to come from renewable sources.

Challenges in the production of hydrogen:

- In China, hydrogen is classified as a hazardous material, so its production, transportation, refueling, and storage are strictly regulated, resulting in low transportation efficiencies and high costs.
- While hydrogen has been designated as a key technology to develop in the energy vehicle market, the government has promoted electric vehicles (EVs) more aggressively. The cumulative stock of EVs exceeded 4 million units compared to 7,000 FCVs sold in China by mid-2020.
- China currently lacks the key technologies to enable renewables-based hydrogen production. It lags behind advanced economies in hydrogen storage, transport technologies, and manufacturing capacity for key materials.

FIGURE 20

China Green Hydrogen Projects: An Overview



Since 2019, China Has Had More Than 30 Green Hydrogen Projects In Development Or Planning

Initiatives for green hydrogen transition:

- In May 2021, China Petroleum and Chemical announced plans for its first solar and wind-powered green hydrogen project, also in Ordos, in 2022.
- Beijing Jingneng Power, a state-owned coal power producer, is building a US$ 3.57 billion green hydrogen plant in Ordos (north China's Inner Mongolia autonomous region) to be powered by solar and wind energy.
- In April 2021, Chinese state-controlled oil firm Sinopec and solar manufacturer Longi Green Energy Technology teamed up to advance the green hydrogen transition, while government policies center on downstream hydrogen applications. A co-operation framework signed on April 13th is a commitment to help Sinopec build its photovoltaic assets, which will be vital for the oil firm's transition to low-carbon or green hydrogen production at the center of its decarbonization strategy. However, no details of a plan for the partnership have been announced.
- Datang announced an investment in a 6MW solar-based hydrogen production demo project in the Datong City of Shanxi Province.
- China Huaneng, the second-largest power company in China, has cemented a deal with the Jilin Baicheng government to develop a 2GW wind farm with a P2G system.
- Huadian plans to co-develop a 100MW solar project with hydrogen automotive company Weichai in Weifang of Shandong. The power generation will be used to support green hydrogen production.
- China will spend billions on hydrogen vehicles despite a minimal supply of clean H_2.
    - Incentivized by government subsidies, 35 projects related to fuel cells, fuel-cell vehicles, and hydrogen refueling stations worth a combined CNY 110 billion (US$ 17 billion) were signed in the first five months of 2021.

Locals lead renewable hydrogen policymaking:

- Several local governments have established hydrogen that encourages the use of green hydrogen and the adoption of renewable power-to-gas (P2G). For example:
    - Guangdong province released a New Energy Industry Fostering Plan for the coming 14th Five-Year Plan period (2021-2025). The province promised (despite its vague terms) to promote chemical by-product hydrogen sources and clean-energy-based H2 production.
- Guangzhou announced a hydrogen development plan with a ten-year span (2019-2030), where the capital city promised to build up over ten green-hydrogen power peakers.

04 Climate Change & Energy Transition

04

04 Climate Change & Energy Transition

India Energy Transition

Nupur Sinha
Ankita Das
Agathe Nicolas

India's energy sector overview: Energy consumption has more than doubled since 2000

India's increase in energy consumption is due to a growing population

- In 2019, almost every household had access to electricity, meaning that over 900 million citizens gained an electrical connection in less than two decades.
- Over 80% of India's energy needs are met by three fuels including coal, oil, and solid biomass. Coal has underpinned the expansion of the electricity generation and industry. It remains the largest contributor to the energy mix.
- Biomass (primarily fuel-wood) makes up a declining share of the energy mix. However, it is still widely used as a cooking fuel.
- Natural gas and modern renewable sources of energy were least affected by the COVID-19 pandemic in 2020 and have started to gain ground.
- In particular, the use of solar PV has been accelerating. This resource has huge potential and therefore has high ambitions with policy support. Furthermore, overall technology cost reductions have quickly made solar PV the cheapest option for new power generation.
- India is the third-largest global emitter of CO_2 (despite low CO_2 emissions per capita). Specifically, the power sector's carbon intensity is well above the global average.
- India has a wide range of policies in place that aim to bring about a secure and sustainable future for energy.

The COVID-19 pandemic disrupted India's energy usage

- According to the IEA, India witnessed an estimated decrease of approximately 5% in the country's energy demand in 2020. This was due to lockdowns and related restrictions, with coal and oil use suffering the most.
- The pandemic also disrupted investments in the energy sector, which fell by an estimated 15% in 2020. This exacerbated financial strain across the board, particularly among India's electricity distribution companies.
- The immediate challenge is financial liquidity. Analysts expect distribution companies' annual losses to double to around $15 billion, which will enhance the cash scarcity and make new investments challenging.
- Before the pandemic, about 90% of power was coming from power purchase agreements (PPAs). Post-pandemic, the demand is down. While power exchanges now have very low prices, PPAs have limited the value of cheap third-party supply.

Since the beginning of the COVID-19 pandemic in early 2020, India has committed a minimum of $135.66 billion to support different energy types through new or amended policies. More specifically, India has committed at least:

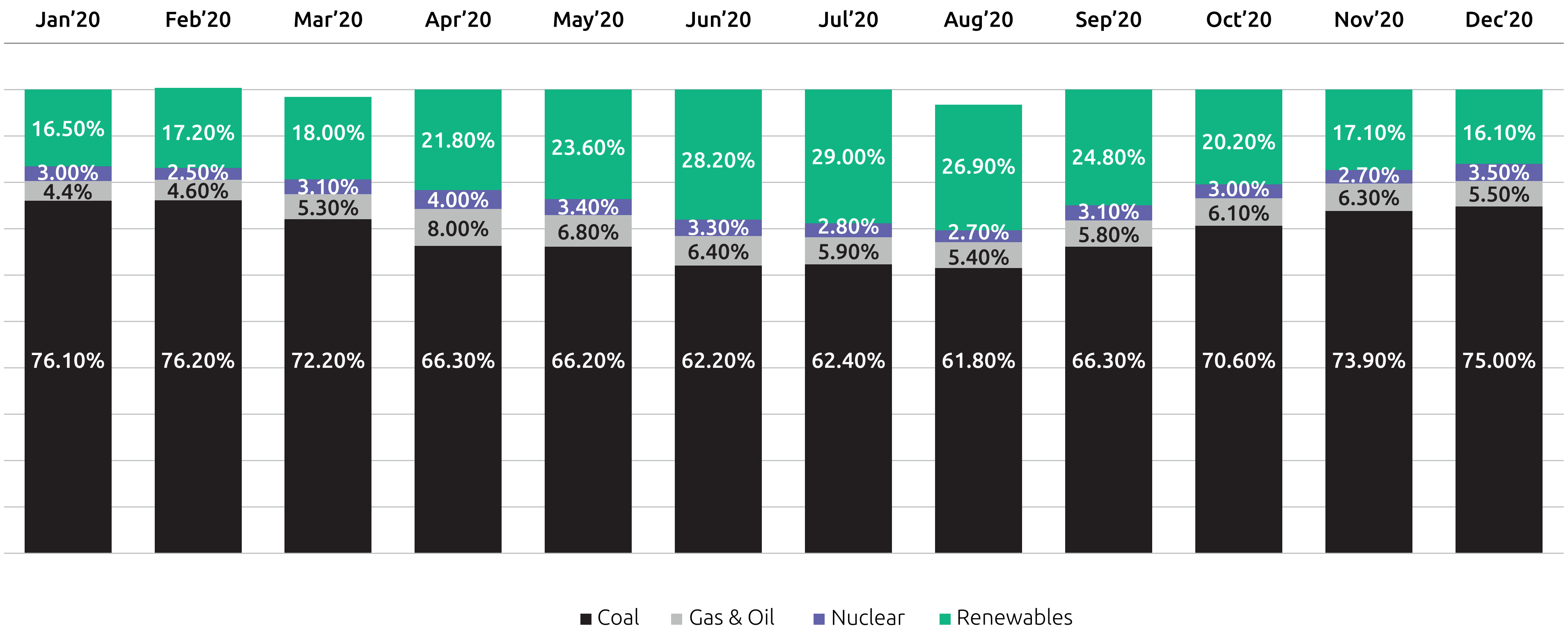
- **$24.39 billion** to **unconditional fossil fuels** through 27 policies.
- **$6.42 billion** to **conditional fossil fuels** through six policies.
- **$4.69 billion** to **unconditional clean energy** through 20 policies.
- **$31.39 billion** to **conditional clean energy** through 14 policies.
- **$68.77 billion** to **other energy** through 13 policies.
- **$6.5 billion** to **Oil and Gas**

In addition, India also committed at least:

- **$23.68 billion** to **coal.**
- **$13.49 million** to **multiple fossil fuels.**

FIGURE 1

Electricity mix in India, January-December 2020



Source: IEA – Dec 2020
Link: https://www.iea.org/data-and-statistics/charts/electricity-mix-in-india-january-december-2020

The impact of COVID-19 on energy demand: High rural consumption is expected to revive demand sooner than expected

The resurgence of COVID-19 infections and the possibility of new restrictions pose a risk to the sustainability of the economic revival and, by extension, power demand

- The country's power demand fell by 25% in 2019. Due to the nationwide lockdown imposed on March 25, 2020 (to contain the spread of the pandemic), the demand was at a historic low in April 2020. As the lockdown was eased in May 2020, commercial centers, manufacturing units, and offices were either closed or operating at a lower capacity. The decrease in demand continued until August 2020.
- Industrial and commercial consumers usually contribute to the power demand at a large scale (followed by the agricultural and residential sectors). Manufacturing units are gradually returning to normal as several office complexes are now open with full or partial capacity.
- However, credit rating agency ICRA Ratings stated that, "It is not industry which is fueling power demand. Demand recovery has been led by states with high rural consumption, while the states with high industrial consumption are showing a slow recovery."

The peak power demand in India in FY 2021 (YTD) is 1.31% lower than FY 2020, even after reducing the COVID-induced slowdown

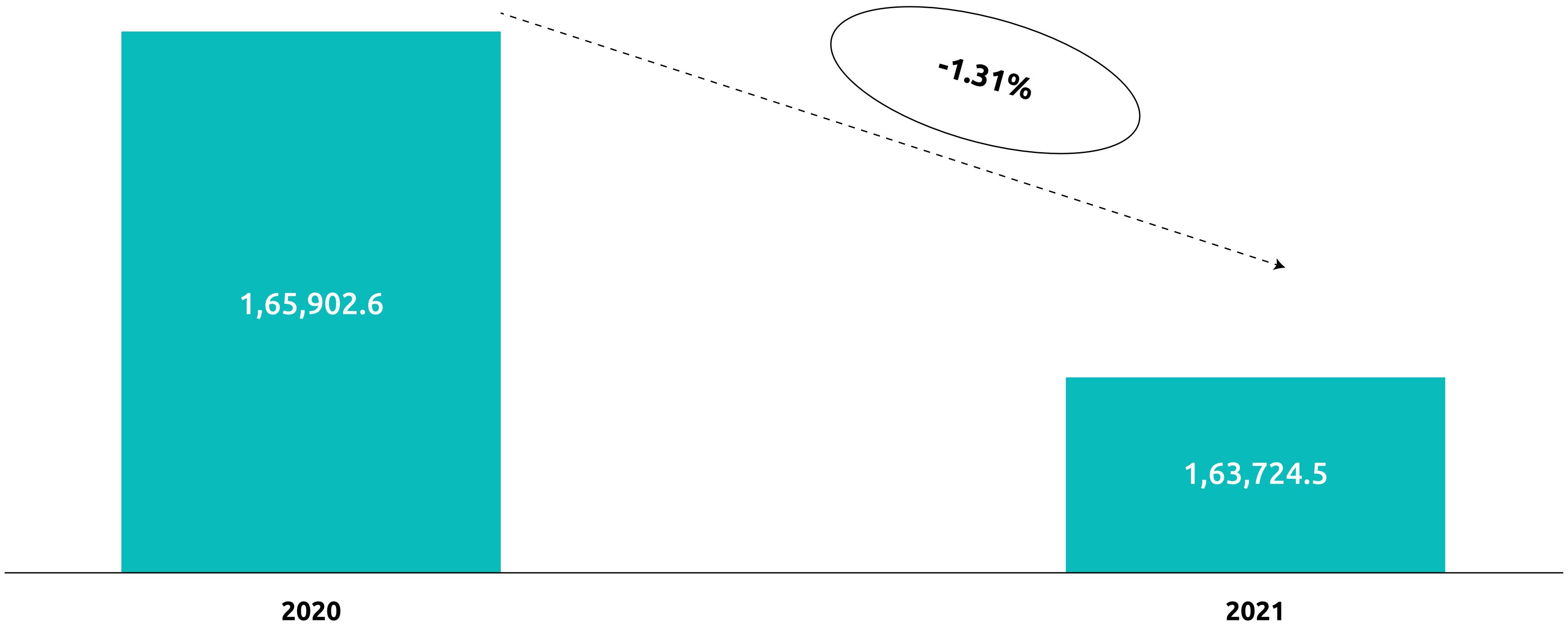
- Towards the end of the financial year, robust growth in demand was declining to the levels of the year 2019.
- In contrast, monthly demand showed a considerable improvement in comparison to peak lockdown months. This was mostly due to thermal power.
- Peak power demand in March 2021 was similar to demand in April 2019, standing at 170.6 GW (up from 157 GW in March 2020).
- DAM Capital Advisors stated, "peak energy demand, which is reflective of per capita consumption, showed flat growth which grew 3.8% on year-on-year basis and demand in March was 23% higher than last year."

According to India Ratings and Research, the lockdowns (due to a rise in COVID cases in various states) are anticipated to impact all of India's energy demand growth recovery in 1Q FY 2022. However, demand is expected to be higher due to lower base effect

- From March 2021, energy demand increased by 22.8% year-on-year to 122 billion units. The early onset of summer was a main contributor to the higher demand.
- Electricity generation increased by 23.5% to 118.6 billion units, supported by 29.2% in thermal generation. However, hydro generation was down by 7.8%.
- According to India Ratings and Research, electricity generation from renewable sources increased by 10.1% with solar generation increasing by 21%.
- Despite the early onset of summer, the imposition of stricter lockdowns in major manufacturing states (due to third wave of COVID cases) may have impacted demand from industrial segments, further impacting thermal plant load factors (PLFs).

FIGURE 2

India Yearly comparison of power demand (MW)



Source: National Load Dispatch Center, Central Electricity Authority
Link: https://www.business-standard.com/article/economy-policy/india-enters-new-fiscal-with-negative-power-demand-robust-growth-missing-121040100418_1.html

According to the IEA's Stated Policies Scenario (STEPS), India accounts for nearly one-quarter of the global energy demand growth between 2019-40 more than any other country

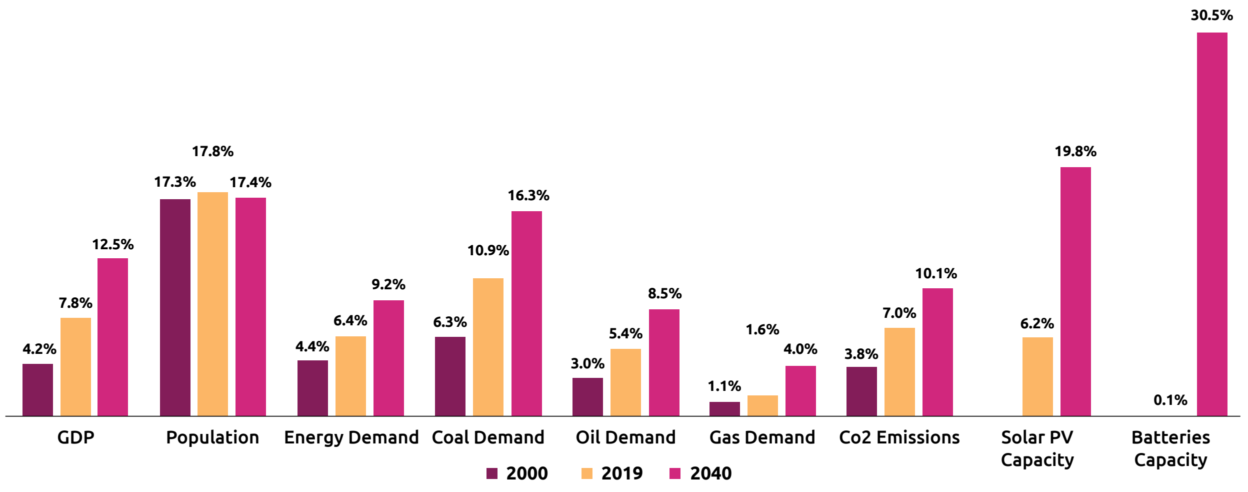
India has become a world leader in battery storage, evidenced by significant usage of solar PV

- By 2040, India's power system is estimated to dominate that of the EU, becoming the world's third largest growth market. India is currently the second largest growth market for renewable energy after China.
  - India's growing strength in the global industrial economy has important implications for coal and gas markets. As stated in STEPS, India leads global oil demand growth (on the back of a fivefold increase per capita in car ownership). India is also becoming the fastest growing market for natural gas.
  - STEPS also states that India is one of the very few sources of coal growth; it is largely used for industrial needs.
  - According to STEPS, India already imports around 40% of its primary energy and is estimated to remain at this level in 2040. However, India's combined import bill for fossil fuels is likely to triple, with oil being the largest component by far.
  - The rapidly increasing requirement for flexibility in the power system's operation is a potential hazard for electricity security in India.
- STEPS claims that the growth in India's annual CO_2 emissions will slow down steadily over time. This is largely due to power sector emissions plateauing after 2030, as a result of the rising share of renewables in electricity generation.

India's choice in technology must consider water availability and competing water demands. Since thermal power plants are already vulnerable to water stress, some low-carbon energy options (most notably nuclear, bioenergy, and concentrating solar power) could, without careful planning, be limited by water availability in the future.

FIGURE 3

India's share of selected global indicators, 2000, 2019 and 2040 in the Stated Policies Scenario



Source: India_Energy_Outlook_2021
Link: https://www.iea.org/data-and-statistics/charts/india-s-share-of-selected-global-indicators-2000-2019-and-2040-in-the-stated-policies-scenario

Energy mix: Coal continues to account for ~71% of energy generation in 2020

Coal and Oil & Gas capture the maximum share in energy consumption by fuel

- ***Coal:*** Accounting for over 71% of India's electricity production in 2020, India had the second-most coal-intensive electricity sector among the G20 countries. India also increased its coal generation by 9% between 2015 and 2020.

- ***Oil & Gas:*** India's gas generation increased by 12 TWh in 2020. The country is highly dependent on oil and gas imports, which in 2019 totaled around 229 million tonnes (MT). The total installed capacity of oil- and gas-based thermal power stood at 638 MW and 24,937 MW, respectively, in 2019.

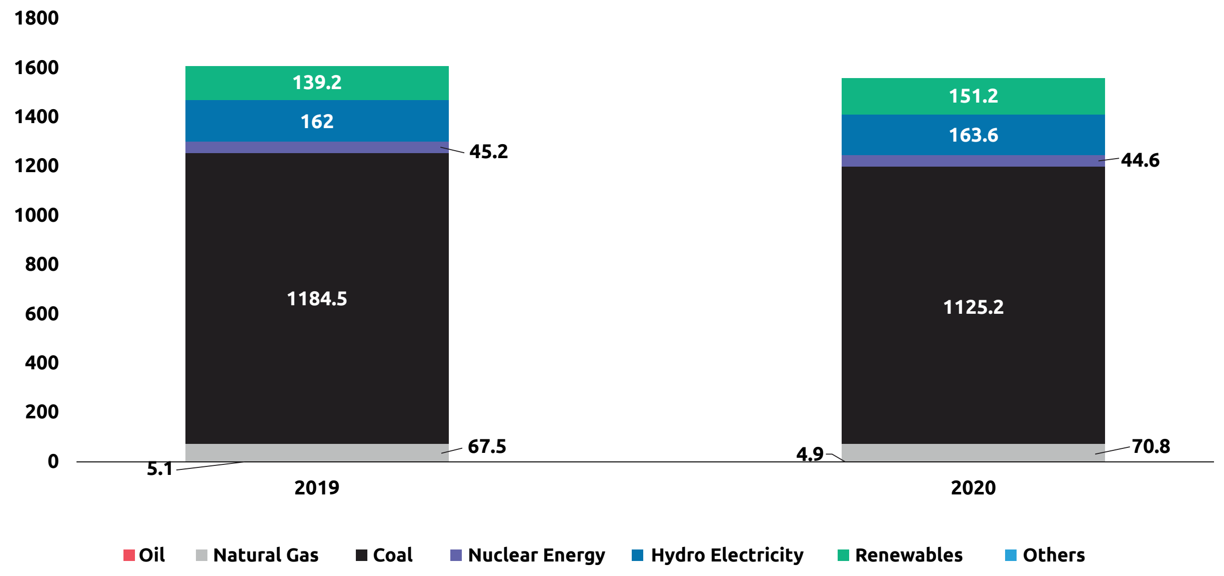
- ***Hydropower:*** In 2019, India had 45.4 GW of hydropower-generating capacity from more than 20 hydroelectric dams. According to the Ministry of Power, the country's hydropower potential is around 145 GW. However, the share of hydropower generation has been declining over time, due to energy from other sources increasing at faster rates and a lack of focus from both government and the private sector.

- ***Nuclear:*** As of 2019, India possessed around 6.8 GW of installed capacity of nuclear energy sources from its 22 nuclear reactors. According to the International Atomic Energy Agency, India produced nearly 35 TWh of electricity through nuclear power in 2017.

- ***Renewables:*** The share of renewable energy in India's energy mix is expected to increase by 91% from 2017 to 2022, as the share of thermal generation declines. This is due to a recent growth in the renewable energy sector. The growth will occur primarily in solar and wind energy.

FIGURE 4

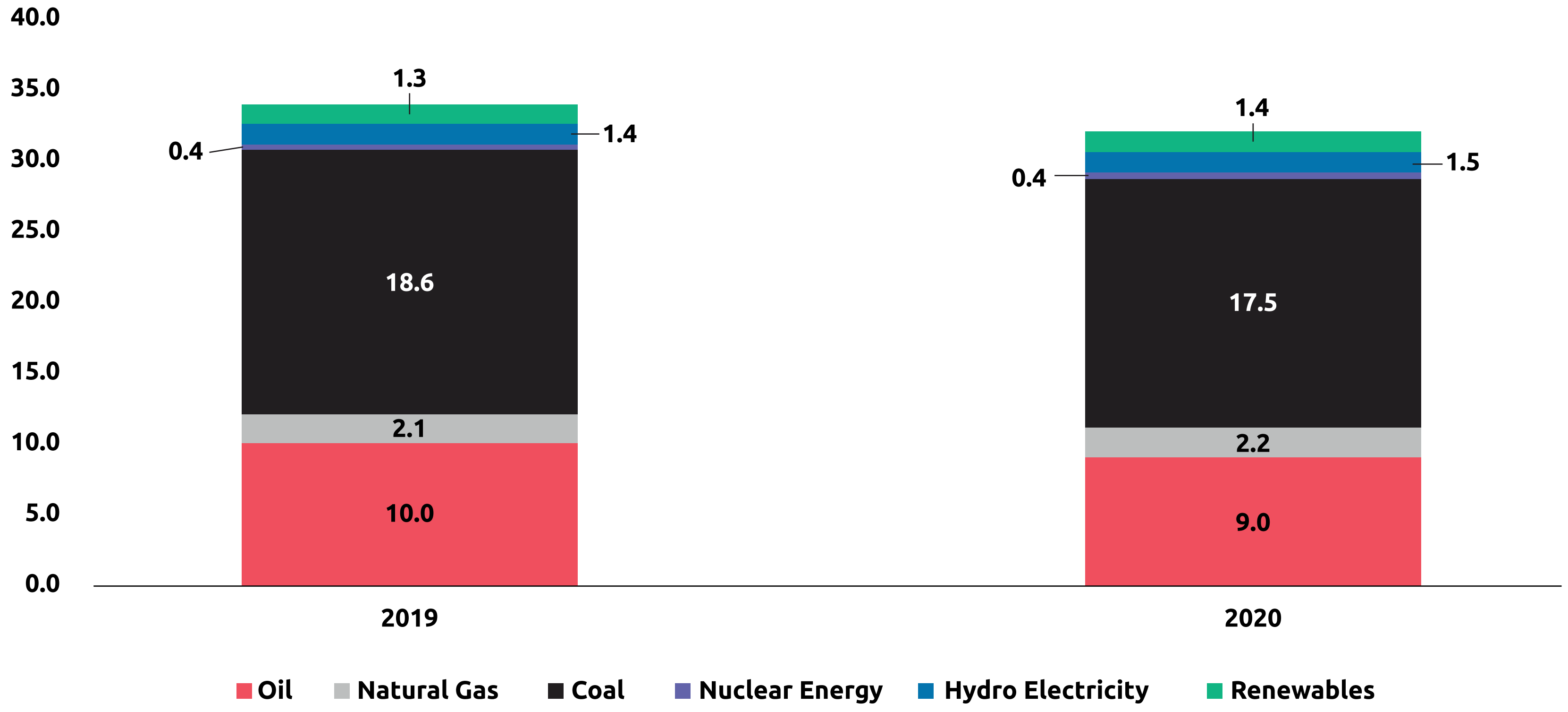
Electricity generation by fuel in TWh (2019-2020)



Source: BPStats
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

FIGURE 5

Primary energy consumption by fuel in EJ (2019-2020)



Source: BPStats
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

India's steep rise in power demand has, so far, been largely been fuelled by coal-fired generation

In 2015, India pledged a 33-35% reduction in carbon emissions intensity (compared to levels in 2005) within its economy by 2030. Since then, political shifts have directed India towards a clean energy transition

- The country remains vulnerable to climate change; droughts, floods, deforestation and depleting groundwater levels are shifting the public's opinion on sustainability.
- As a developing nation, India is still on the pathway to poverty eradication and middle-income status. Nonetheless, it has pursued ambitious low-carbon programs, including liberalization reforms to the power sector, 24/7 green power, clean cooking, and energy efficiency.
- India's renewable energy target of 175 GW by 2022 includes 60 GW of onshore wind. As of February 2021, there have been 39 GW of wind capacity installed, comprising 10.25% of the power mix.
- Growth of wind over the next five years will be driven by the expiration of the inter-state transmission (ISTS) waiver of charges, set to take place in 2023. The growth will be further encouraged by the trend of hybrid tenders that combine wind, solar, and storage technologies. The government has also shared its vision for longer-term renewable energy targets of 450 GW by 2030, including 140 GW of wind.

In the absence of a broader carbon neutrality strategy, meeting India's clean energy targets requires urgent and targeted implementation of regulatory reforms

- As well as renewables, accelerating energy generation through wind is in line with the government's principles of Aatmnirbharta (self-reliance) and "Make in India", which focuses on energy security and supply chain competitiveness.
- The development of offshore wind and green hydrogen capacity is also anticipated to further support India's shift to a more flexible, resilient, and clean energy system.

Renewable power generation: Solar and wind energy continue to grow

Growth trends across the renewable energy sector vary. However, India renewables' overall progress possible largely due to the timely energy market reforms and policy decisions

- India has seen exponential growth in its renewable energy (RE) sector in the past five years, due to a highly conducive policy environment, a steady influx of capital, falling prices, and new technologies.
- India's renewable energy growth between 2010-2020 was 18.7% CAGR. According to the India Brand Equity Foundation (IBEF), installed renewable power-generation capacity has increased over the past few years, recording a CAGR of 15.51% between FY 16 and FY 21.
- There has been a visible impact of solar energy in the Indian Energy Scenario during the last few years.
  - India's solar energy sector has emerged as a significant player in the grid-connected power generation capacity. The Gujarat Solar Power Policy (2009) and the Jawaharlal Nehru National Solar Mission became stepping stones to achieving growth.

- In comparison, the wind, biomass, and small-hydro power (SHP) segments have been on a downward spiral. Wind power saw steady growth in India for about three decades (1985-2015).

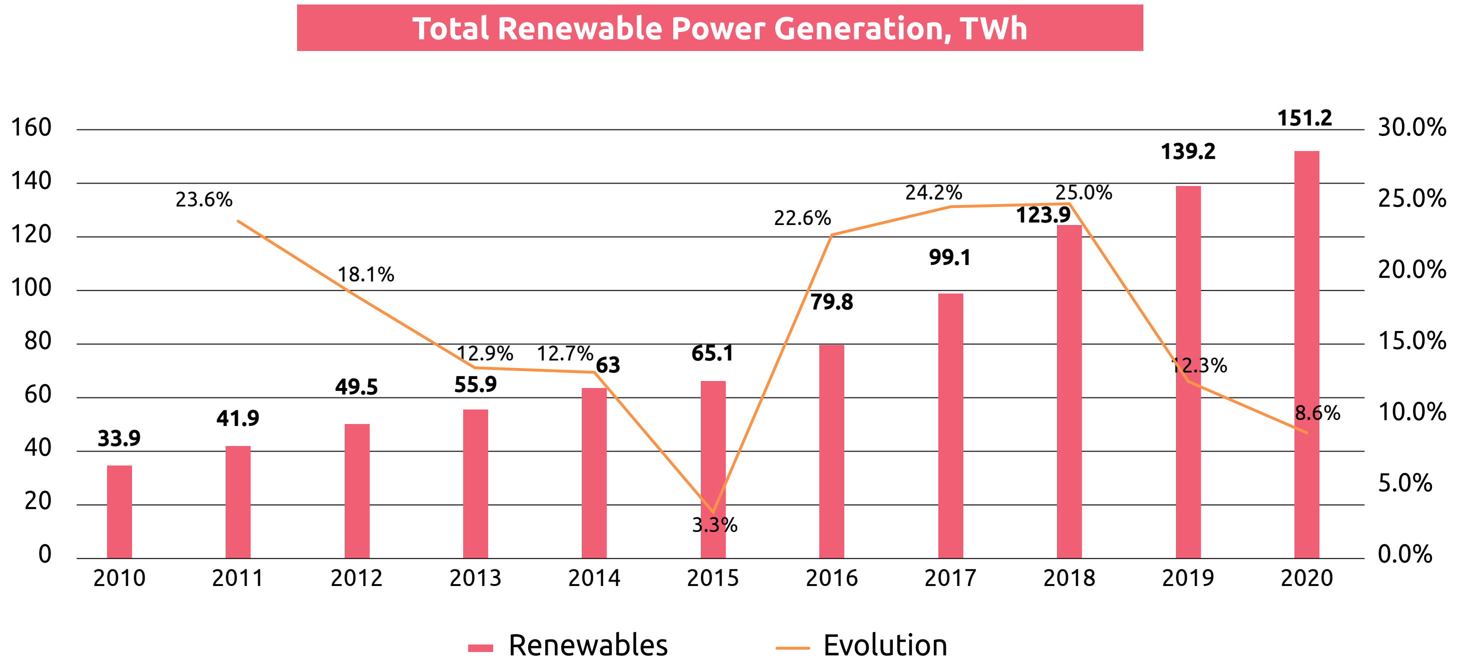
Investments and government initiatives boost the renewable energy sector

- Growing urbanization, rising incomes and a steadily increasing population will also increase consumers' demand for electricity. Studies suggest that India's share of the total global primary energy demand is set to roughly double to around 11% by 2040. This would require roughly half the additional output to come from renewables. An expansion of this magnitude will require funding of $76 billion in 2022, growing to $250 billion between 2023-30.

- India's government is demonstrating its commitment to green energy, by strengthening macroeconomic fundamentals, ensuring policy stability, and introducing several fiscal incentives. India permits 100% FDI to go towards RE projects, which facilitates an easy transfer of capital and technology.

FIGURE 6

India~ Total Renewable Power Generation (TWh) (2010-2020)



Source: BPStats
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

Renewable capacity: India has so far installed 1,34,197 MW of renewable capacity. The country's target is to install 450 Gigawatts (GW) of renewable energy capacity by 2030.

India's renewable energy sector is the fourth most appealing renewable energy market in the world. Since 2019, India has been globally ranked fifth in wind power, fifth in solar power and fourth in renewable power installed capacity.

India's renewable installed capacity has grown at a CAGR of 9.76% between 2011-2020.

- Since December 2020, India has installed 1,34,197 MW of renewable capacity. The country aims to install about 450 GW of installed renewable energy capacity by 2030 – about 280 GW (over 60%) is expected to come from solar power.
- Wind energy capacity in India has increased by 2.2 times, from FY 2016-17 to FY 2020-21.
- Solar power capacity has increased by more than five times in the last five years.
    - Before March 2019, 42 solar parks with an aggregate capacity of 23,499 MW were approved in 17 states.
    - Solar parks in Pavagada (2 GW), Kurnool (1 GW) and Bhadla-II (648 MW) were included in the top five operational solar parks of 7 GW capacity in the country.

According to data released by the Department for Promotion of Industry and Internal Trade (DPIIT), FDI investments to the Indian non-conventional energy sector stood at $9.83 billion, between April 2000 and December 2020. More than $42 billion has been invested in India's renewable energy sector since 2014.

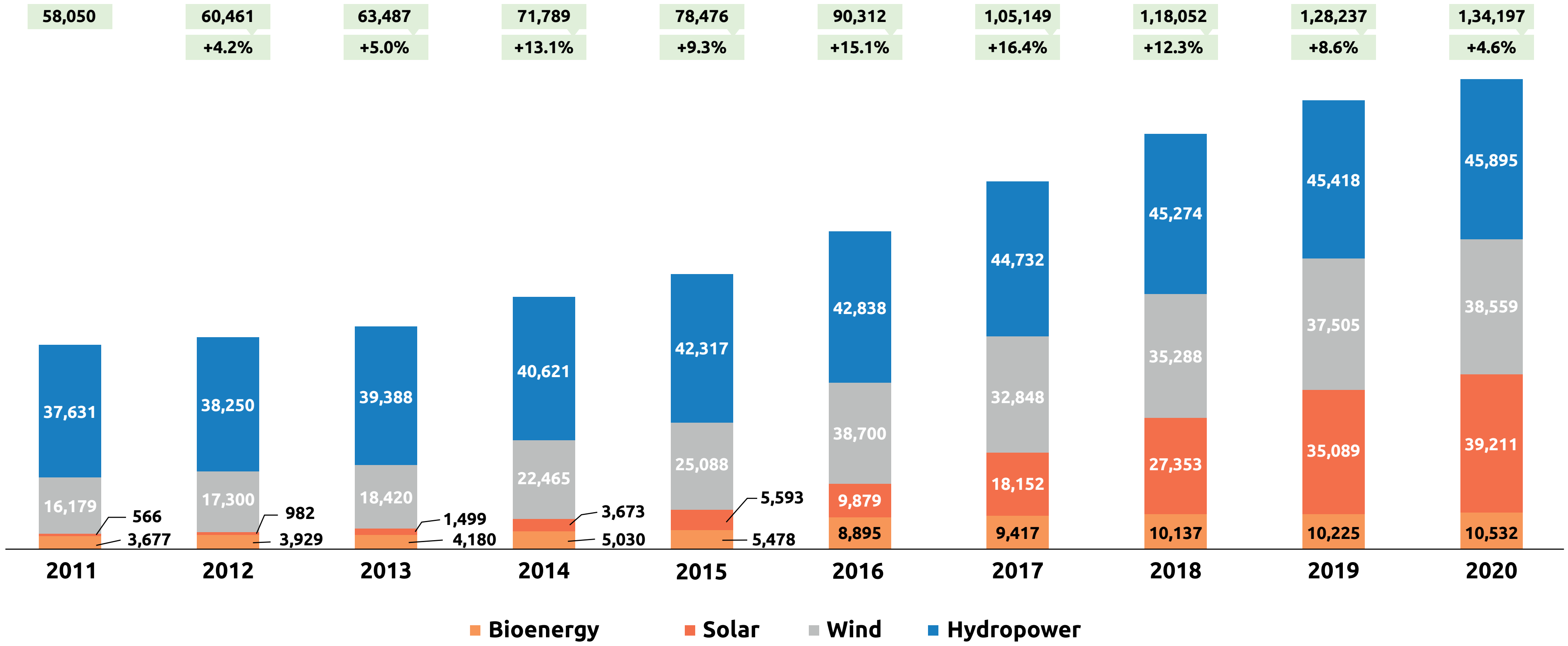
- In May 2021, Adani Green Energy Ltd. (AGEL) signed share purchase agreements for the acquisition of 100% interest in SB Energy India from SoftBank Group (SBG) and Bharti Group. The total renewable portfolio is 4,954 MW, which has been spread across four states in India.
- In April 2021, the Central Electricity Authority approved the uprating of the JSW Energy Karcham Wangtoo hydropower plant, from 1,000 MW to 1,091 MW.
- In April 2021, GE Power India approved the acquisition of a 50% stake in NTPC GE Power Services Pvt. Ltd. for INR 7.2 crore ($0.96 million).
- The NTPC is expected to commission India's largest floating solar power plant in Ramagundam, Telangana by May-June 2022. The expected total installed capacity will be 447 MW.

The financial impact of COVID is mostly affecting the renewable energy sector. With demand falling by 20–25%, the distribution companies already stand at a revenue loss of over $12 billion, making them incapable of paying for renewable electricity generators

- India previously aimed to increase its renewable energy capacity to 175 GW by 2022. Nevertheless, the growth was halted by a large margin.
- As of 2019, India has been the fourth-largest installed onshore wind market globally, with 38.06 GW of wind capacity. However, the wind installation in India is also expected to be affected by the outbreak.
- Due to COVID-19, challenges such as land acquisition, grid unavailability, supply chain bottlenecks, and a lack of project financing have occurred, making it difficult to achieve any previously set targets set by the government.

FIGURE 7

Renewable Installed Capacity, 2011-2020 (MW)



Source: IRENA, 2021
Link: https://www.irena.org/

Subsidies to India's renewable sector are falling and need renewed support

The government's push for renewable energy has been its main line of argument when defending its use of fossil fuels. However, government subsidies to the renewable sector have fallen by nearly 45% since their peak in FY 2017.

- So that India's clean energy transition is smooth, it is crucial that financial support for the renewable energy sector continues.
- Renewable energy subsidies are at a standstill due to a combination of factors, including grid-scale solar and wind achieving market parity, lower deployment levels, and subsidy schemes nearing the end of their allocation period.
- For India to reach even close to the 2030 target of 450 GW, the sector needs a strong push not only in terms of subsidies, but also through ramping up ambition by state-owned companies. There also needs to be an increase in electric mobility infrastructure, battery storage, grid storage, and other emerging clean technologies.

Major subsidies have been provided to the oil and gas sector, electricity transmission and distribution vendors, and electric vehicles

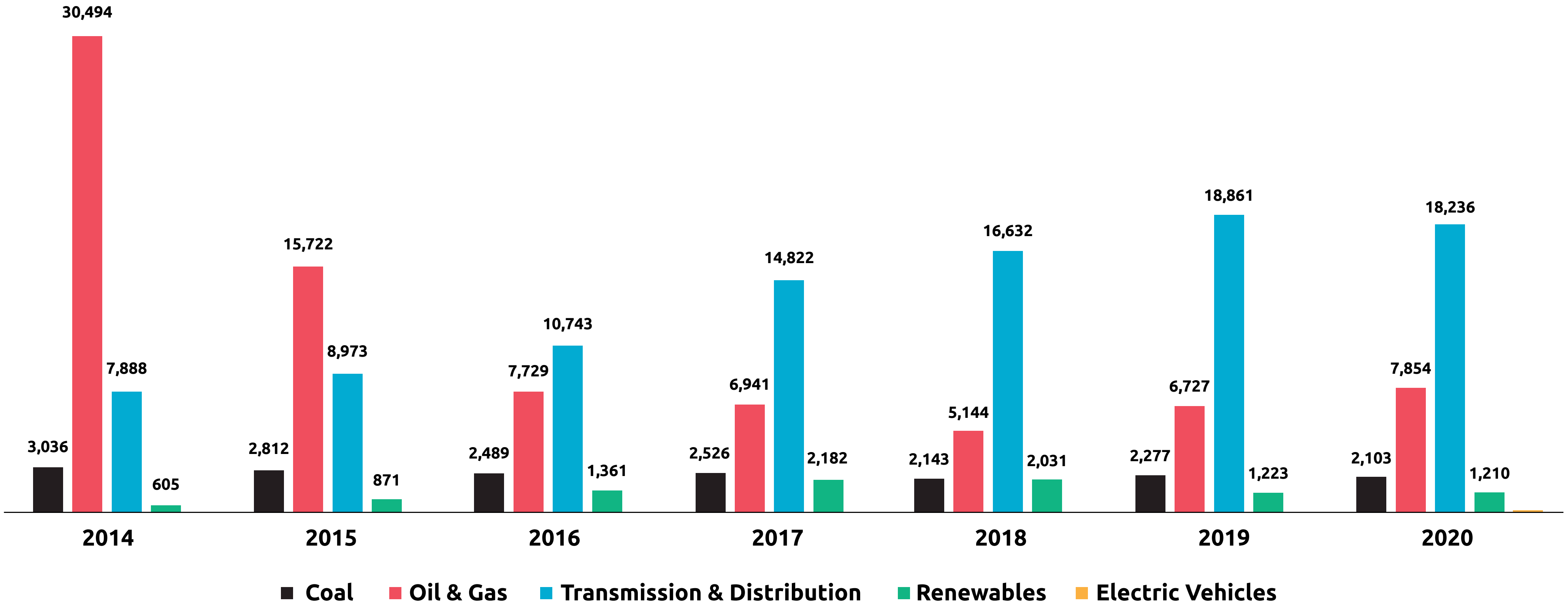
- Oil and gas subsidies jumped by about 16% in FY 2020 (compared to FY 2019) and reached INR 55,347 crore. This was due to financial support given for household consumption of liquefied petroleum gas (LPG).
- Subsidies to electricity transmission and distribution make up the largest bucket at around INR 1.3 lakh crore ($18.2 billion) in FY 2020.
- Subsidies for electric vehicles have risen more than 2.3 times, reaching INR 1,141 crore in FY 2020. This was mainly driven by growing sales. However, further support is needed for manufacturing capacity.
- Concessional tax benefits continue to be the largest subsidy for the coal sector, coming in at INR 13,154 crore and making up 87% of all coal support.

Investment trends in public sector undertakings (PSUs)

- In FY 2020, CAPEX from the 14 most significant energy PSUs stood at INR 1.6 lakh crore ($22.4 billion).
- This is a significant level of support from government owned institutions, equivalent to 76% of all quantified energy subsidies in FY 2020.
- PSUs focused on fossil fuels accounting for 77% of total CAPEX in FY 2020, while only 34% of quantified subsidies went directly to fossil fuels.
- Among these 14 PSUs, the seven Maharatnas accounted for 87% of the total expenditure, with NTPC, IOCL, and ONGC being the biggest.
- For FY 2021, the government requested oil sector PSUs to double CAPEX to stimulate economic recovery. However, early reports suggest that many PSUs have struggled to achieve their spending targets.

FIGURE 8

Total quantified energy subsidies in India, FY 2014–FY 2020 (US$ Million)



Source: Mapping India's Energy Subsidies 2021:
https://www.iisd.org/system/files/2021-07/mapping-india-energy-subsidies-2021.pdf

Crude oil production in India is dominated by two major state-owned exploration and production companies: ONGC and Oil India

The oil and gas sector is among the eight core industries in India. It plays a major role in influencing the decision-making within all other important sections of the economy.

- India is expected to be one of the largest global contributors to non-OECD petroleum consumption growth. Crude oil import rose sharply from $70.72 billion in 2016-17, to $101.4 billion in 2019-20.
- As of December 2020, India's oil refining capacity stood at 259.3 million metric tonnes (MMT), making it the second-largest refiner in Asia. Private companies owned about 35.29% of the total refining capacity in FY 2020.
- India's crude oil production fell by 5% and natural gas output slumped by 8% up until March 2021, when private and public sector firms produced less.
- According to the latest data released by the Ministry of Petroleum and Natural Gas, crude oil production fell from 32.17 million tonnes in 2019-2020 to 30.5 million tonnes in 2020-21,
- Oil and Natural Gas Corporation (ONGC) produced over 2% less oil at 20.2 million tonnes within a year, due to a nationwide lockdown.
- Oil India Ltd (OIL) produced 5.4% less oil, while fields operated by private firms, such as Vedanta's Cairn, saw 12.6% less output.

Why is India's crude oil and natural gas production falling?

Experts have noted that most of India's crude oil and natural gas production comes from ageing wells that have become less productive over time.

- Crude oil production in India is dominated by two major state-owned exploration and production companies, ONGC and Oil India.
- These companies are the key bidders for hydrocarbon blocks in auctions and were the only successful bidders in the fifth and latest round of auctions (under the Open Acreage Licensing Policy (OALP) regime). ONGC bagged seven of the eleven oil and gas blocks on offer and Oil India acquired rights for the other four.
- Experts noted that interest from foreign payers in oil and gas exploration in India had been low.
- The government has asked ONGC to boost its investments in explorations and increase tie-ups with foreign players to provide technological support in extracting oil and gas from difficult oil and gas fields.
- One of the key reasons for low private participation in India's upstream oil and gas sector (as cited by experts) are delays in the operationalization of hydrocarbon blocks. This is due to delays in major clearances, including environmental clearances and approval by the regulator of field development plans.

Here are some of the major initiatives taken by the Government of India, to promote the oil and gas sector:

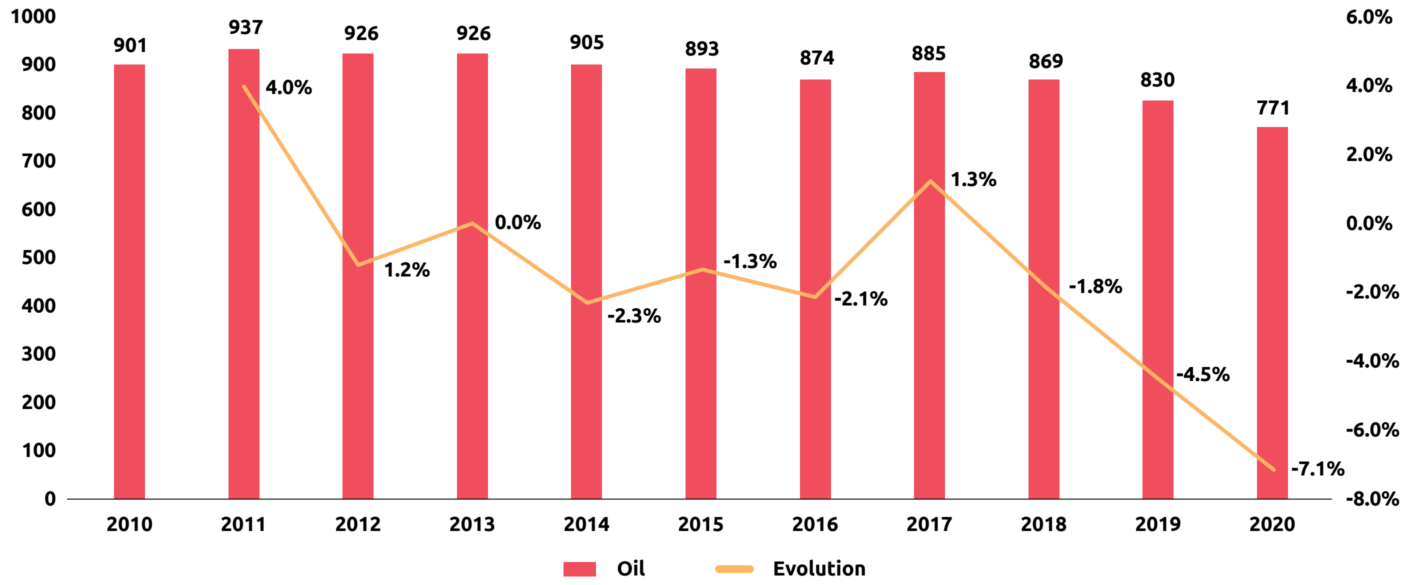
- In February 2021, Prime Minister Mr. Narendra Modi announced that the Government of India plans to invest ~INR 7.5 trillion ($102.49 billion) in the oil and gas infrastructure over the next five years.
- The government is planning to set up around 5,000 compressed biogas (CBG) plants by 2023.
- The government is planning to invest $2.86 billion in the upstream oil and gas production, doubling natural gas production to 60 bcm and drilling more than 120 exploration wells by 2022.

The future:

- Crude oil consumption is expected to grow from 221.56 million tonnes in 2017, to a CAGR of 3.60% to 500 million tonnes by 2040.
- India's oil demand is projected to rise at the fastest pace in the world, reaching 10 million barrels per day by 2030, from 5.05 million barrel per day in 2020.

FIGURE 9

Total oil production (Thousand barrels daily) (2010-2020)



Source: BPStats
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

Energy codes and voluntary rating schemes in buildings are to be mandatory, as India seeks to improve its energy efficiency

India has made significant progress on improving its energy efficiency

- India is seeking to improve the energy efficiency of its buildings through mandatory energy codes and voluntary rating schemes, as well as through programs to improve the efficiency of appliances and equipment.
  - In biomass, the pulp and paper industry focuses on improving energy efficiency. This is done by attaining power generation through an increased use of non-bagasse-based fuel (for example, wood waste), and by appropriate use of steam.
- By raising its energy efficiency ambition, India could save some $190 billion annually in energy imports by 2040 and avoid electricity generation of 875 terawatt hours per year – almost half of India's current annual power generation.

Deregulation

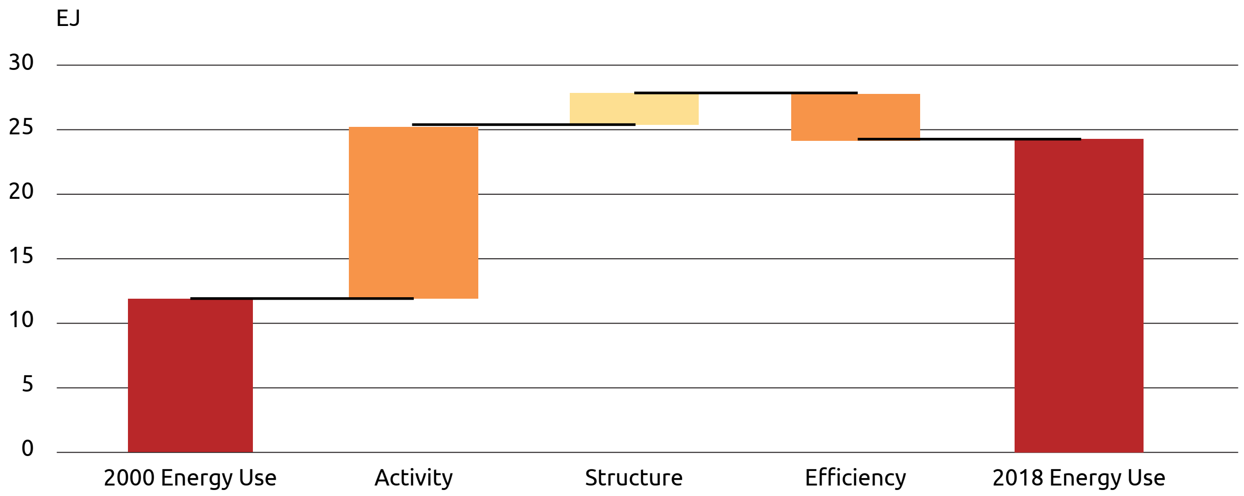
- The generation of power has been deregulated in India since 2003; the supply of power to consumers is generally carried out by government-owned power distribution companies (DISCOMs).
- Deregulation measures aimed to reduce the consumers' electricity cost. However, changes in power prices were achievable only in the long-term and not in the short-term.

Energy efficiency has avoided an additional 15% of energy demand in India since 2000

- Additionally, government regulators and stakeholders participated in implementing various measures, ensuring that deregulation achieved its primary objective of reducing power prices. Such efforts include developing divestiture policies and implementing rate cuts.
- Restructuring the energy sector is another method utilized by most countries. India implemented restructuring methods by using vertically integrated power utilities of the state, thus monopolizing the power market.
- However, in February 2021, the Indian government announced that it is seeking to amend the Electricity Act to end the monopoly of power distribution companies in India.

FIGURE 10

Composition of energy demand (2000 and 2018)



The Green India Mission (GIM) is one of eight missions listed under the National Action Plan on Climate Change (NAPCC)

The pandemic resulted in an economic standstill. Although this led to sharp reductions in emissions in the short term, emissions will likely increase at the same rate as before unless India develops a focused green COVID-19 recovery strategy.

- While no new coal power stations were built in 2020, the government encouraged more coal mining which increased coal production. This is not consistent with a green recovery.
- India needs to develop a viable transition strategy before 2040 in order to phase out coal for power generation.
- The CAT rates India's NDC target as "2°C compatible", indicating that India's climate 2030 goals and plans represent a fair share of the global effort. This is based on its responsibility and capability.
- The COVID-19 pandemic has brought India's economy to a standstill, with demand for fuels and electricity falling sharply (although some parts of the economy have already started recovering).

The Green India Mission

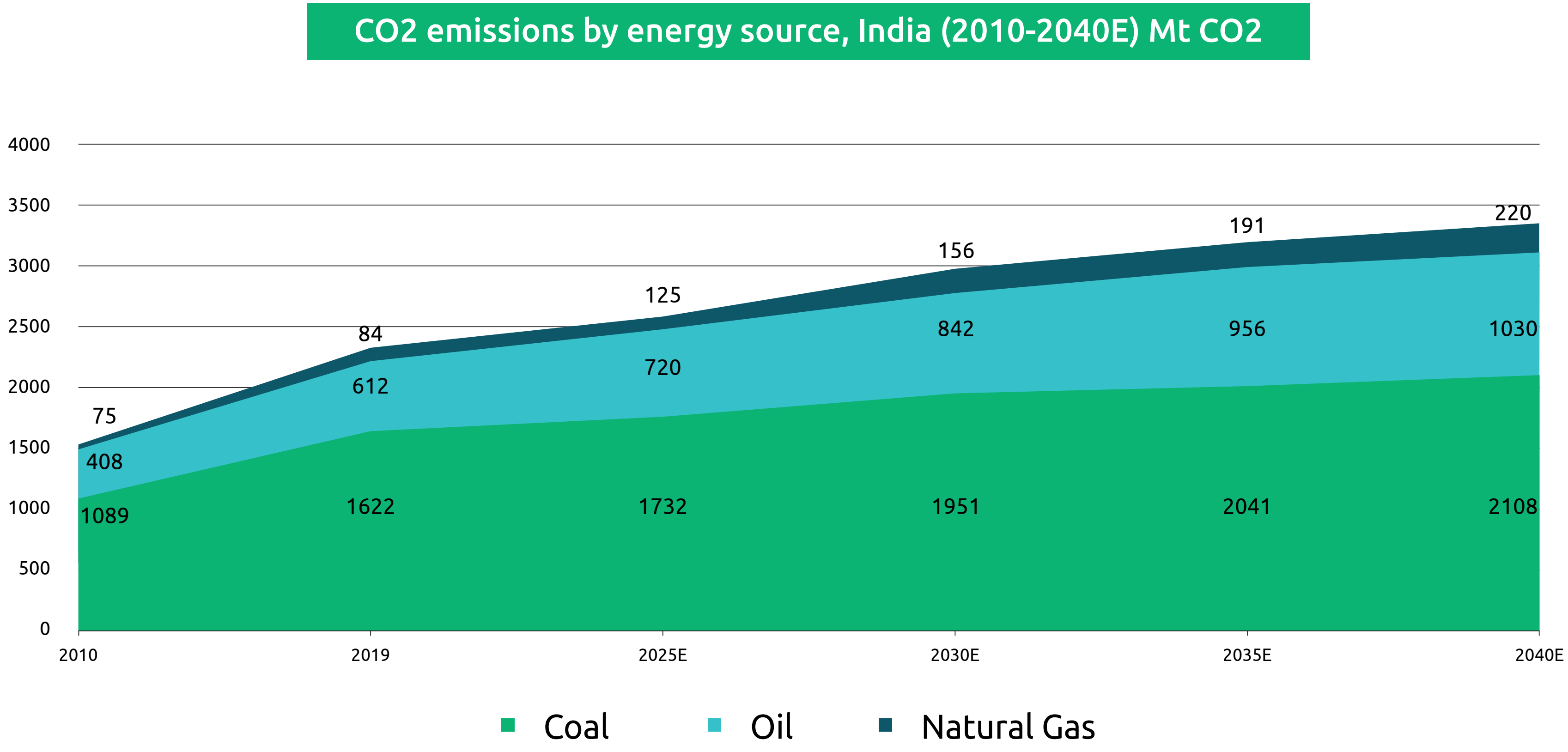
- The Green India Mission (GIM), which is one of the eight missions under the National Action Plan on Climate Change (NAPCC), was launched in 2015 with objectives in line with meeting the Paris agreement.
- The goals include:
  - increasing forest/tree cover and improving the quality of forest cover in millions of hectares of forest/non-forest lands.
  - improving ecosystem services including biodiversity, carbon sequestration and hydrological services along with provisioning services like fuel and fodder.
  - timber and non-timber forest produce, as well as increasing the forest-based livelihood income of households living in and around forests.
- GIM aims to increase India's forest cover by 5 million hectares and enhance carbon sequestration over a span of ten years.
- Lack of funding (at both national and state levels) is what causes GIM to continually fall short of its annual targets, pushing the NDC target farther away.
  - The GIM was allocated INR 311 crores in 2020's budget and INR 240 crores in 2019's budget.

Government initiatives towards climate change

- 5,000 compressed bio-gas plants will be set up to turn municipal and agriculture waste into energy (though the target of mixing 20% ethanol has been shifted to 2025).
- The switch to energy-efficient LED bulbs has helped save 38 million tonnes of carbon emissions. Furthermore, modern techniques of irrigation and a greater awareness of improving soil health has reduced the use of pesticides.
- The share of non-fossil sources in India's installed capacity of electricity has grown to 38%. India also adopted Bharat-VI emission norms in April 2020, reducing vehicular pollution.
- India is working to increase the share of natural gas in the energy basket, from 6% (as it is currently) to 15% by 2030. This is more environment friendly and less polluting.

FIGURE 11

India ~ CO2 Emissions by energy source(2010-2040E) (million metric tons CO2)



Source: India IEA
Link: https://iea.blob.core.windows.net/assets/1de6d91e-e23f-4e02-b1fb-51fdd6283b22/India_Energy_Outlook_2021.pdf

FIGURE 12

Overview of India's net zero plans	
Net zero target, if any	• N/A
Status of the legislation	• N/A
Public investment announced alongside the net-zero target	• N/A
Nationally determined contributions (as of February 2021)	• Reduce emissions intensity of GDP by 33-35% by 2030 (from 2005 levels). • Raise renewables to 40% of total power generation capacity by 2030. • Create additional carbon sink of 2.5-3 billion tonnes CO_2e through afforestation by 2030.
Renewable energy targets	• 175 GW by 2022, including 100 GW solar; 60 GW onshore wind; 5 GW offshore wind; 10 GW biomass; 5 GW small hydro • 450 GW by 2030, including 30 GW of offshore wind
Installed wind capacity (from the end of 2020)	• 38.6 GW onshore wind
Key technology strategies on energy transition	• Ambitious targets for wind and solar capacity • Round the clock tenders, including hybrid tenders combining wind and solar with energy storage • The National Hydrogen Energy Mission to expand green hydrogen uptake in steel, chemicals and transport sectors
Other drivers of clean energy transition	• Green Energy Corridor, Green Term Ahead Market and 'Aatmnirbhar Bharat' • National Electric Mobility Mission Plan 2020 • National Mission for Enhanced Energy Efficiency • Smart City Mission

04

04 Climate Change & Energy Transition

04 Climate Change & Energy Transition

South East Asia Emissions, Carbon Taxes, Renewables and Energy Efficiency Measures

Nupur Sinha
Ankita Das

South East Asia Emissions, Carbon Taxes, Renewables and Energy Efficient Measures

In 2020, the largest decline in CO2 emissions was seen in Hong Kong and the Philippines driven by revised government policies

Hong Kong, Singapore, Malaysia, Taiwan, Vietnam, and the Philippines have shown a decline in CO2 emissions in 2020. The largest decline was shown by Hong Kong, followed by the Philippines.

FIGURE 1

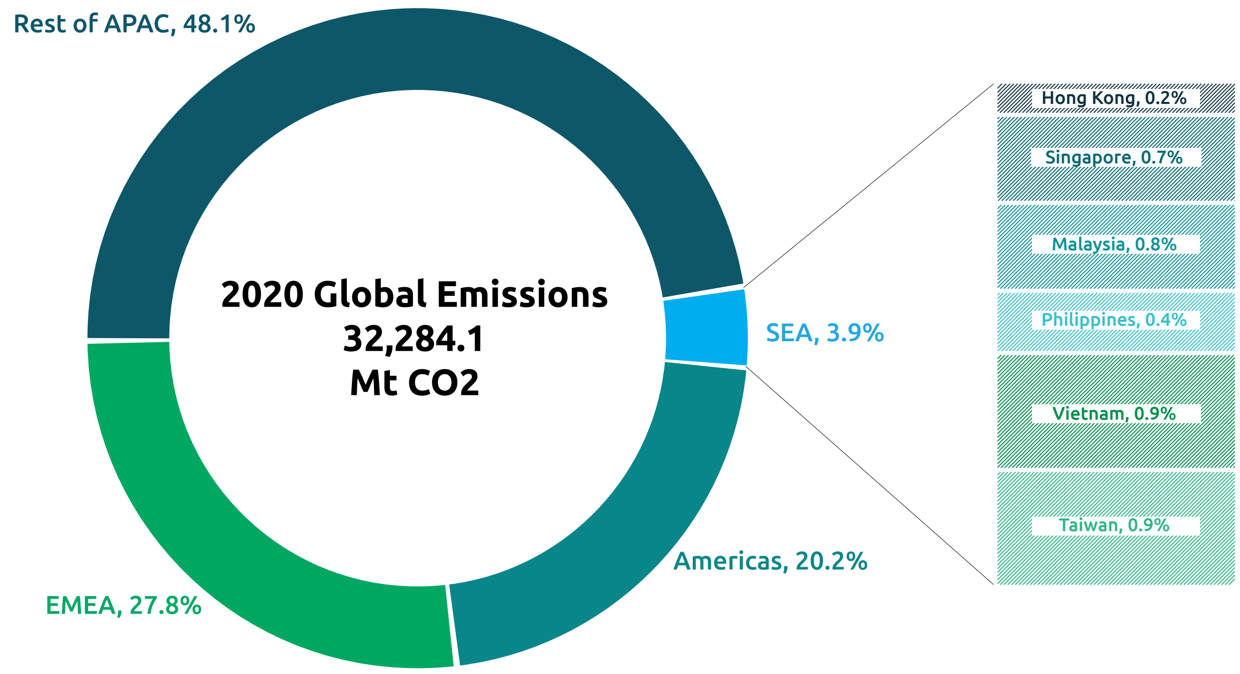
Energy-related CO2 Emissions Growth, 2020 (million metric tons)

Source: BP Statistical Review of World Energy, 2021
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

- **Hong Kong's emissions declined by 28% to 68 Mt in 2020**
    - To further reduce carbon emissions in Hong Kong, the government has been taking the lead in developing renewable energy. Where technically and financially feasible, it's been creating conducive conditions that encourage the private sector to participate.
- **The Philippines' emissions declined by 9.8% to 127.4 Mt in 2020**
    - In April 2021, the Philippines, under its commitment to the Paris Agreement on Climate Change, revised its target to cut greenhouse gas emissions by 75% by 2030. That increase is up from the 70% target set four years ago.
    - Breaking down the target – 72.29% is conditional on the support of climate finance, technologies, and capacity development provided by developed countries, as prescribed by the Paris Agreement.
    - Under a "business-as-usual" scenario, the government estimates the country's overall emissions during the 2020-2030 period will be 3,340.3 metric tons of carbon dioxide equivalent (MTCO2e).

FIGURE 2

Southeast Asia's Share in Global Emissions, 2020 (million tons CO2)



Source: BP Statistical Review of World Energy, 2021
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

Southeast Asian countries are closing the door on new coal projects with strict government intervention

Southeast Asia may be seeing their last new coal plant projects. This year government officials in Bangladesh, the Philippines, Vietnam, and Indonesia have announced plans to cut up to 62.0 gigawatts (GW) of planned coal power.

The Philippines has 10.3 megawatts (MW) of operating coal-fired capacity, half of which has been added since 2015.

- Coal accounts for 40% of the country's power capacity, far more than any other energy source.
- Years ago, coal was perceived to be a low-cost power option. However, the Philippines has some of the highest-priced electricity in the Association of Southeast Asian Nations.
- More than three-quarters of the Philippines' coal is imported, making the country subject to volatile fuel prices and foreign exchange risk. Those costs are passed on to consumers.
- In October 2020, the Philippines Department of Energy announced plans for a moratorium on new coal plant permits. If approved, up to 9.6 GW of planned coal power may be canceled.

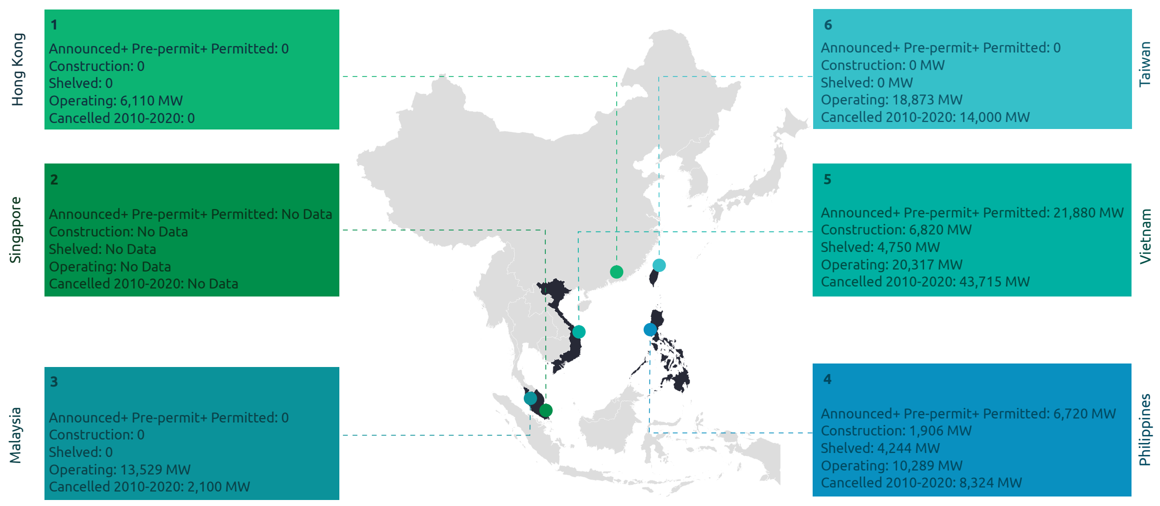
The coal fleet in Vietnam has grown faster than in almost any other country. The country has 20.3 MW of operating coal plants.

- Due to strong public opposition and difficulty securing financing, many coal projects in the country have been stalled.
- A preliminary draft of Vietnam's next energy plan (PDP8) proposes that the country cancel or postpone half of its planned coal capacity, totaling 17.1 GW. The final plan will be released in 2021.

These government announcements are notable as Southeast Asia has long been regarded as the next center for coal power growth, after China. Yet, lower power demand and slowed coal plant development from the COVID-19 pandemic, coupled with tightened financing for coal plants and decreasing solar and wind power costs, are closing the door on coal in the region.

FIGURE 3

Coal Plants in Southeast Asia, Jan 2021



Note: Includes coal plants of 30 MW or larger, as well as every plant proposed since January 1, 2010.

Source: Information available till Jan 2021, Global Energy Monitor
Link: https://docs.google.com/spreadsheets/d/1W-gobEQugqTR_PP0iczJCrdaR-vYkJ0DzztSsCJXuKw/edit#gid=822738567

Investment in adaptation and resilience is needed in Southeast Asian countries – one of the regions that is most affected by climate change

The Global Climate Risk Index (CRI) for 2021 identified Southeast Asia as the region most susceptible to climate change.

- The number and intensity of extreme weather events in the region have been markedly increasing, causing severe social and economic damage.
- Southeast Asian economies are also exposed to the gradual effects of global warming, as well as transition risks stemming from policies aimed at mitigating climate change.

Although the vulnerability to climate change varies significantly across Southeast Asian countries, the region constitutes one of the most climate-vulnerable areas in the world. Four countries – Myanmar, the Philippines, Vietnam, and Thailand – are among the ten countries most affected by climate-related disasters from 1999 to 2018.

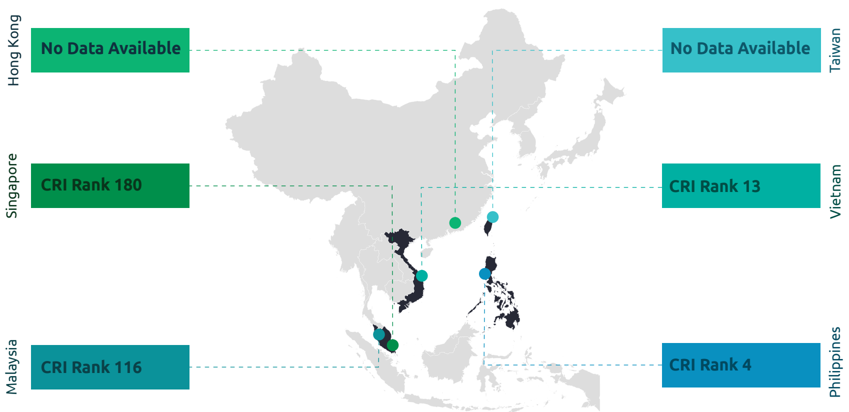
- Due to recurring catastrophes like Bopha in 2012, Hayan in 2013 and Mangkhut in 2018, the Philippines has continuously ranked as one of the most affected countries in the annual index as well as the long-term index.
- The Germanwatch report stated Vietnam was 15th in annual fatalities between 2000 and 2019, 11th in losses in Purchasing Power Parity (PPP) and 47th in terms of both fatalities per 100,000 inhabitants and losses per Gross Domestic Product (GDP) unit.
- At the same time, the report stated that Singapore has the fewest fatalities and least damage.

Southeast Asian countries will not only be exposed to an increase in the frequency and intensity of extreme weather events but will also suffer from chronic physical impacts such as worsening heat, water stress, and a rising sea level. This is expected to have a significant impact on economic activity. **With global warming accelerating, disaster losses will rise further unless investment in adaptation and resilience is scaled up substantially.**

Note: *The Global Climate Risk Index 2021 analyses to what extent countries and regions have been affected by impacts of weather-related loss events (storms, floods, heat waves etc.). The most recent data available — for 2019 and from 2000 to 2019 — were taken into account.*

FIGURE 4

Risk of Southeast Asian Countries in Global Climate Risk Index, 2000-2019



The countries most affected from climate related events of 2000 - 2019 as featured in CRI, 2021

CRI Rank (2000 - 2019)	Country	CRI Score
1	Puerto Rico	7.17
2	Myanmar	10.00
3	Haiti	13.67
4	**Philippines**	**18.17**
5	Mozombique	25.83
6	The Bahamas	27.67
7	Bangladesh	28.33
8	Pakistan	29.00
9	Thailand	29.83
10	Nepal	31.33
	//	
13	**Vietnam**	**35.67**
	//	
116	**Malaysia**	**105.67**
	//	
180	**Singapore**	**172.00**

Note: 1) CRI evaluates countries that have been affected by impacts of weather-related loss events (storms, floods, heat waves etc.). Taking into account data from 2000-2019, the index quantifies impacts of such extreme weather events – both in terms of fatalities as well as economic loss and ranks the countries accordingly.
2) Each country's index score has been derived from a country's average ranking in all four indicating categories, according to the following weighting: death toll, 1/6; deaths per 100,000 inhabitants, 1/3; absolute losses in PPP, 1/6; losses per GDP unit, 1/3.
3) GDP = gross domestic product; PPP = purchasing power parity

Source: Germanwatch and Munich Re NatCatSERVICE (2021)
Link: https://germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021_1.pdf

The Southeast Asia power market has not recovered from the effects of COVID-19

Since the COVID-19 pandemic began, Southeast Asia's power market crashed and has yet to recover.

- Comparing year-on-year power demand growth shows no recovery of the Southeast Asian power market.
- Malaysia suffered a 2.8% year-on-year decline as compared to a normal scenario. It also saw a 0.5% year-on-year increase when compared to the post-COVID-19 scenario.
    - Malaysia's power market experienced weak demand in the first two months of 2021, with declines of 4% and 3% year-on-year, respectively. However, the market rebounded to 8.6% year-on-year in March 2021. This demonstrated a recovery in power demand from the first COVID-19 outbreak.
    - That said, the power market was still a long way from recovery. It recorded an average 2.8% year-on-year (normal) decrease.
- The power market in Singapore is also yet to recover. It experienced a decrease of 0.4% year-on-year for a normal scenario and dipped further to 1.8% year-on-year for a post-COVID-19 scenario.
    - Over the first two months of 2021, the power demand remained stable, declining at a rate of 2.7% and 2.1% year-on-year, respectively.
    - Following March 2021, the year-on-year fall in power demand was narrowed to 0.4%, signaling that the country was on track to recover.
    - Nonetheless, as compared to a normal scenario, Singapore's power market fell by 0.4% year-on-year.
    - This suggests that the country is starting to recover from the COVID-19 pandemic.
    - Furthermore, as the country with the highest COVID-19 vaccination rate in the Southeast Asia region, Singapore is expected to quickly regain momentum in power market growth.

Low carbon market opportunities are adding volatility to the Southeast Asian power market

Climate change awareness is growing in the Southeast Asia region. The aim is to combat climate change and reduce greenhouse gas (GHG) emissions.

- Vietnam's recently announced third revision of its power development plan (draft PDP8) for 2021-2030 continues to prioritize renewables while gradually reducing coal-fired plants. By 2030, wind and solar capacity accounted for a combined 28% of the national total, double the amount planned in the PDP7 revision.
- For the first time in the Philippines, Meralco awarded a new 20-year power supply contract to a liquefied natural gas (LNG) based power plant. The move to integrate LNG into the country's energy mix represents a shift away from coal toward gas to comply with the recent moratorium on new greenfield coal-fired power plants. The winner's historically low levelized costs of electricity (LCOEs – 20% less than reserve price at PHP 5.2559/kWh) signaled a potential price cut by using LNG as power.

The latest moves by the Philippines and Vietnam demonstrated the countries' favor of gas and renewables in their energy mix. Overall, this could be a significant turning point for clean energy development in the region, motivated by energy security concerns and emerging opportunities in the low carbon market.

04 Climate Change & Energy Transition

04

04 Climate Change & Energy Transition

Australia Emissions, Carbon Taxes, Renewables and Energy Efficiency Measures

Nicole Alley
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Emissions Targets, Renewables and the Energy Transition in Australia

Australia is on track to meet and beat its 2030 emissions reduction target

Australia is progressing well against its emission reduction targets. This is helped by its accelerating shift to renewables and the reduction in fuel consumption through the COVID-19 pandemic. In Australia, the rate of acceleration towards net zero is beginning to shift as sustainability-related priorities move higher on the agenda of the Australian government (federal and state), major energy industry participants, and ultimately Australian energy consumers. As a resource-led economy with a heavy focus at the exploration and generation end of the energy value chain, Australia has an important part to play globally in bringing down its average CO2 emissions per capita.

Australia is making progress towards meeting its Paris Agreement target to cut emissions by 26% to 28% below 2005 levels by 2030 to help curb global warming.

- To achieve Australia's 2030 target of 26% to 28% below 2005 levels, emissions reductions of 403 Mt CO2e is required by 2030.

- Due to the growth in wind and solar energy production, a reduction of transport fuel consumption caused by coronavirus lockdowns, and a rise in carbon capture at the huge Gorgon Liquid Natural Gas (LNG) project, Australia's carbon emissions fell by 5% in 2020.

- As of May 2021, Australia's emissions already stand at 20% below 2005 levels. To reach the target reduction by 2030, Australia requires further emission reduction of 56 to 123 Metric ton CO_2e between 2021 and 2030. When past overachievement is included, Australia is on track to beat its 2030 target.

- Looking at the key contributors to carbon emissions in Australia, we can see that:
  - The power sector in Australia accounts for one-third of emissions. This is despite a 4.9% drop in emissions due to a decline in coal-fired and gas-fired generation.

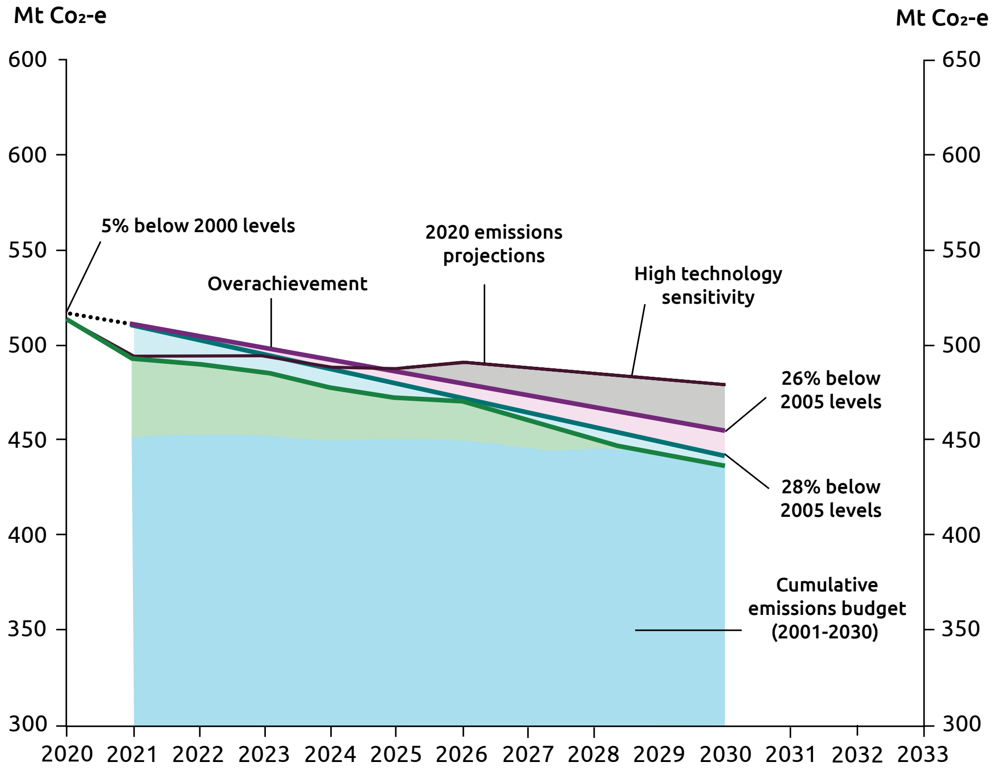
  - Emissions from liquefied natural gas (LNG) plants, which had grown over the previous four years with the start-up of new LNG plants, fell as a long-delayed carbon capture and storage project at the Gorgon LNG plant commenced.

Despite great progress … "The power sector remained Australia's biggest polluter, accounting for one-third of emissions, even with a 4.9% drop in emissions due to a decline in coal-fired and gas-fired generation"

– Reuters May 2021

FIGURE 1

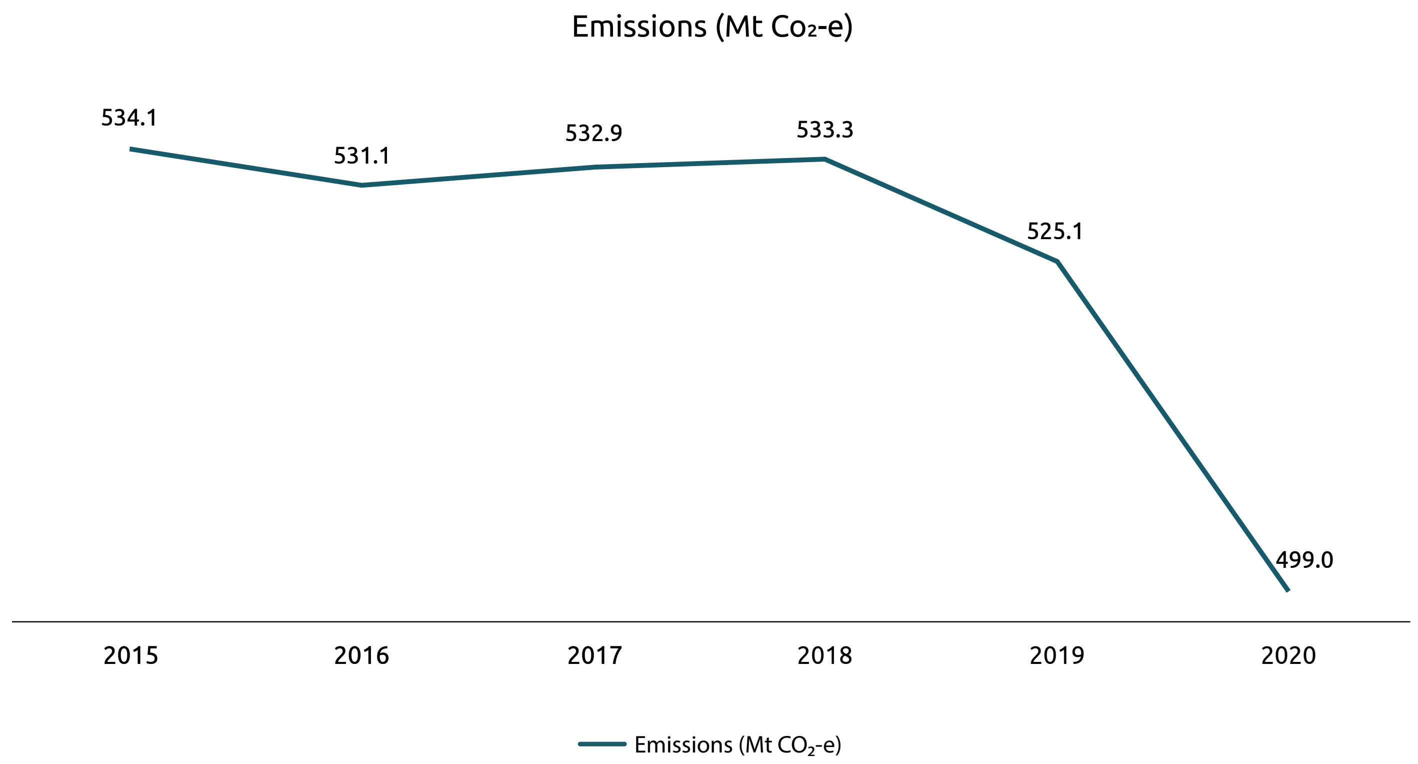
Australia's cumulative emissions reduction task to 2030



Sources: www.industry.gov.au
Link: https://www.industry.gov.au/sites/default/files/2020-12/australias-emissions-projections-2020.pdf

FIGURE 2

Annual emissions data: 2015 - 2020



Sources: National Greenhouse Gas Inventory Quarterly Update: December 2020
Link: https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-quarterly-update-december-2020#annual-emissions-data

Despite short term La Niña effects, greenhouse gas emissions are making Australia hotter and more prone to extreme weather conditions

Australia is experiencing long-term drying in its weather patterns, which is, in turn, increasing the scale of bush-fire events, impacting availability and importance of water resources, and increasing the risk of drought. These effects have political, economic, and investment impacts for Australia as a whole and the energy sector, in particular. As a reprieve to this long-term weather trend, La Niña has brought short-term relief in the past 12 months.

Concentrations of all major long-lived atmospheric greenhouse gases (GHG) rose in 2020, despite a temporary slow-down in global fossil fuel emissions of carbon dioxide (CO2) during early 2020, as driven by the COVID–19 pandemic.

- Australian rainfall is highly variable and is strongly influenced by drivers such as El Niño, La Niña, the Indian Ocean Dipole, and the Southern Annular Mode. La Niña, an oceanic and atmospheric phenomenon, was the most significant climate driver during 2020. The Pacific ocean began cooling in March, with early indicators of a developing La Niña emerging by June. The event matured over July and August and was declared in September. The El Niño–Southern Oscillation was neutral during the first half of 2020. La Niña was established during September 2020 and reached moderate strength by the end of the year. The Southern Annular Mode also influenced the Australian climate during 2020.

- Despite a short period of better weather conditions, there are several conditions indicating continuing climate change in Australia:

  - Rainfall between April-October 2020 has declined by around 16% in the southwest of Australia and by around 12% in the southeast of Australia, as compared to the rainfall amount in 1970.

  - Australia experienced a downward trend in the number of tropical cyclones observed in the region since 1982.

  - Oceans around Australia are acidifying and have warmed by around 1°C since 1910, contributing to longer and more frequent marine heat waves.

  - Global average sea levels have risen by around 25 cm since 1880. Rates of sea level rise vary across the Australian region, with the largest increases to the north and southeast of the Australian continent.

  - There has been an increase in extreme fire weather, as well as the length of the fire season, across large parts of the country since the 1950s, especially in southern Australia. Extremely dangerous fire conditions were observed during the 2019–20 summer, as well as in Canberra (2003) and Victoria (2009).

- One of the major factors contributing to climate change in Australia is increased anthropogenic greenhouse gas emissions. These emissions caused changes in large-scale circulation which led to a shift towards drier conditions in Southern Australia. At the end of 2020, atmospheric CO2 was 410.6 parts per million (ppm), an increase of 2.1 ppm for the year. This marks a 47% increase from the pre-industrial concentration of 278 ppm in 1750.

La Niña and El Niño definition- Both El Niño and La Niña impact climate variability

- La Niña is a complex weather pattern that occurs every few years as a result of variations in ocean temperatures in the equatorial band of the Pacific Ocean. A strong correlation exists between the strength of La Niña and rainfall: The greater the sea surface temperature and Southern Oscillation difference from normal, the larger the rainfall change. Increased risk of widespread flooding, tropical cyclones, and the monsoon season starts earlier.
- El Niño is the warm phase of the El Niño–Southern Oscillation (ENSO), which is associated with a band of warm ocean water that develops in the central and east-central equatorial Pacific. El Niño events are thought to have been occurring for thousands of years. This warming causes a shift in the atmospheric circulation with rainfall becoming reduced over Indonesia, India, and Australia.

Concern about the impacts of fossil fuels accelerates the transition to lower emissions generating energy sources

Australia is the world's twentieth largest consumer of energy and fifteenth in terms of per capita energy use. To date Australia's energy needs have been largely met by fossil fuels. Australia's abundant and low-cost coal resources provide some of the cheapest electricity in the world. The mix of electricity generation is changing, both as it pertains to the grid and at the individual customer level. Some ageing coal-fired and gas-powered generation has left the market and been replaced by large-scale wind and solar capacity. There is still more capacity to transition.

Australia's electricity markets are undergoing a profound transformation from a centralised system of large fossil fuel (coal and gas) generation towards an array of smaller-scale, widely dispersed wind and solar generation, with grid-scale batteries and demand response.

Coal-fired power plants:

- Australia has substantial resources of coal, both black and brown.
- Australia is the world's largest exporter of coal. Coal accounts for more than half of Australia's energy exports. Australia is one of the world's largest exporters of uranium and is ranked sixth in terms of LNG exports. In contrast, more than half of Australia's liquid fuel needs are imported.
- Since 2014 more than 4 Gigawatts of coal- and gas-powered generation has left the market (coal accounts for approximately 75% of Australia's electricity generation and gas accounts for 16%). Over this same period, around 12.5 GW of large-scale wind and solar capacity and 8.5 GW of rooftop solar Photovoltaic has been added.
- No significant coal-fired generation has been added since a 240 MW upgrade of the Eraring Power Station in 2012; since then several major plants have closed, including Wallerawang (New South Wales), Hazelwood (Victoria), and Northern (South Australia).
- At current rates of production, there are nearly 500 years of brown coal resources remaining.

Gas-fired power plants:

- Australia also has significant resources of gas that include large conventional gas resources located mostly in the Carnarvon, Browse, and Bonaparte basins off the northwest coast. Economic demonstrated resources (EDR) of conventional gas are adequate at current levels of production for around 60 years.
- Around 4 GW of gas-powered generation is forecast to retire over the next 2 decades.

- Investment in gas-powered generation over the past decade has been limited, but there are still plans for investment.
- Multiple proposals for new gas plants have been announced in Queensland, New South Wales, Victoria, and South Australia.
- In May 2021, EnergyAustralia committed to developing a 316 MW gas plant in NSW by 2023–24.
- The federal government has signaled the need for new gas-powered generation in NSW to fill the gap left by the closure of the Liddell power station; it has backed a new 660 MW plant to be operated by Snowy Hydro in the Hunter region of NSW.

"The much needed transition away from coal and gas presents an industry wide challenge around workforce 'just transition' and with it an opportunity to get ahead of the curve by supporting reskilling and new jobs creation in emerging and technology based sectors."

Nicole Alley, Energy & Utilities Sector Lead, Capgemini Australia

The Australian government continues to support renewable energy generation with investment roadmaps and new funding

Australia's Technology Investment Roadmap aims to accelerate development and commercialisation of low emissions technologies.

- In September 2020, the Australian Minister for Energy and Emissions Reduction Angus Taylor released the government's first Low Emissions Technology Statement, the first milestone in Australia's Technology Investment Roadmap.
- The Statement outlines five priority technologies and economic stretch goals to make new technologies as cost-effective as existing technologies. These are:
  - Hydrogen production under AUD $2 per kilogram.
  - Long duration energy storage (6-8 hours or more) dispatched at less than AUD $100 per MWh. This will enable reliable, firmed wind and solar at prices around the average wholesale electricity price of today.
  - Low carbon materials, including low emissions steel production under AUD $900 per tonne and low emissions aluminum under AUD $2,700 per tonne.
  - Carbon Capture and Storage (CCS), CO_2 compression, hub transport, and storage under AUD $20 per tonne of CO_2.
  - Soil carbon measurement under AUD $3 per hectare per year.
- Additionally, AEMO has published its Integrated System Plan in June 2020, which describes a whole-of-system transformation roadmap to Australia's energy future through 2040.

The Australian Renewable Energy Agency (ARENA), the main funder of energy innovation in Australia, welcomed the Australian Government's first Low Emissions Technology Statement.

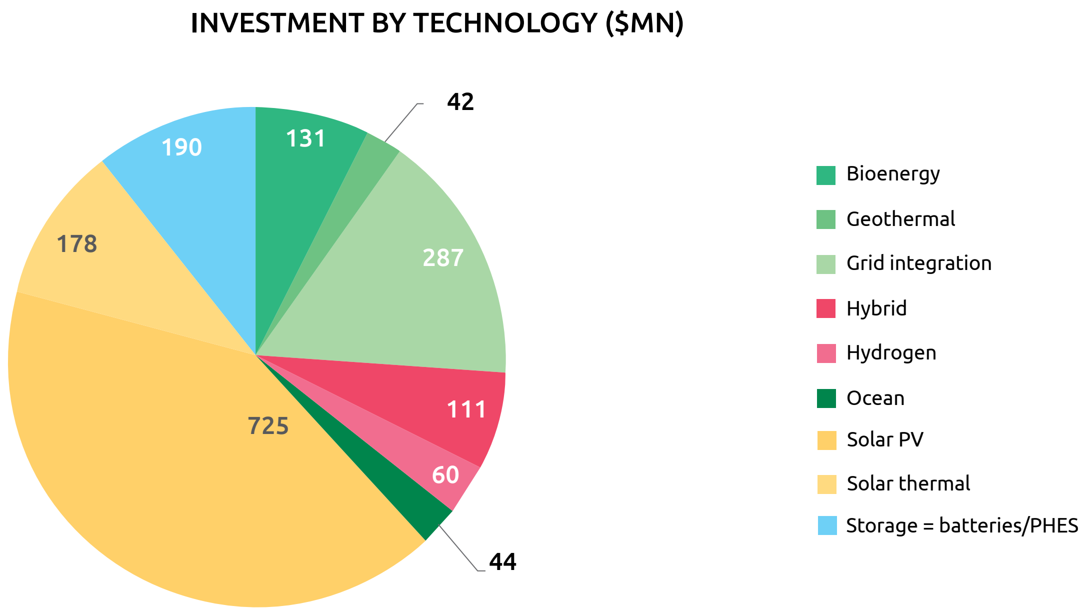
- The inaugural statement also outlines emerging and enabling technologies, several which are currently supported by ARENA, including energy efficiency, electric and hydrogen vehicle charging and refueling, and low emission energy system enablers such as virtual power plants.
- In September 2020, in support of the Low Emissions Technology Statement, the Australian federal government announced a AUD $1.9 billion package including AUD $1.62 billion in new funding for ARENA over the next 10 years.

The Australian federal government has created a pro-investment environment for renewable technologies through its Renewable Energy Target (RET) Scheme.

- **Large-scale Renewable Energy Target (LRET):** The LRET incentivizes investment in renewable energy power stations, such as wind and solar farms, or hydro-electric power stations, by legislating demand for large-scale generation certificates (LGCs).
    - The LRET imposes an annual target of 33,000 gigawatt hours per year until the scheme ends in 2030. At the end of January 2021, the LRET target of 33,000 GWh of additional renewable electricity generation was met on a rolling 12-month basis.
- **Small-scale Renewable Energy Target (SRET):** The Scheme incentivizes households, businesses and the community to install eligible small-scale systems such as rooftop solar panels, solar water heaters, or small-scale wind or hydro systems by legislating demand for small-scale technology certificates. Small scale technology certificates (STC). are created at the time of installation according to the system's deeming period—the estimate of years the system will create renewable energy from installation until 2030.

FIGURE 3

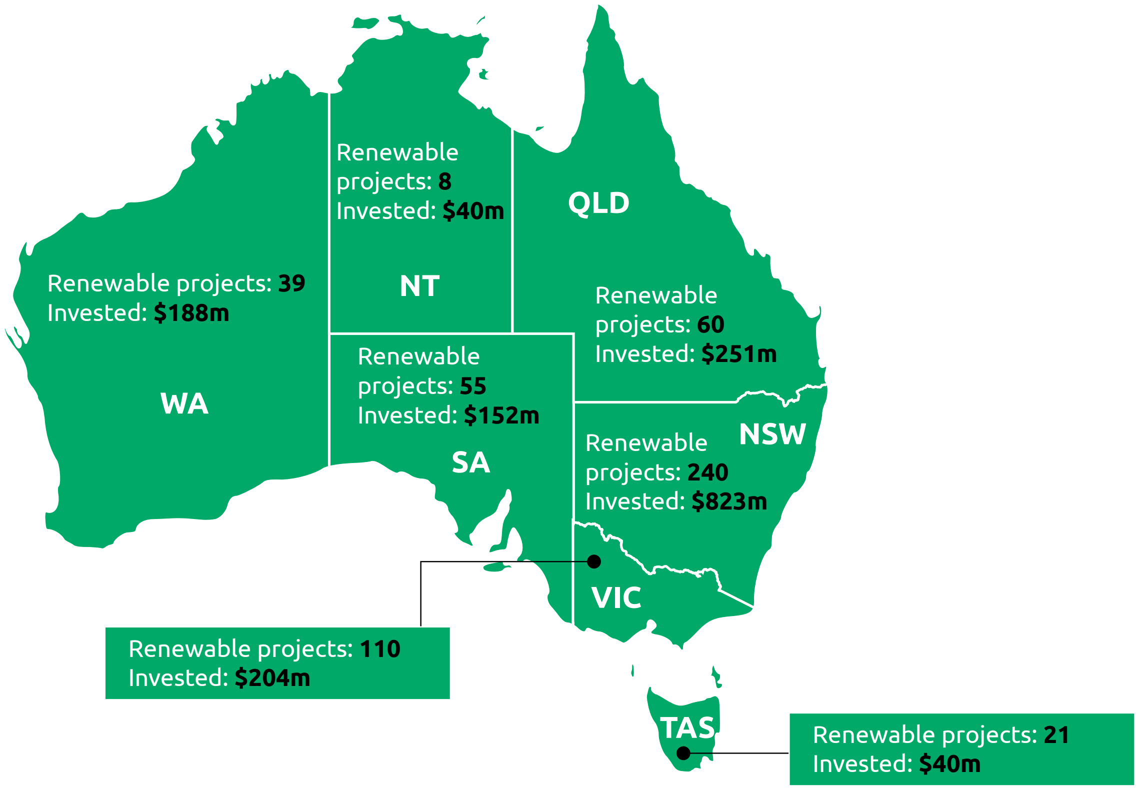
Australian Renewable Energy Agency (ARENA) Investment by Technology: 2012 – 2021
(Updated till June 2021)



Sources: ARENA at a glace – As of June 30, 2021
Link: https://arena.gov.au/arena-at-a-glance/

FIGURE 4

Arena Investment by State (as of June 2021)



Source: ARENA at a glace – As of June 30, 2021
Link: https://arena.gov.au/arena-at-a-glance/

"The government is committed to reducing emissions without imposing new costs on households, businesses or the economy."

-Hon Angus Taylor MP Minister for Energy and Emissions Reduction

Ambitious policies have been introduced across Australian states and territories to accelerate Australia's renewable energy transition

Renewable electricity generation is rapidly accelerating in Australia.

- The Australian electricity generation mix is still dominated by thermal-based power generation, representing 76% or 200,566 GWh of total electricity generation in 2020.
- However, renewable generation is accelerating very rapidly. From 2016 to 2020, the electricity generated from renewables in Australia has increased from ~16% to 24%.
- The largest source of renewable generation is solar (9% of total generation) followed by wind (9%) and hydro (6%).

In the continued absence of federal energy policy, the states and territories took the lead in 2020, presenting a range of policies to fast-track Australia's renewable energy switch.

- **New South Wales (NSW):** After lagging many of its state and territory counterparts on renewable energy policy in recent years, NSW vaulted into the lead after releasing Australia's most ambitious renewable energy plan in November 2020: NSW Electricity Infrastructure Roadmap.
- **Northern Territory (NT):** The Northern Territory continued to make steady progress towards its target of 50% renewable energy by 2030, sourcing 16% of its electricity from renewables in 2020, up from 8% the previous year.
- **Queensland (Qld):** The most significant renewables development in Queensland was the state government's announcement of three new renewable energy corridors in the north, central and south-west parts of the state. These corridors will be supported by AUD $145 million in infrastructure investments, with the idea that each corridor will host several renewable energy zones (REZs). The plan gained further momentum in September 2020, when the government devoted half of its AUD $1 billion COVID-19 recovery spending in the state budget to a Renewable Energy Fund.
- **South Australia (SA):** The remarkable work done in recent years to transform South Australia into a renewable energy powerhouse came to fruition in 2020, with the state breaking several clean energy records during the year as it rapidly approaches its 100% renewable energy target.
- **Tasmania (Tas):** Tasmania achieved a significant milestone, becoming the first Australian state to reach 100% renewable energy in November. The mark was reached well ahead of the original schedule of 2022 and put Tasmania in the illustrious company of the few jurisdictions worldwide – including Scotland, Iceland, and Costa Rica – that have made the transition to 100% clean energy.
- **Victoria (VIC):** COVID-19 had a major impact on the Victorian renewable energy industry. The state's lockdown forced the rooftop solar industry to shut down completely for almost two months in the middle of the year. However, this failed to dent the industry's momentum in the state, with new records set for both rooftop solar capacity and installations in 2020.
- **Western Australia (WA):** Despite traditionally lagging the eastern states when it comes to renewable energy, Western Australia made up significant ground resulting from its substantial distributed energy resources and increasing ambition in utility-scale clean energy. The most significant development was the release of WA's first Whole of System Plan (WOSP), which provides a 20-year outlook on the future of the South West Interconnected System.

FIGURE 5

Key Renewable Energy Initiatives by States

KEY INITIATIVES

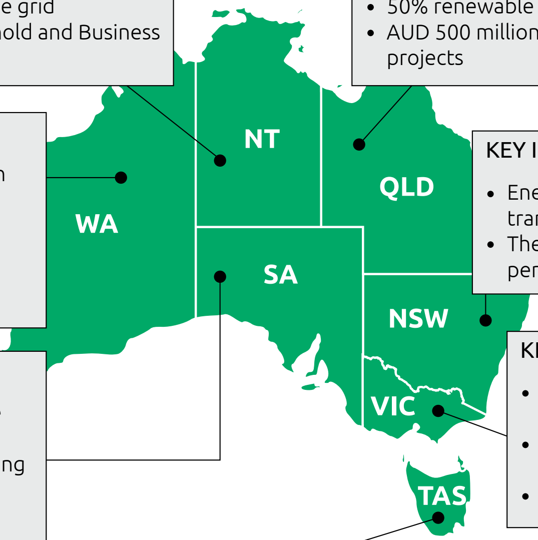
- 50% renewable energy target by 2030
- 35 MW battery to support the Darwin-Katherine grid
- AUD 6000 grants available through the Household and Business Battery Scheme

KEY INITIATIVES

- AUD 145 million to support three new renewable energy corridors
- 50% renewable energy target by 2030
- AUD 500 million Renewable Energy Fund to support renewable energy projects

KEY INITIATIVES

- 100 MW/200 MWh battery planned, the first on WA's main grid
- Renewables expected to account for 70% of generation by 2040
- AUD 22 million investment to bring forward renewable hydrogen targets to 2030



KEY INITIATIVES

- Energy Infrastructure Roadmap to deliver 12 GW of new transmission capacity
- The roadmap will increase NSW's renewable energy penetration to over 60% by 2030

KEY INITIATIVES

- Plan for renewable energy to account for more than 500% of the state's electricity demand
- Three renewable hydrogen export hubs featuring electrolysers of up to 2.6 GW
- AUD 3 billion wind and solar project with a 900 MW/1800 MWh battery

KEY INITIATIVES

- Second renewable energy auction to procure 600 MW of new solar and wind energy
- AUD 540 million committed to establish six renewable energy zones
- Solar Homes program expanded to landlords & renters

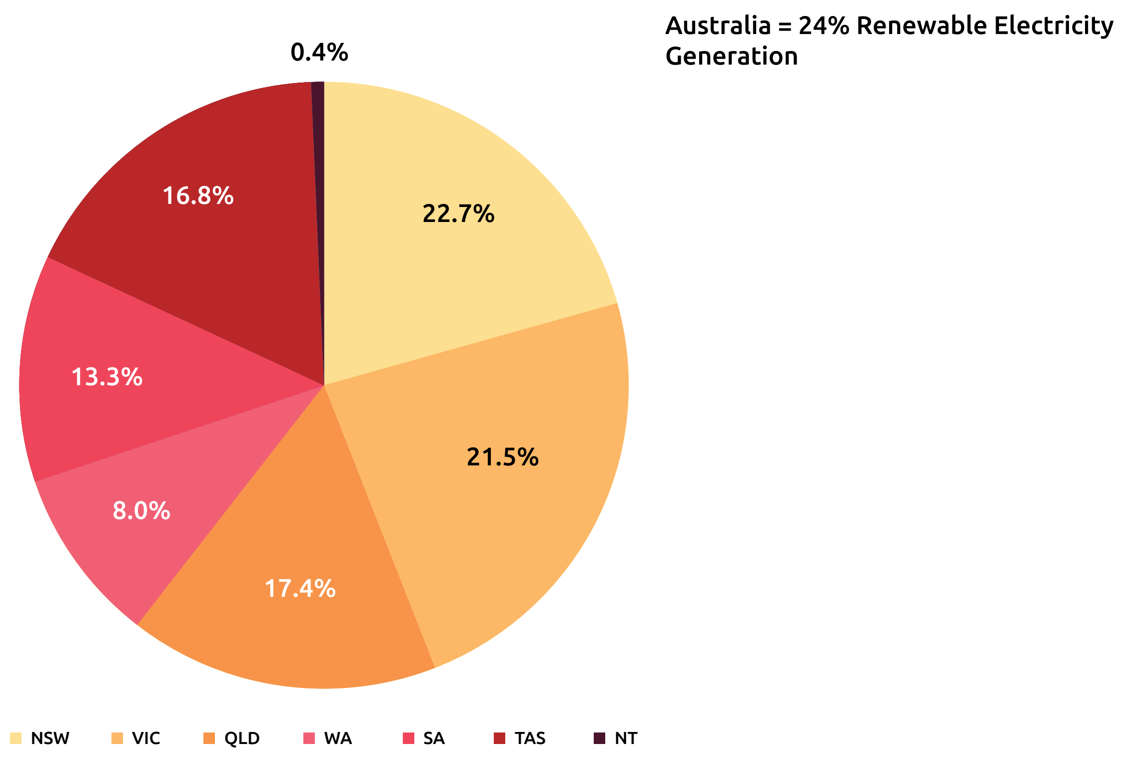
KEY INITIATIVES

- 200% renewable energy target by 2040 renewable Hydrogen Action Plan to make Tasmania a significant global producer and exporter of renewable hydrogen by 2030
- Battery of the Nation names first pumped hydro site

Source: ARENA at a glace – As of June 30, 2021
Link: https://arena.gov.au/arena-at-a-glance/

FIGURE 6

Renewable Electricity Generation – Australia State-level CY - 2020 (%)



Source: Australian Energy Statistics, Table O Electricity generation by fuel type 2019-20 and 2020
Link: https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2019-20-and-2020

Energy companies and large industrials are leading Australia's shift to net zero by making changes and setting ambitious targets

Participants in the Australian market will recognise Australia has been slower than some other parts of the world in supporting the shift to net zero emissions with action. However, now the journey to net zero in Australia is gaining momentum, led by major Australian energy GenTailers, Grid Operators, Mining & Metals, and Oil & Gas companies.

Net zero emission aspirations of key energy market players and large commercial and industrial customers:

- **AGL (Electricity and Gas Generation and Retail)** committed to net zero emissions by 2050 via its Greenhouse Gas Policy not to extend the life of its coal-fired power plants in 2015. In 2021, AGL has started working towards full closure of these plants.

- **Ausgrid (Electricity Transmission and Distribution)** aims to achieve an 8% reduction of emissions by financial year end (FY) 2024 (44% excluding line losses, or energy lost in the transmission and distribution of electricity); and 17% reduction by FY2030. The company's carbon footprint is 1 million tonnes of CO2e per annum. These targets are expected to remove 83,700 tonnes of CO2e by mid-2024.

- **BHP (Mining)** has been active in addressing climate risks for more than two decades and has already established its long-term goal of achieving net zero operational emissions by 2050 and its short-term target of maintaining operational emissions at or below FY2017 levels by FY2022, using carbon offsets as required.

- **BlueScope Steel (Metals manufacturer)** is driving towards net zero carbon emissions by 2050 by covering direct and indirect emissions across their operational footprint. Bluescope Steel has set a medium-term steelmaking emissions intensity reduction target of 12% and introduced a new target of a 30% improvement in non-steelmaking greenhouse gas emissions intensity by 2030.

- **Chevron (Oil and Natural Gas) aims to** achieve the following Upstream production net greenhouse gas emissions intensity reduction metrics by 2028:
  - 24 kg CO2e/boe for oil, which is a 40% reduction from 2016.
  - 24 kg CO2e/boe for gas, which is a 26% reduction from 2016.
  - 2 kg CO2e/boe for methane, which is a 53% reduction from 2016; the company will also run a global methane detection campaign.
  - 0 routine flaring by 2030 and 3 kg CO2e/boe for overall flaring, which is a 66% reduction from 2016.

- **EnergyAustralia (Electricity and Gas Generation and Retail)** has announced the expansion of its existing Tallawarra power station in the Illawarra region. This will be Australia's first net zero emissions hydrogen and gas capable power plant, with direct carbon emissions from the project offset over its operational life. This project sets a new benchmark for how gas generators can be consistent with NSW's plan to be net zero by 2050 by using green hydrogen and offsetting residual emissions.

- **Fortescue Metals Group (Mining)** has set an ambitious plan to become carbon neutral by 2030, bringing forward the target by 10 years, as it aims to start producing green hydrogen as soon as 2023 and stepping up investments in ways to remove coal from the emissions-intensive steel-making sector.

- **Newcrest Mining Ltd (Mining)** has recently announced the company purpose as "To create a brighter future for people through safe and responsible mining" and committed to net zero carbon emissions by 2050 by setting a target to reduce its greenhouse gas emissions intensity by 30% by 2030.

- **Origin Energy (Electricity and Gas Generation and Retail)** plans to update its existing science-based target to a 1.5°C pathway with a target to achieve net zero emissions by 2050 by:
  - halving its Scope 1 (direct emissions from owned or controlled sources) and Scope 2 (indirect emissions

from the generation of purchased system) greenhouse gas emissions by 2032;
- reducing its Scope 3 (indirect emissions from company's value chain) emissions by 25% by 2032 from a FY2017 baseline of 27,451 kt CO_2e; and
- planning to exit coal-fired generation entirely by 2032.

- **Rio Tinto (Mining)** announced plans in 2020 to invest around AUD $1 billion over the next five years to support the delivery of its new climate change targets and a company objective for net zero emissions from operations by 2050. The targets for 2030 provide a further 30% reduction in emission intensity and 15% reduction in absolute emissions from 2018 levels. Rio Tinto has recently intensified its efforts to decarbonize by 2050 by joining Japan's Green Value Chain (GVC) Platform Network to work together in sharing solutions related to renewable energy conservation in an economically feasible and effective manner.

- **SA Power Networks (Electricity distributer)** has set a target to double the amount of solar on their network by 2025. The company is also preparing for growing investment in home batteries and electric vehicles to meet South Australia's goal of net 100% renewable energy by 2030 and zero emissions by 2050.

- **Western Power Distribution (Electricity distributer)** has outlined plans to reach net zero emissions for its operations by 2028, as part of a new environmental strategy that aims to convert its commercial fleet to low-carbon vehicles in the same timeframe.

- **Woodside (Petroleum Exploration and Production)** aims to be net zero in its direct emissions by 2050 or sooner. It has offset over 2.28Mt CO_2e to date and is aiming to lower rates by 15% and 30% below the baseline by 2025 and 2030, respectively.

"We are committed to playing our part through meaningful action in our value chain, continued support for low-carbon technology solutions, and advocating for policy outcomes that enhance the global response to climate change,"

Mike Henry, Chief Executive, BHP

2020 was Australia's highest single year of renewable energy capacity additions with 7 GW of capacity added

Renewable generation as a percentage of total generation reached 27.7% in 2020. While this represents an acceleration, it is only a small percent of total electricity generation in Australia. However, a record 7 GW of new renewable capacity was installed in 2020.

Solar is Australia's largest source of renewable energy

- At the end of 2020, solar was the largest source of renewable energy at 9% (~23,843 GWh including large and small-scale) of total electricity generation, up from 7% in 2019. One in four Australian homes have rooftop solar panels in place, the highest uptake in the world.

- The COVID-19 pandemic has not had a significant impact on continued acceleration in rooftop solar. More than 3 GW of new capacity was added to Australian rooftops in 2020. Additionally, 32 large scale solar projects with a capacity of almost 2 GW were completed throughout the year.

Wind is contributing the newest renewable generation

- Australia's wind sector accounted for the bulk of new generation. Roughly 10 wind farms were commissioned in 2020 adding 1097 MW. This was a new record for the sector, comfortably surpassing the 837 MW record set in 2019.

- 76 large-scale wind and solar projects were under construction at the end of 2020. Victoria had the largest concentration with 21 wind farms and 658 MW wind capacity installed.

Hydro still plays a critical role

- Hydro's contribution to Australia's total renewable generation has fallen significantly in recent years, largely due to the rapid rise of wind and solar.

- However, with several large projects (like the Snowy Mountains Hydro-Electric Scheme) in the works, this technology is set to play a vital role in Australia's clean energy future.

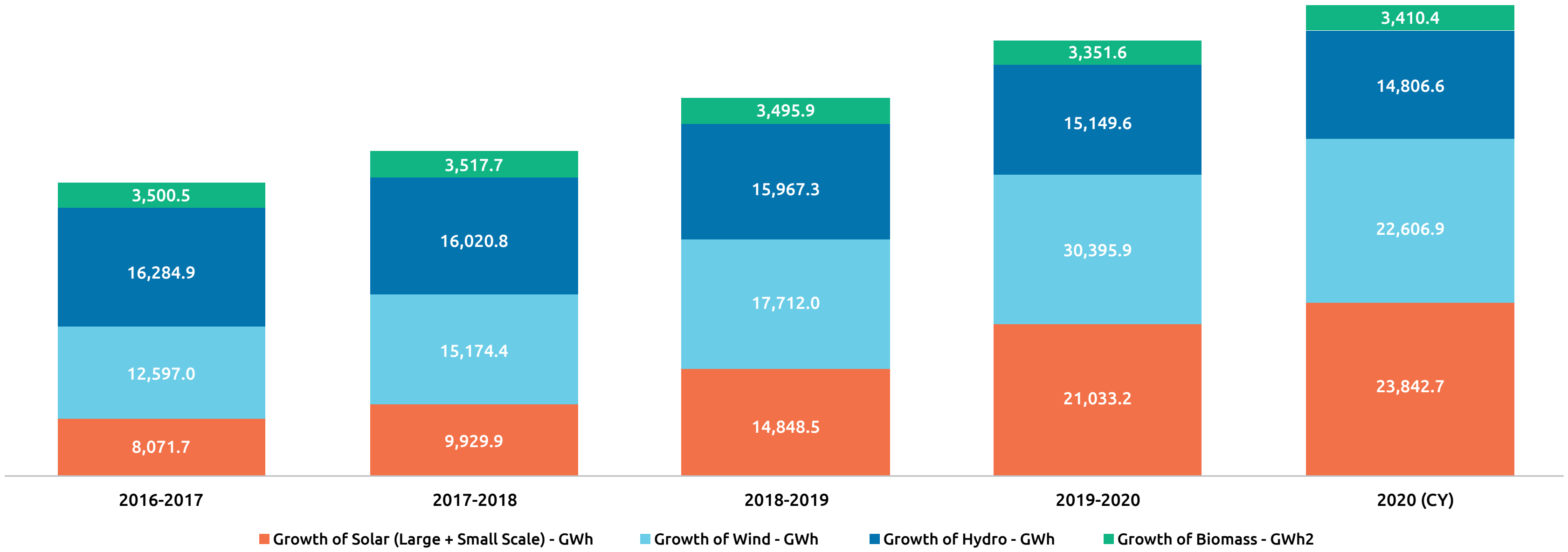
- In 2020, Hydro accounted for 5.6% (14,807 GWh) of total electricity generation compared to 5.7% and 6% in 2019 and 2018, respectively.

Bioenergy generation is small but accelerating

- There was a significant acceleration in the level of interest and development of bioenergy projects in 2020. In 2020, bioenergy accounted for 1.3% (generating 3,410 GWh) of Australia's total electricity generation, and 5% of total renewable generation.

FIGURE 7

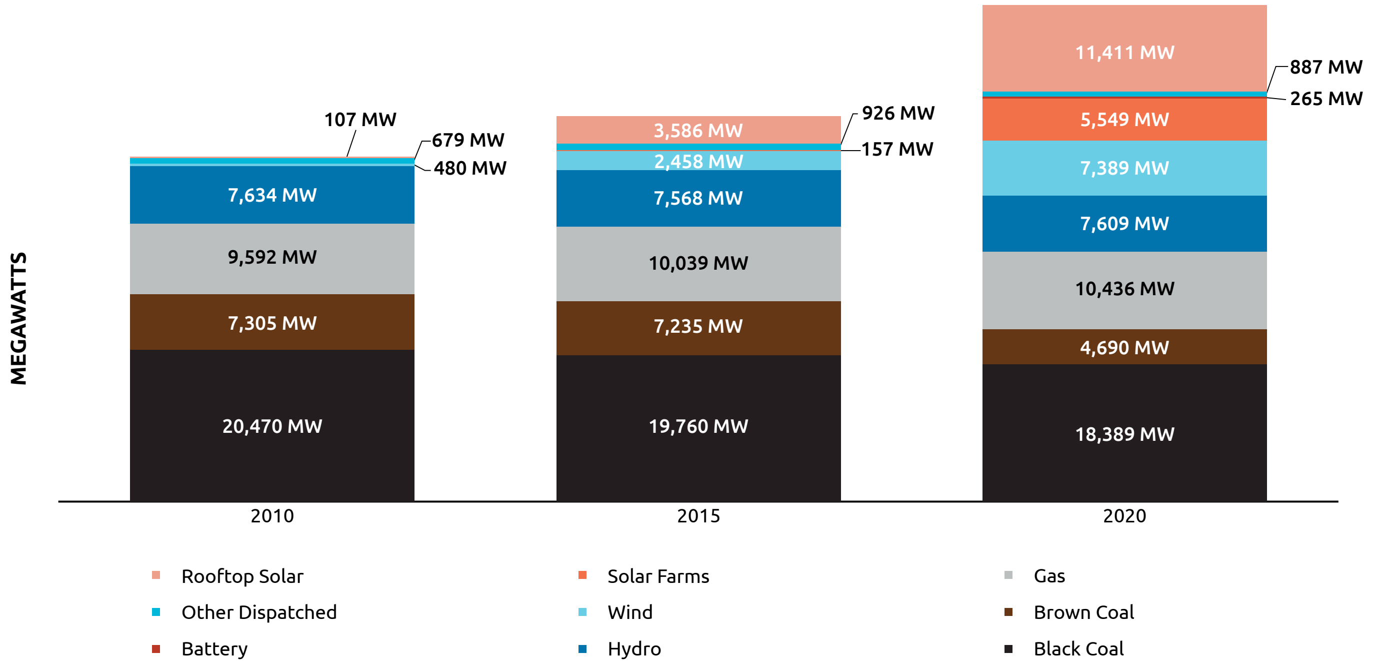
Renewable Growth by technology in GWh: 2016 - 2020



Australian electricity generation, by fuel type, physical units, calendar year – Table o – (Calendar Year 2020 – 2016)
Link: https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2019-20-and-2020 &
https://www.energy.gov.au/government-priorities/energy-data/australian-energy-statistics

FIGURE 8

Generation capacity, by technology (GW)



AER: State of the energy market report - 2021 data
Link: https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2021-data

The battery storage sector rose to prominence in 2020, with 16 utility scale batteries under construction atthe end of 2020

Batteries are beginning to accelerate in the Australian energy landscape, driven by South Australia and New South Wales. However, battery storage still only represents a tiny proportion of total energy generation storage in Australia.

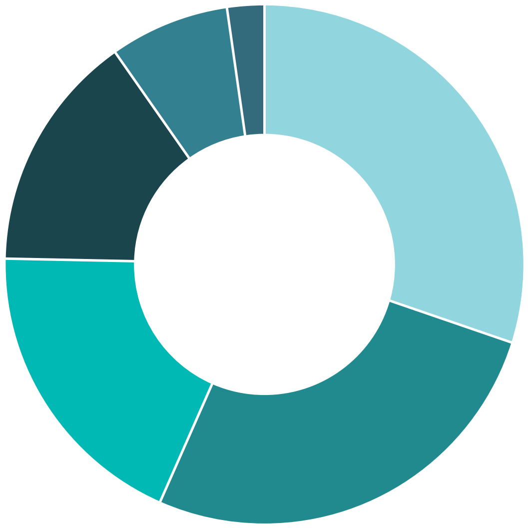
Battery storage investments are accelerating in Australia

- As reported in the Clean Energy Council Report 2021, 16 large-scale batteries were under construction at the end of 2020, representing more than 595 MW of new capacity.
- Several other notable utility-scale battery projects were announced in 2020, including the NSW Government committing to build four new large-scale batteries under its Emerging Renewables program.
- Australian households installed 23,796 small scale batteries with a combined capacity of 238 MWh in 2020.

- Generators are contributing to storage investments and planning to build several large-scale batteries on the sites of its existing fossil fuel power station assets.
- Several states have significant battery programs and investments in place:
    - The Western Australian Government is tendering for a 100 MW battery, the first to be built on the state's main grid.
    - South Australia witnessed 7,152 household batteries installed in 2020, the most in Australia, due to strong uptake of the SA Government's Home Battery Scheme. This was followed by NSW, which installed 6,264 household batteries as a result of the NSW Government's Empowering Homes battery loan program.

FIGURE 9

Number Of Small Behind-the-meter Battery Systems Installed In 2020



State	Systems	Capacity (MWh)
SA	7,152	71.5
NSW	6,264	62.6
VIC	4,476	44.7
QLD	3,576	35.8
WA	1,788	17.9
TAS	540.0	5.4
TOTAL	23796.0	237.9

Source: Clean Energy Australia Report 2021
Link: https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2021.pdf

Australia is the only country in the world sitting on all the raw materials needed to make lithium-ion batteries and the new roadmap presents an opportunity to position the country at the forefront of an industry rapidly growing in significance and profitability."

Mark Chilcote,
Managing Director Energy Renaissance

The Australian federal and state governments are making significant progress in implementing the country's National Hydrogen Strategy

Australia is placing a big bet on hydrogen. It is driving significant investment and programs through the federally funded National Hydrogen Strategy and initiatives at a state level.

Australia's National Hydrogen Strategy aims to grow Australia's hydrogen industry and position Australia as a major hydrogen player globally by 2030.

- Australia's National Hydrogen Strategy sets a vision for a clean, innovative, safe and competitive hydrogen industry that benefits all Australians. It aims to position Australia's industry as a major global player by 2030. Australia is accelerating the commercialization of hydrogen, reducing technical uncertainties and building up its domestic supply chains and production capabilities.

- Australia has the resources and skills to build an economically sustainable domestic and export hydrogen industry which can help meet agreed emissions targets and address concerns around energy security.

- The government's 2021-22 budget invests a further AUD $539.2 million in new clean hydrogen and carbon capture, use and storage (CCS/CCUS) projects that are aimed to support Australian industry, create jobs, help cut emissions and drive investment.

    - AUD $275.5 million is committed to accelerate the development of four additional clean hydrogen hubs in regional Australia and implement a clean hydrogen certification scheme.

    - AUD $263.7 million to support the development of CCS/CCUS projects and hubs.

Every state and territory in Australia has excellent prospects for hydrogen production. Through the National Strategy, all of Australia's state governments are committing to remove barriers to industry development. The states are taking an aggressive approach towards hydrogen.

- **New South Wales:** In March 2021, the NSW Government unveiled a plan to invest AUD $750 million for a green industrial revolution in which AUD $175 million is expected to set up low carbon industries such as green hydrogen. In May 2021, a consortium of Australian energy industry heavyweights led by renewables advisory firm Energy Estate, in partnership with AGL Energy, APA Group, and ITM Power, unveiled plans to develop the Hunter Hydrogen Network (H2N), a large-scale renewable hydrogen production, transportation and export hub in the NSW Hunter region that could give rise to the nation's first hydrogen electrolyzer "gigafactory."

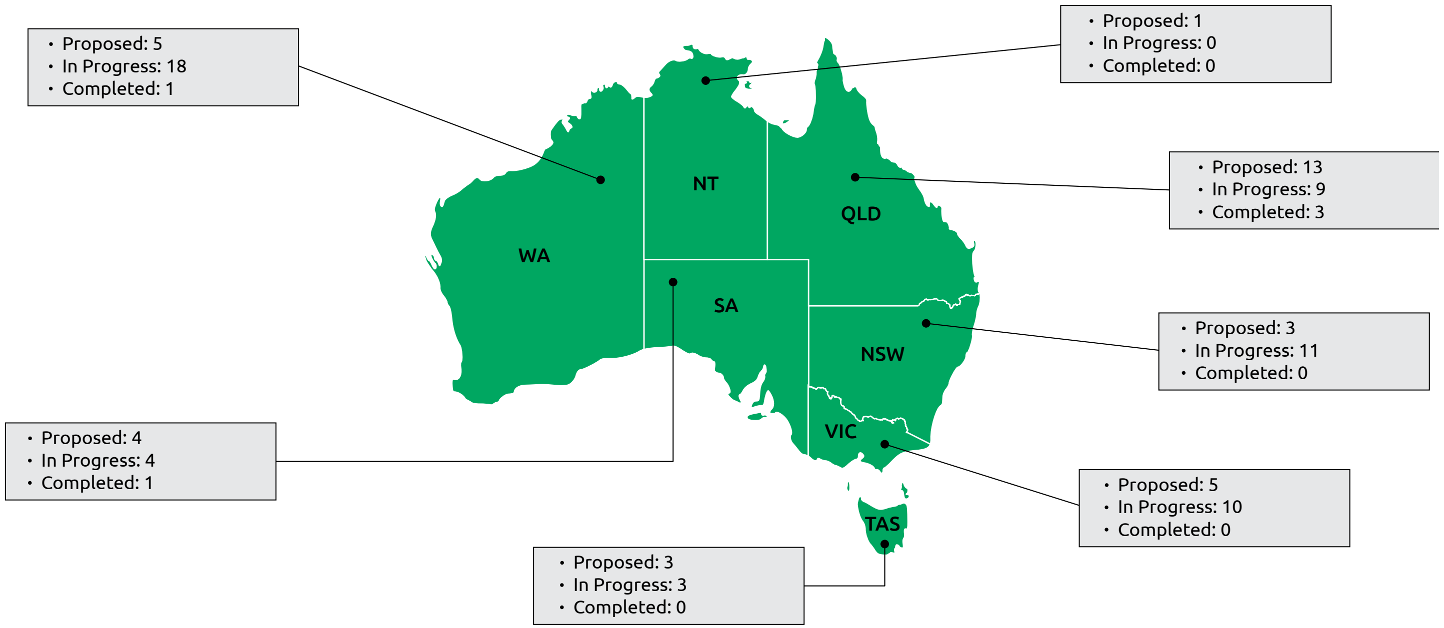
- **Northern Territory:** In February 2021, the Northern Territory government announced a renewable hydrogen trial in Tennant Creek using 'water from air' technology. The hydrogen plant will run on solar energy and trial a new technology developed by Aqua Aerem which "captures water from the atmosphere in arid environments".

- **Queensland:** In December 2020, Origin Energy and Kawasaki Heavy Industries announced their collaboration to assess the potential of a green hydrogen production facility in Townsville. It will have an initial scale of 300 MW / 36,000 tonnes per annum of hydrogen production for export and domestic supply.

- **South Australia:** In December 2020, SA set a 500% renewable energy target and goal to export the energy in the form of green hydrogen, ammonia, or electricity over transmission lines. The SA government wants to go even further, suggesting in its newly unveiled climate action plan that green hydrogen has the potential to deliver six times more clean energy than its annual electricity consumption, which it could support exports to other states and countries.

FIGURE 10

Australia: Hydrogen (98) Projects by State and Life-Cycle Stage – As of Jan 2021



- **Tasmania:** In March 2020, Tasmania announced a 200% renewable energy target and big goals for lower-cost green hydrogen production as the island state ramped up its ambitions as a clean power provider for the rest of Australia.
- **Victoria:** In March 2021, as part of the Renewable Hydrogen Development Plan, the Victorian Government allocated AUD $10 million in additional support for budding hydrogen development.
- **Western Australia:** In September 2021, Western Australia provided a AUD $61.5 million boost for its renewable hydrogen industry.

Is ammonia the biggest near-term opportunity for developing a clean Australian hydrogen industry in the drive to cut carbon emissions?

Ammonia is now seen almost universally as an important contributor to the hydrogen economy. Its easy conversion from gaseous hydrogen to liquid ammonia offers a simple way to store and transport a safe, high-energy density liquid fuel using existing global infrastructure.

Australia’s pipeline of green ammonia projects is growing

- In July 2021, an international consortium unveiled ambitious plans for a 20m tonne/year green ammonia mega project in Australia that is anticipated to provide clean energy to domestic and foreign customers. Per the plan, the Western Green Energy Hub (WGEH) is to be built in phases to produce up to 3.5 million tonnes of zero-carbon green hydrogen or 20 million tonnes of green ammonia each year, which will be provided to domestic markets as well as international markets, as the green fuels market continues to expand post-2030.
- At the domestic level, the 2021-22 budget has allocated AUD $25 million to help new gas-fired generators run on hydrogen.
- In May 2021, upon conclusion of ARENA’s Renewable Hydrogen Deployment Funding Round, the Yara-ENGIE Pilbara Renewable Ammonia ‘YURI’ project received a conditional funding award of AUD $42.5 million towards a 10 MW electrolyzer to produce renewable hydrogen at an existing ammonia facility.
- In May 2021, ARENA awarded AUD $42.5 million grant to Norway’s Yara International SA and France’s Engie SA to build a renewable hydrogen plant to make green ammonia.

Challenges:

- In June 2021, the Australian government rejected plans for a AUD $36 billion wind, solar and hydrogen project in Western Australia as it was set to have unacceptable impacts on internationally recognized wetlands and migratory bird species. The project was designed to initially build 15 GW of renewable energy capacity and would eventually be expanded to 26 GW and produce green hydrogen and ammonia for export.
- Another main challenge will be the cost. By most estimates, green ammonia will cost two to four times as much to make as conventional ammonia.

State based approach for green ammonia:

- **Western Australia:** In July 2021, the West Australian state government welcomed a proposal for a new hydrogen project in the Goldfields-Esperance region that is set to produce up to 3.5 million tonnes of renewable hydrogen or 20 million tonnes of green ammonia each year.

- **South Australia:** The AUD $240 million H2U Eyre Peninsula Gateway Hydrogen Project, the world's largest green ammonia plant, has received a boost from the South Australian government. In November 2020, the SA Government allocated AUD $37 million to upgrade the nearby Port Bonython jetty as part of its plan to become an exporter of green energy to world markets.

- **Queensland:** In July 2021, the Queensland government became a founding partner in the Zero Carbon Certification Scheme, run by the Smart Energy Council and Hydrogen Australia. The scheme assesses the embedded carbon in participating hydrogen, green ammonia and metals produced in Australia. It is a certification to guarantee that green ammonia is produced from renewable sources. It will also provide a carbon rating through the issue of a Guarantee of Origin certificate.

- **Victoria:** In May 2021, Victoria joined the Zero Carbon Certification Scheme.

"Green Hydrogen is perhaps the single biggest opportunity we have to impact carbon emissions, not just in Australia, but globally, with leading production and export capability being developed across various exciting local programs and with international partners. With the right policy and investment environment, we have the ability to lead the world in this emerging sector."

Nicole Alley, Energy & Utilities Sector

Lead, Capgemini Australia

Government incentives are helping Australian Electric Vehicle (EV) sales gain momentum

EV momentum has begun, but it is still a very small proportion of total vehicles in Australia. The mix of a few concentrated cities and a large sparsely populated country means a different set of business model choices. Regardless, government policies still have an ongoing role to play in accelerating adoption.

In 2020, there were 6,900 electric cars sold in Australia, a 2.7% increase from the 6,718 sold in 2019. The 2020 figures show electric cars account for 0.7% of total Australian car sales. There is a growing momentum of EV sales in Australia.

- Overall, 6,900 electric cars were sold in 2020 and 3,226 EVs have been sold in the first half of 2021.
- 1,530 EVs were sold in 2016, while the number steadily increased each year through 2019 with 6,718 EVs purchased.
- The current number of EVs in the country is estimated to be close to 20,100 units
- Electric vehicle sales experienced a surge in 2019 in Australia, tripling from 2,216 new vehicles in 2018 to 6,718 in 2019. This jump came despite a 7.8% fall in combustion engine vehicle sales in the same period.
- According to available data, which excludes Tesla sales, private purchases accounted for 51% of electric vehicle sales in 2019, as compared to 37% in 2018.

Electric vehicle uptake in Australia has been slower than in other developed countries, but the number of electric vehicles is expected to grow as costs fall and charging infrastructure is expanded.

- According to the State of Electric Vehicles 2020 report from the Australian Electric Vehicle Council:
  - Australia's market share for plug-in electric vehicles still lags other developed nations at 0.6%, but the steady introduction of new models presents an opportunity for growth.
  - Australia is currently missing out on battery manufacturing opportunities. The growth in European investment in battery manufacturing demonstrates the path for Australia to expand its own activities along the battery value chain.

Australian Federal Government is promoting Electric Vehicles.

- In February 2021, the Australian Federal Government launched the first round of a fund to address barriers to rolling out new vehicle technologies. The fund will provide AUD $16.5 million in grants to pay for electric vehicle fast-charging stations across capital cities and key regional centers.
- In September 2020, the Federal Government announced it would inject AUD $74.5 million of funding into the take-up of emissions-free vehicles across Australian businesses and communities.

"The slow adoption of electric vehicles in Australia could be attributed to the lack of government policies and monetary incentives rolled out in comparison to other countries.

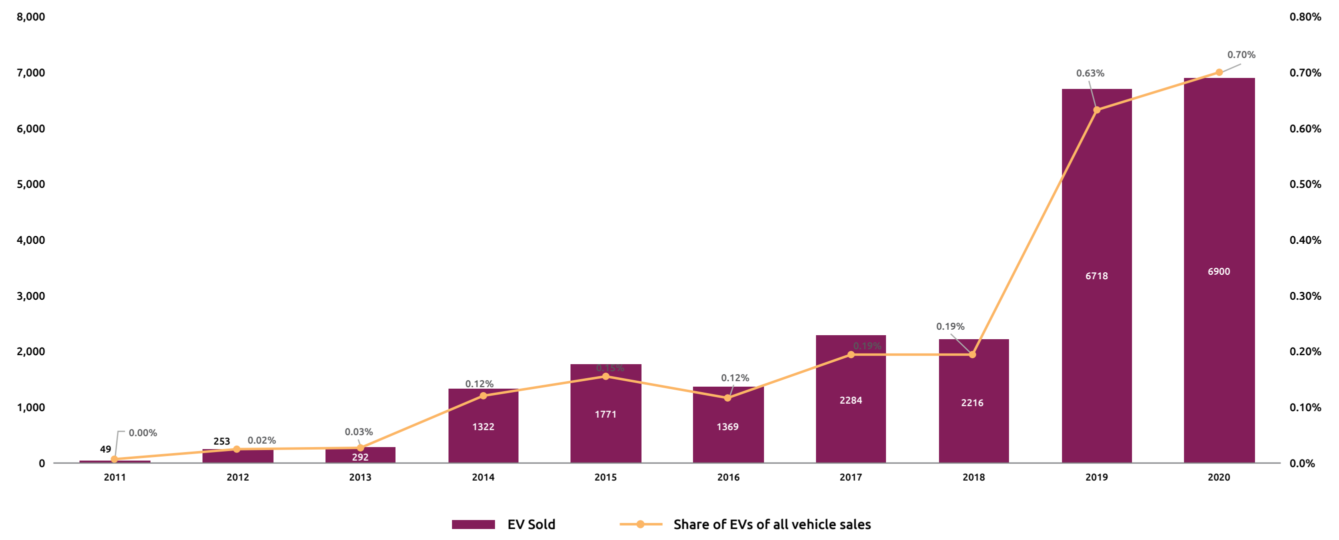
– Budget Direct

In reference to Ausgrid's JOLT Partnership: "The NSW Government is committed to getting more electric vehicles on the road and free charging stations are a great incentive and a key step in the ongoing transition towards cleaner transport options."

Matt Kean,
NSW Minister for Environment and Energy

FIGURE 11

Sales of electric vehicles (cars) in Australia (2011-2020)



Source: Electric Vehicle Council - https://electricvehiclecouncil.com.au/wp-content/uploads/2020/08/EVC-State-of-EVs-2020-report.pdf;
https://electricvehiclecouncil.com.au/new-electric-car-sales-figures-show-australia-stalled-with-hazards-flashing/;
https://www.budgetdirect.com.au/car-insurance/research/electric-car-sales-australia.html

Australian states and businesses are also playing their part in promoting the uptake of EV

State-based policy transformation supporting Electric Vehicles:

- **NSW:** In June 2021, the NSW Government unveiled a AUD $490 million plan that includes substantial taxpayer-funded incentives to buyers of electric vehicles, as well as the eventual introduction of a per-km road usage fee for electric and plug-in hybrid cars.
  - From September 2021, the NSW Government has proposed to waive stamp duty for new and used battery electric vehicles under AUD $78,000 (including GST).
  - **Rebate:** Beginning in September 2021, the NSW government has proposed to offer a AUD $3,000 rebate on the first 25,000 new battery electric vehicles purchased for less than AUD $68,750 (including GST).

- **South Australia:** In May 2021, The South Australia Government announced its plans to spend AUD $13.4 million to install 530 fast-charging stations across the state.

- **ACT:** Brand new electric vehicles are eligible for a full stamp duty exemption. As of May 2021, new or used electric vehicles are eligible for 2 years of free registration.
  - **Stamp duty exemption:** Zero emissions vehicles (including electric vehicles) that are purchased for the first time are eligible for a full stamp duty exemption.

- **Victoria:** EVs are exempted from the “luxury vehicle” rate of stamp duty, paying a flat rate of AUD $8.40 per AUD $200 of market value, as compared to up to AUD $18 for traditional vehicles. All electric vehicles also receive a AUD $100 annual discount on vehicle registration.
  - **Victoria ZEV Subsidy:** The Victorian Government has introduced ZEV Subsidy of AUD $3,000 on new zero emissions vehicles with a Vehicle Subtotal (dutiable value) under AUD $68,740 in the first stage of the program.
  - **Road Tax:** The Victorian Government has introduced new legislation to Parliament to impose a tax on the distance an EV is driven. But Electric Vehicle Council of Australia claims that the tax is about creating fairness and the long-term sustainability of the road network.

- **Queensland:** Electric and hybrid vehicles pay reduced stamp duty: AUD $2 per AUD $100 up to AUD $100,000, and AUD $4 per AUD $100 value thereafter (compared to up to AUD $6 per AUD $100 for more polluting vehicles).

- **Tasmania:** From July 2021, stamp duty is waived for all new and used EVs.

- **Western Australia:** Customers receive an incentive of AUD $200 for the first year (excluding GST) as part of the EV Home Plan Incentive.

- **Northern Territory:** In July 2021, the NT Government released its five-year plan outlining the shift to EVs, which includes the withdrawal of registration fees.
  - From July 2022, EV buyers will enjoy free NT registration and a AUD $1,500 reduction in stamp duty, effectively removing the cost of stamp duty for electric models costing up to AUD $50,000.

New EV value propositions being offered by power providers:

- **AGL:** AGL provides subscription-based plans for EVs. The AGL EV Subscription claims to be the first electric vehicle with a subscription model available in the Australian market. As of May 2021, AGL offers an energy subscription service for six different electric cars, at the below prices:
  - AGL offers up to AUD $480 in bonus credits over two years, offering customers who have an EV subscription AUD $60 in credit each time a quarterly bill is due.

FIGURE 12

From 2020 to 2024	From 2025 to 2030	From 2030 to 2050
The European Union aims to install at least 6 gigawatts (GW) of renewable hydrogen electrolyzers and produce up to 1 million tonnes of renewable hydrogen. During this phase, public support should be quite	The European Union aims to install at least 40 GW of renewable hydrogen electrolyzers and produce up to 10 million tonnes of renewable hydrogen. It is expected for hydrogen to become a fully incorporated part	The European Union aims for renewable hydrogen technologies to reach maturity and be deployed at a large scale.

- **Origin Energy:** In March 2021, Origin Energy launched Australia's first EV fleet solution. The "Origin 360 EV Fleet" brings together the energy retailer with fleet management company, Custom Fleet, to provide a one-stop-shop for EV fleet procurement, management, and charging.
  - The program is the first full-service electric vehicle fleet management program of its kind in Australia. It aims to help businesses achieve cleaner travel and save money on transportation costs.

- **Powershop:** Powershop's model focuses on maximising savings of EV owners by offering cut-rate tariffs on charging. Powershop also offers state-based tariffs for EVs.

- **Ausgrid:** In April 2021, Ausgrid launched a partnership with JOLT, Australia's newest EV charging network, where Ausgrid existing street-side kiosks are used as charging stations for EVs, allowing people to charge in 15 minutes.

"Electricity networks in Australia have a fundamental role in enabling efficient EV adoption, which, if effectively achieved can provide huge opportunities for improved network utilisation, decarbonization of transport, integration of renewable energy resources, and economic growth."

Energy Networks Australia report

"I'm excited Ausgrid is part of this vision which is taking existing, essential community infrastructure and giving it new life to provide a free service for electric vehicle users. This is the future of energy. With this partnership, we are supporting the electrification of transport by giving our customers and community access to renewable energy choices, making it easier for people to charge their vehicles and using 100 per cent green energy."

Richard Gross,

CEO Ausgrid

Key takeaways: Carbon emissions and drive to net zero in Australia

In this chapter, we have explored how Australia is progressing on its energy transition journey and how it is helping combat global climate change. Based on our observations, there is good progress but much work still to do.

Emission Reductions

- Australia is on track to meet or even potentially beat its 2030 emission targets (26-28% below 2005 baseline) per the Paris Agreement. The trajectory is set to continue even when discounting one-off impacts from COVID-19. However, there is still a challenge to reduce global warming to ~1.5 degrees or less.

- It remains to be seen if there will be a rebound in transportation emissions in a post pandemic world and whether the targets Australia has set are ambitious enough.

- The United Nations climate change conference in Glasgow later this year will be a key event for Australia to demonstrate its net zero commitment.

Climate Change

- Australia is a country prone to extreme weather conditions such as droughts and bushfires; increases in greenhouse gas emissions are only making these weather events more volatile. Research shows that Australia's average temperature is continuing to rise, and with this increased heat, the country becomes more prone to extreme weather conditions. Multiple climate indicators (rising ocean temperatures and sea levels, bushfire frequency and severity, and temperature extremes) confirm the trend. El Nino is expected to bring only short-term relief, if any.

- Despite the slow-down in global fossil fuel emissions, the concentration of greenhouse gases in the Australian atmosphere continues to rise.

- While the energy sector continues to better plan and prepare for these extreme weather events, such as bushfires, there is an opportunity to harness the community's interest and concern with the impact of fossil fuels in Australia to enact positive change and to ensure the reliability of essential services.

Energy Transition Policy and Roadmap

- While a bi-partisan federal energy strategy and policy setting in Australia still has a long way to go, the states continue to "lead the pack" with ambitious local targets, policies, and investment commitments. Large energy companies (GenTailers and grid operators) and energy-heavy industry players (mining, oil & gas) are actively progressing their plans and accelerating policy changes.

- Australia's federal and state governments are creating a pro-investment environment to accelerate Australia's renewable energy transition. In September 2020, the federal government released its first Low Emissions Technology Statement, which is the first milestone in Australia's Technology Investment Roadmap. The Statement includes a focus on five priority technologies and economic stretch goals to make new technologies as cost-effective as existing technologies. The priorities include hydrogen, long duration energy storage, low carbon materials, carbon capture and storage, and soil carbon investment. The opportunity to make strides in the emerging hydrogen sector is significant, further speeding up replacement of fossil fuels and with outstanding potential for international energy exports.

- AEMO has published its Integrated Systems Plan in June 2020. This describes a whole-of-system transformation roadmap to Australia's energy future to 2040, which will be discussed in Chapter 2. A key question for the industry is how to support the required workforce transition and new skills needed as part of the energy transition.

Energy Transition progress to date

- Australia's energy transition is well underway and has made significant progress thanks largely to consumer, community, and industry interest, which has become the primary driver for the acceleration of change. A record additional 7 GWh of renewable energy generation has been added to the energy system in 2020.

- However, renewable generation is still only 27.7% of the energy mix with solar contributing 9.9% of total generation, wind 9.9%, hydro 6.4%, and biomass and waste another 1.4%. This is close to on par with the U.K. at 33% and advanced compared to the U.S. at 15%. However, Australia is a long way behind countries like Iceland which have 100% renewable generation. Increasing the amount of renewables generation in the energy mix, particularly in a country that enjoys so much sun, is the ongoing opportunity ahead.

In summary, Australia is making progress towards reducing emissions and transition towards renewable energy sources. This is indeed in Australia's best interest given the extreme climate change impacts that Australia is exposed to on a regular basis. The question remains (as it does globally): Are we moving fast enough and being ambitious enough in our renewable energy transition?

"Australia's energy transition progress is one of the fastest in the world. Even in a 'worst case do-nothing' scenario we expect to see 74% of our energy generation from renewables by 2040. If we leverage our geographical advantages, innovation capabilities and agree to a nationwide transition plan, we can become a carbon-neutral energy world leader in record time."

Nicole Alley, Energy & Utilities
Sector Lead, Capgemini Australia

04 Climate Change & Energy Transition

04

04 Climate Change & Energy Transition

Energy Mix & LCOE

Jon Krome
Marianne Boust
Augustin Danneaux

Energy Mix & LCOE

1. Energy Mix

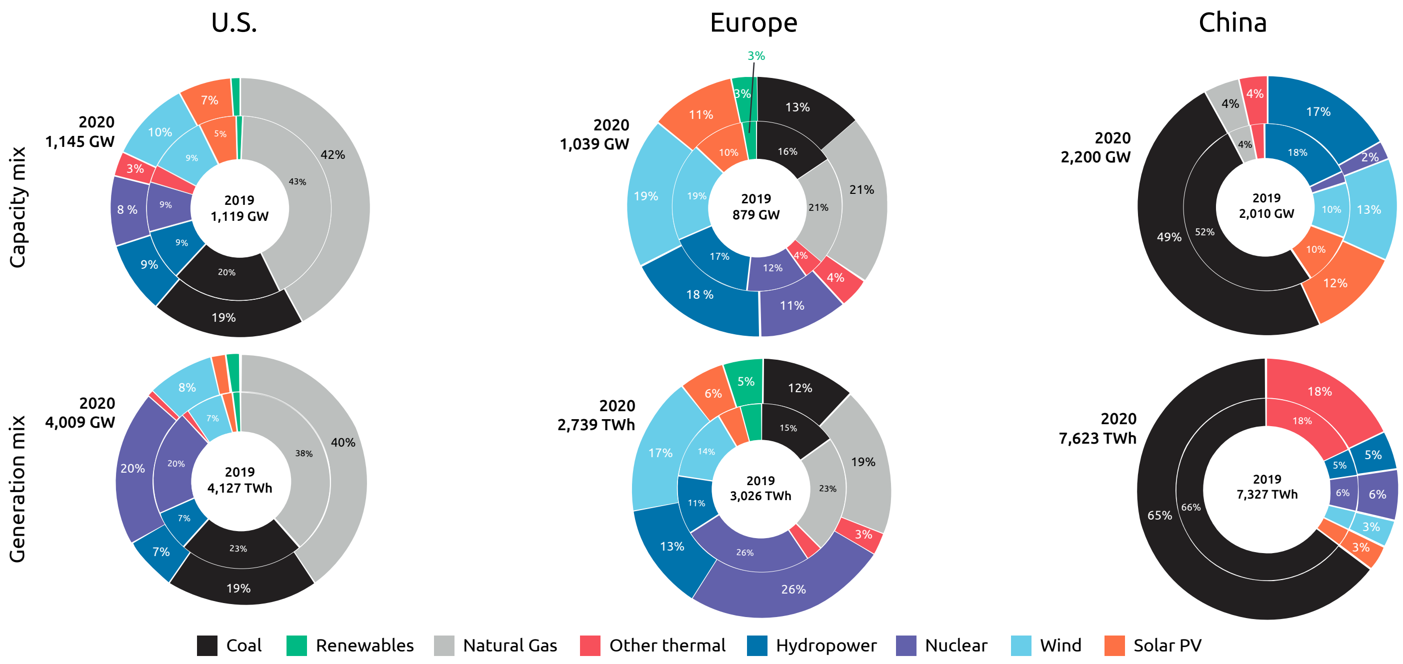
Energy diversity will benefit producers and consumers

- A robust mixture of energy sources is a low-risk approach for both energy consumers and producers as we head into the initial phases of energy transition. Today, nearly 100% of all transportation consumes roughly half of all petroleum liquids, while the rest supports a vast industrial base as plastic and chemical feedstock. Coal and natural gas supply most electricity production in much of the world – though examples exist of high regional uses of nuclear and hydro. Each of these three "fuel domains" – transportation, electricity generation, and feedstock – will evolve into a more fluid, ever-changing mix of sources based on a complex, and difficult-to-codify, combination of factors, including economic considerations, social acceptance, regulatory demands, and access.

- Energy demand is projected to rise by nearly 50% in the next 20-30 years, as driven by a growing middle class in India, China, and throughout Africa. The middle class uses much more energy – in transportation and mobility, home energy consumption, and through the production of consumer products. Developed countries in the OECD will likely have little influence on curbing these growing appetites, especially after losing the moral high ground themselves in their own pursuit of middle-class luxuries, material wealth, and economic growth.

FIGURE 1

Capacity and Generation mix by regions in 2019 and 2020



Source: EIA, BP, China Electricity Council, ENTSO-E, IRENA, Global Energy Monitor, Reuters, Oxford Energy, Capgemini Analysis

An energy base that possesses a diverse set of options should be considered as a method to manage the risk of supply – for both consumer and producer alike

- At first blush, producers might balk at the possibility of losing market share of their own product of choice. And in an era where the fuel sources are limited, such as the turn of the 20th century, the Rockefeller monopolies were in the producer's best interest. Though there was possible competition from others who could supply the same energy products, there was little choice in the basic type of energy products. It was oil, oil, and more oil. And coal.

- But today, other sources present an opportunity to the producer. Most strategists will admit that any strategy built on a single product will have intrinsic shortcomings, except in the most narrow of circumstances. Today, a new race is upon the producer, vying for the optimal source of energy. Electrons, generated from a myriad of sources will compete with carbon-based fuels. It will be full game on, and the winner will not be determined for years to come. Thus, at this early time of this new "power race", companies should distribute the risk of these sources as possible winners to manage their energy portfolios towards and efficient frontier.

- Every credible forecasting agency agrees that for the foreseeable future, carbon-based energy will need to be produced and consumed in portions of the transportation and electrical power production sectors. Older model vehicles will linger, especially in the developing world, as well as in regions will little access to other forms of transportation energy. Natural gas will also power turbines for some time, as LNG commitments bridge coal-fired plants to a cleaner alternative. Highly northern or southern latitudes will struggle with 100% renewables and will have to rely on a fuel that is still carbon-laden until alternatives are both economical and ubiquitous. Here, the emphasis will be carbon-mitigation, such as carbon capture or the use of carbon-sequestering catalysts. Offsets can also provide relief to the carbon dilemma. But offsets, even those with improved sequestering estimates and trustworthy certification, will need to provide additional assurance and performance. Net neutral is the best option until we reach a future that is truly carbon-free.

- Consumers should be viewing the situation from the same vantage, but for different reasons. To the consumer of energy, competition and choice yield a more adapted source based on the complex combination of factors. It breeds market efficiency given fair, level playing fields. In the end, the consumer wins. Combined with this view of energy diversity, energy decentralization also presents a lower risk approach to energy production and distribution. The proverbial "all eggs in one basket" scenario can be mitigated with electricity production from distributed renewable microgrids, which avoid reliance on a large, single, and distant energy supplier.

- This decentralization also relies on a new energy mix. Some will find wind or solar most useful, and at times, augmented by the central power production. In this example, during times of low wind or sunshine, power previously stored in batteries is discharged for use until central power can be supplied or the renewables can once again be engaged. This new and diverse energy ecosystem is being created now, though slowly.

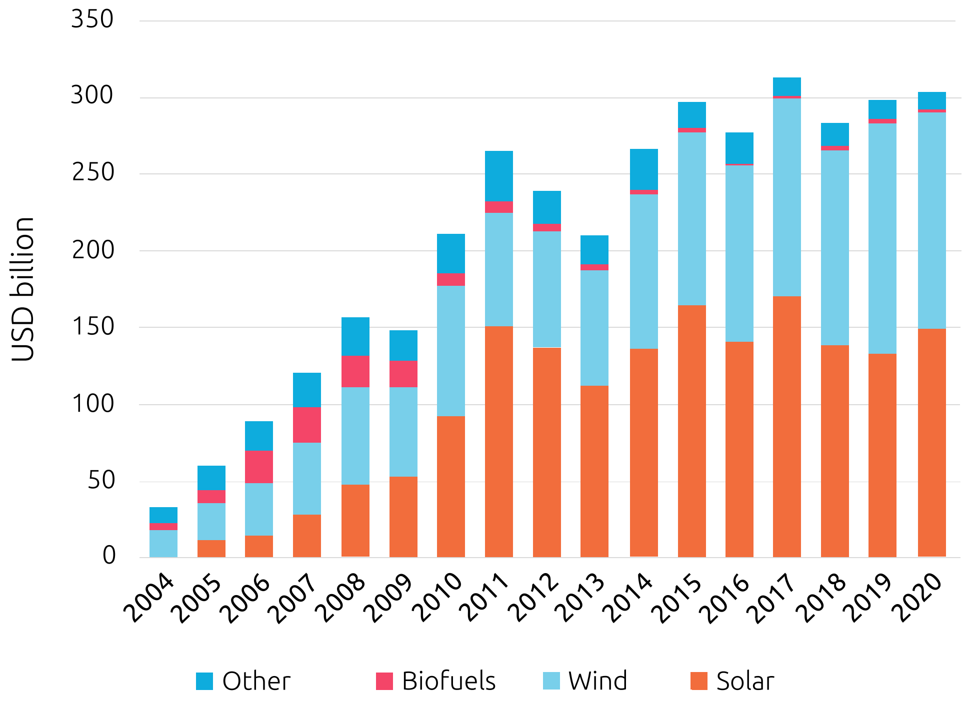
The development of renewables are boosting manufacturing value chains

- Energy production is no longer merely the domain of the "resource exploiter" or centralized power producer, such as oil and gas production companies, electric utilities, or even the developers of renewables. Product designers and manufacturers are noting that much of the energy transition is reliant upon new devices, fostered by the latest technologies, to support a decentralized energy production marketplace. Battery storage for cars, homes, and industries is the most obvious example. But fuel cells and electrolyzers, smart grid equipment, and other electrical components will all support and enable a decentralized energy system of the future and broader energy transition efforts.

- However, the biggest challenge will be the feedstocks of the future. Hydrogen-rich products will likely erode a portion of this feedstock market, as driven by products such as methanol or ammonia. But pressure on these two products, due to their energy content as hydrogen carriers, will come under the stresses of market supply and demand. As such, these sources will be largely inadequate in replacing the carbon atom that is required in existing plastics and chemicals designs.

FIGURE 2

Investments in renewables has slowed in the past decade but should increase as the industry focuses on energy transition



Source: BNEF (2021)

One of the main reasons for the slow increase of investment in renewables is the very fast decrease in the cost of components for these energies.

Going forward these investments are expected to accelerate as the share of renewables in the global energy mix increases.

2. Costs of electricity generation in 2020

Record low prices for renewables in Europe in 2020, but tensions on the supply chain push up auction prices for 2021

- The **cost for renewables** has kept falling in Europe in 2020 thanks to cheaper more efficient technologies and higher capacity factors:
  - Costs are site specific and there is a wide gap between countries (resource potential but also differences in market structure). For example, in Q4 2020 the 25th percentile of solar PPA prices was €31/MWh in Denmark and €62/MWh in Austria. For wind, it was €30/MWh in Finland and €91/MWh in France[1].

- The **number of unsubsidized contracts for offshore wind** increases : latest auction prices for projects in Northern Europe went between €42 and €51/MWh[2].

- **Utility-scale solar with battery** now ranges from €50-100/MWh, competing directly against natural gas[3].

- The cost of **nuclear generation** for existing plants is increasing as maintenance is more complex. The **generation cost of new nuclear** is driven at around 80% by CAPEX[4]. This makes it very susceptible to construction delays.

- **Carbon prices have become a considerable part of conventional power generation.** They must now be included in our analysis.
  - European ETS price increased to an average of €24.8/t in 2020.
  - Carbon price made up to half of coal generation cost in Germany in 2020[5].

- Gas-fired power plants were cheaper to run than coal-fired plants in 2020.
  - This is because of high ETS prices and a 30% y-o-y decrease in the European price of gas.
  - Commodities prices plummeted in 2020 before rallying in the autumn with the economic recovery.

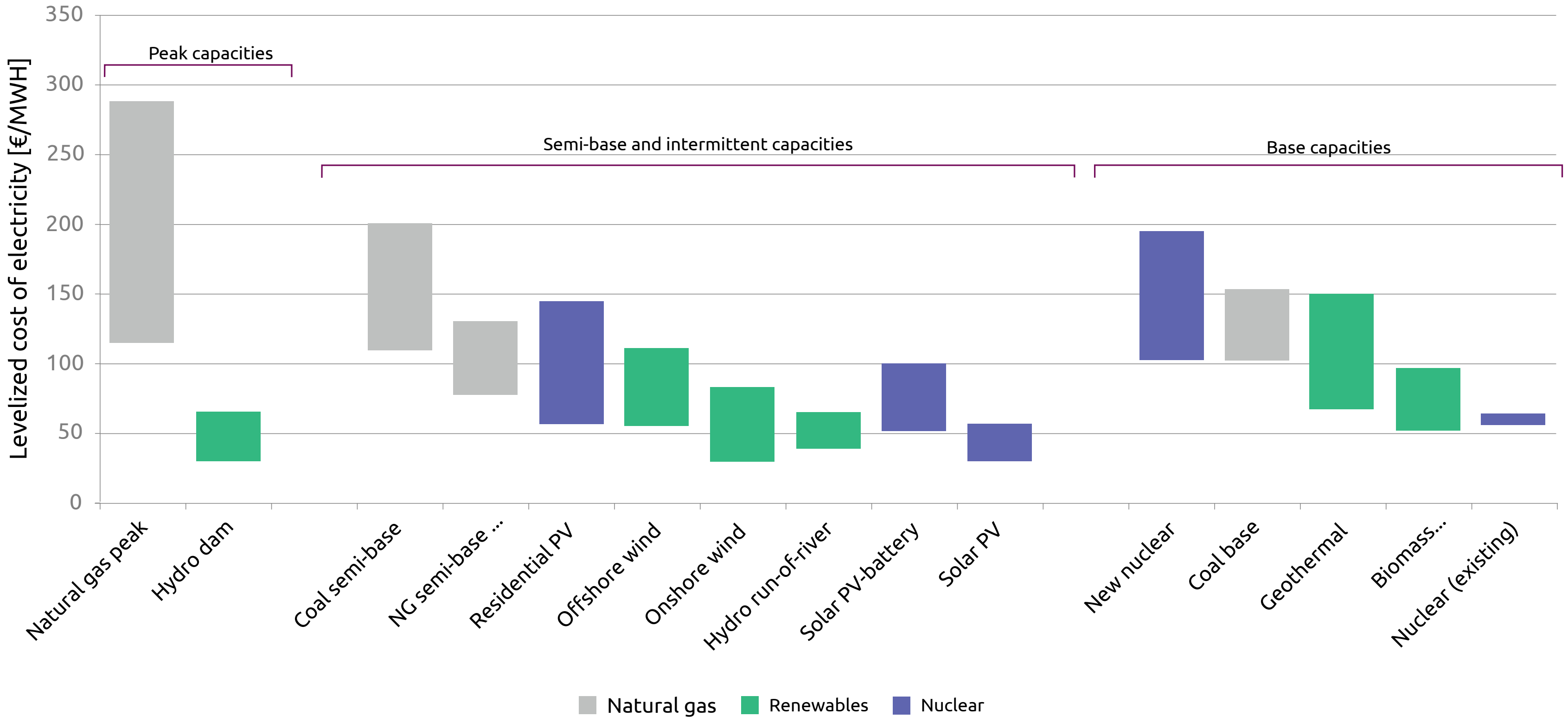
- **New coal plants** have higher installation costs because they use supercritical technology but at the same time they have much higher efficiency (60% for Datteln 4 coal plant that was commissioned in 2020) Ultimately the coal LCOE for new plants is lower than for existing ones.

Material costs, especially copper and steel, have increased in the first half of 2021 driven by high demand for post pandemic economic recoveries. The surge in raw material and transport prices is particularly weighing on wind and solar, and technology costs are poised to increase in 2021. In June 2021, PV module prices were 20% higher than in Q4 2020[6]. Manufacturers are under pressure, underscored by global wind maker Siemens Gamesa reporting loss in June 2021[7].

1 LevelTen Energy PPA Price Index Europe, Q4 2020
2 IRENA Renewable power generation costs in 2020
3 NextEra
4 IEA-NEA: Projected Costs of Generating Electricity 2020
5 Fraunhofer: Levelized Cost of Electricity Renewable Energy Technologies 2021
6 https://www.pv-magazine.com/2021/07/09/eu-spot-market-module-prices-climate-targets-pv-price-trends-for-2030-a-viable-mix/
7 https://www.reuters.com/business/energy/siemens-gamesa-posts-q3-net-loss-confirms-fy-profit-warning-2021-07-30/

FIGURE 3

Levelized cost of electricity for new generation built in Europe (2020, including carbon price)



Sources: IRENA 2021,IEA-NEA 2021, Fraunhofer 2021, CRE, Capgemini Analysis

In the US renewables are pushing conventional generation out of business

Technology improvements and capital costs decline have continued to improve the economics of renewable technologies.

- The cost for onshore wind has decreased by 2.5% to USD40/MWh in 2020. Factoring production tax credits, onshore wind prices are estimated at USD15-20/MWh in states with optimal wind conditions.
- In a context of booming US market, solar PV costs have decreased by 8% y-o-y in 2020.
- Renewables are cheaper than marginal costs of existing coal plants, which is leading to the closure of several coal-fired power plants and lower capacity factor.
- Natural gas and coal could not compete against renewables in most states and low commodity prices (average 2020 Henry hub price averaging at USD1.99/MMBtu or USD6.79/MWh).

The decrease of global offshore wind costs has helped kick-start the offshore wind industry in the US.

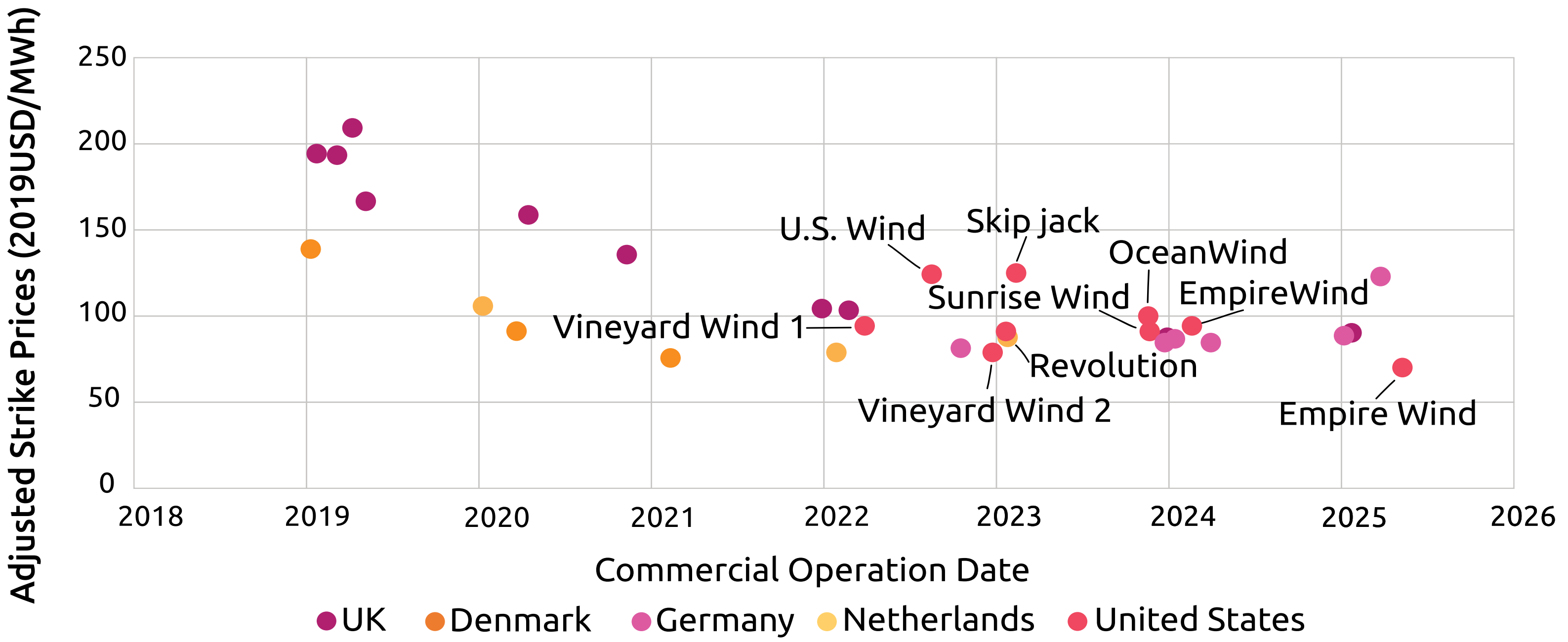
- According to NREL, the estimated cost of offshore wind in 2020 was USD89/MWh, 70% lower than in 2019 (USD124/MWh) and about half of the cost level in 2018 (USD173/MWh)[3].
- In February 2020, Shell and EDP Renewables announced they had signed a PPA at USD58.47/MWh levelized of the 20-year lifetime for the 804 MW Mayflower Wind project.[4]

The price of an individual PPA is very different from the cost of generation for renewable project. The cost of generation is generally determined as a levelized cost of energy (LCOE) calculation that includes the initial installed capital cost as well as operations and maintenance (O&M) costs, the cost of financing, amount of energy to be generated, long-term system reliability, and decommissioning costs. Renewable energy projects receive subsidies from governments and include attributes such as renewable energy credits (RECs) and the value of capacity credits. These attributes produce additional revenue streams and allow project owners to sell output below the actual cost of generation.

1 Lazard's levelized cost of energy analysis
2 Fraunhofer: Levelized Cost of Electricity Renewable Energy Technologies 2021
3 https://www.nrel.gov/docs/fy20osti/76079.pdf
4 https://www.windpowermonthly.com/article/1673776/mayflower-lowers-us-offshore-58-mwh

FIGURE 4

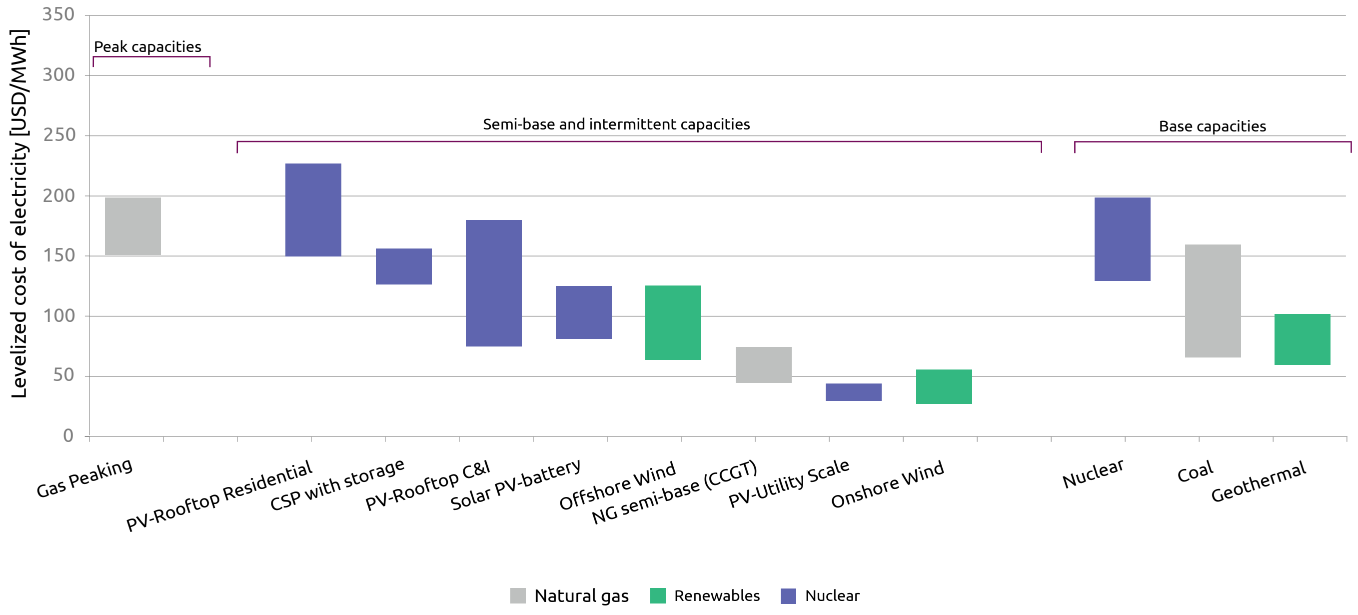
Adjusted Strike Prices from U.S. and European Offshore Wind Auctions



Sources: NREL 2019
World Energy Markets Observatory 2021

FIGURE 5

US Unsubsidized LCOE, 2020 (US$/MWh)



Sources: Lazard 2020, NREL

LCOE remains a very theoretical concept, and it is not fully sufficient for comparison because it does not reflect all externalities (storage cost for renewables, cost of reinforcing networks, end-of-life cost for nuclear, impact on biodiversity and landscapes ...) nor the fact that production can be adjusted to demand in real time.

Indeed, it is not possible to directly compare a MWh produced by a controllable means of production (gas, coal, nuclear, hydro) with a MWh of production whose availability is not the result of a choice (e.g. wind, photovoltaic).

04 Climate Change & Energy Transition

04

04 Climate Change & Energy Transition

Hydrogen as a Vector for Energy Transition: Legal Framework & Financing

Christine Le Bihan Graff
Maxime Gardellin

Hydrogen as a vector for Energy Transition: Legal framework & financing

The European Union (EU), and specifically France, have set ambitious strategies to develop the production and use of hydrogen

Because hydrogen has been identified as a crucial enabler of the energy transition, the European Union and France have begun to build a legal framework conducive to its emergence.

To achieve the energy transition objectives, the EU and France are interested in the production and use of hydrogen because renewable or low-carbon hydrogen emits minimal carbon dioxide and almost no air pollution.

Renewable or low-carbon hydrogen is, therefore, a central lever for reaching the goal of carbon neutrality in 2050, which both the European Union and France have committed to.

Hydrogen produced from renewable or decarbonated sources is considered one of the available and efficient solutions to meet energy transition goals. It can be used as a raw material, fuel, energy carrier, and storage solution for electricity.

The European and French strategies specifically aim to use hydrogen to help decarbonize other industrial sectors (such as the steel industry), ensure the storage of electricity, or power the transportation sector.

The development of the hydrogen sector is also of interest to the European and French economic recovery plans designed to contribute to remedying the immediate economic and social damage caused by the Coronavirus pandemic.

Indeed, it is estimated that the hydrogen sector could create up to one million high-quality direct jobs by 2030 and 5.4 million by 2050[1].

However, the implementation of hydrogen technologies requires overcoming a certain number of barriers. Today, renewable hydrogen and low-carbon hydrogen are not cost competitive when compared to hydrogen from fossil fuels.

Therefore, public support and an appropriate legal framework are necessary to support the development of this new sector and match European and French ambitions. These support mechanisms will also need to include sufficient flexibility and clarity to provide legal certainty to investors.

1 European Parliament resolution of May, 19 2021 on a European strategy for hydrogen (2020/2242(INI))

FIGURE 1

Estimated current cost of fossil hydrogen	Estimated cost of low-carbon hydrogen	Estimated current cost of renewable hydrogen
€1.5/kilogram	€2/kilogram	between €2.5 - €5.5/kilogram

Since the European and French legal frameworks are still in the process of being built, it is too early to say how efficient they will be.

However, the main lines of these legal frameworks have already been drawn. The purpose of this article is to present the first steps taken by the European Union **(1.)** and France **(2.)** to create a legal environment favorable to the development of the hydrogen industry.

Hydrogen needs strong support to become profitable and competitive. Public support, including financial support mechanisms and appropriate legal framework, is necessary to achieve the rapid and large-scale deployment of hydrogen.

The first milestones of the European legal framework for the development of the hydrogen sector have been taken

In a communication from the European Commission dated July 8, 2020, the European Union adopted a strategy to develop clean hydrogen, which provides several measures to promote and support the hydrogen sector

The ambitious European roadmap to develop clean hydrogen is divided into different phases allowing the measures to be adapted to the maturity of the sector.

The European Union has chosen to prioritize the development of renewable hydrogen and low-carbon hydrogen in the short and medium-term.
To do so, it has set quantified objectives, which are spread over three phases corresponding to the different stages of maturity of this new sector:

FIGURE 2

From 2020 to 2024	From 2025 to 2030	From 2030 to 2050
The European Union aims to install at least 6 gigawatts (GW) of renewable hydrogen electrolyzers and produce up to 1 million tonnes of renewable hydrogen. During this phase, public support should be quite significant since the hydrogen sector will still be relatively young.	The European Union aims to install at least 40 GW of renewable hydrogen electrolyzers and produce up to 10 million tonnes of renewable hydrogen. It is expected for hydrogen to become a fully incorporated part of the integrated energy system and its cost will gradually become competitive compared to other forms of energy production. During this transitional phase, it will be necessary to start preparing for the gradual withdrawal of public support mechanisms.	The European Union aims for renewable hydrogen technologies to reach maturity and be deployed at a large scale.

The identification and coordination of viable investments will be carried out by the European Clean Hydrogen Alliance.

Achieving the roadmap's objectives requires a robust and coordinated investment program that makes the most of the leverage effect while avoiding over-support.

In this respect, the European Union has launched the European Clean Hydrogen Alliance (the Alliance), which brings together leading actors from the sector, national and local governments, civil society representatives, the European Investment Bank, and other stakeholders.

This Alliance aims to build a pipeline of investment projects to increase the production and support the demand for clean hydrogen in the European Union and to identify and coordinate viable investment projects since effective coordination of investments is essential to the success of the sector.

At the occasion of the forum held on June 17 and 18, 20211, the Alliance presented 997 projects out of the 1,052 submitted. The eligibility of the selected projects was based on the following criteria: Alliance membership, geographic location, project maturity, and CO2 emission threshold.

Several European funds are mobilized to financially support hydrogen projects, as well as enable small- and medium-sized companies and less developed state members to take part in the development of hydrogen sector

The European Union intends to mobilize different funds to help finance hydrogen related projects and encourage the emergence of the sector. These funds should enable hydrogen sector operators, especially small businesses, to find the financial assistance adapted to the nature and the scale of their project.

A plurality of existing European funding instruments is suitable to fund the development of hydrogen projects because a wide scope of hydrogen-related activities must be developed to enable the sector to emerge. These activities range from the production of renewable and low-carbon hydrogen, to its transportation and distribution, and its application in industry and mobility purposes.

As an example, it is estimated that funding in electrolyzers alone is expected to represent between €24 and €42 billion by 2030.

To facilitate access to relevant information on financial support, the European Commission has launched the Hydrogen Public Funding Compass, which is an online guide for all interested stakeholders to identify public funding sources for hydrogen projects.

This funding compass not only contains information on European funding programs and funds, but also on programs implemented at the national level by member states.

The significant budgets contributing to the financing of clean hydrogen projects will be guided by the sustainable finance strategy adopted on July 6, 2021, the EU Taxonomy on Sustainable Finance adopted on April 21, 2021, and the Alliance.

About fifteen European funds and programs are mobilized. Their purpose is to finance innovative technologies, research, sustainable energy infrastructures, small and medium-sized companies, sustainable development and energy beneficial to the environment.

For instance, the Innovation Fund is dedicated to financing innovative low-carbon technologies. The focus of this program is not to fund research, but to promote the market introduction of highly innovative technologies. Therefore, this fund will be available to finance demonstration projects on the innovative production and use of renewable and low-carbon hydrogen on a pre-commercial scale.

European funding instruments offer five different types of financing. Depending on the case, hydrogen projects can benefit from:

- grants
- loans
- guarantees
- equity
- trust fund prizes

As an example, the Invest EU Fund mobilizes public and private investments through a €38 billion budget guarantee to support the investment projects of the European Investment Bank Group (EIB) and other financial partners.

Certain European funding instruments, such as the European Regional Development Fund and the Cohesion Fund, specifically target small and medium-sized enterprises and least developed member states, so they can take part in the process of supporting the emergence of the hydrogen sector.

Hydrogen projects may receive funding from multiple European funding instruments, provided that these funds are not intended to cover the same costs.

The EU launched an important project of common European interest (IPCEI) specifically dedicated to hydrogen

Important projects of common European interest consist of gathering the know-how and financial resources of the European Union's private and public actors to implement cross-border and large-scale projects that benefit the Union and its citizens

By exception to the principle of the prohibition of state aids, the promotion of IPCEIs may be considered compatible with the internal market[1].

To ensure that an IPCEI is compatible with the internal market, the European Commission assesses each project on its communication, dated June 20, 2014. It assesses the criteria relating to the analysis of the compatibility with the internal market of state aid to promote the execution of an IPCEI. **Projects that meet the criteria are exempt from competition and state aid rules.**

Pursuant to this communication, three categories of projects can be qualified as IPCEI:

- RDI projects with a major innovative character (Article 21)
- Projects involving industrial deployment for the development of a new R&D-intensive product (Article 22)
- Projects in the fields of environment, energy and transport with a major impact on European strategies (Article 23).

In December 2020, the European Commission launched the IPCEI Hydrogen and a manifesto for the development of a hydrogen value chain has been signed by 23 member states. This IPCEI should be implemented in 2021 and other hydrogen related IPCEIs are expected to follow.

The coordination of the investments in the framework of these projects will also be operated in light of the recommendations set out in the Strategic Forum for IPCEI report.

IPCEIs seem particularly well-suited to the development of the hydrogen sector since it requires significant research and innovation efforts across the entire value chain. This legal instrument will also encourage synergy between member states because the projects selected in this framework **must involve more than one member state and benefit a significant part of the Union** without being limited to those who have contributed to its financing.

The major advantage of IPCEIs is they secure the flow of public money to investors at an early stage of the project.

However, the success of the IPCEI Hydrogen will also depend on the clarity of its legal regime.

In order to facilitate this complex implementation, the European Commission intends to clarify certain notions, give additional guidance on certain eligibility and compatibility criteria of the Communication, and facilitate the participation of small and medium-sized companies.

1 Article 107 (3) (b), Treaty on the Functioning of the European Union.

The first milestones of the French legal framework for the development of the hydrogen sector are also on the road to full implementation

On September 9, 2020, the French Ministries of Ecological Transition and of Economy presented the national strategy for developing low-carbon hydrogen. It was identified as a priority area of investment given the environmental, economic, energy sovereignty, and technological independence issues associated with the development of hydrogen.

The French strategy for the development of clean hydrogen aims to reach approximately 20% to 40% of total hydrogen and industrial hydrogen consumption by 2030[1].

Following the example of the European strategy, the French strategy for the development of the hydrogen sector mainly focuses its efforts on clean hydrogen, which is produced from decarbonized energies. This strategy is based on three main axes:

1. decarbonizing the industry by developing a French electrolysis industry;
2. developing heavy mobility with carbon-free hydrogensupporting research, innovation, and skill development; and
3. building an industrial sector that creates jobs and guarantees technological expertise for France.

The realization of these objectives requires strong public financial support. The French government intends to devote **€7.2 billion** to encourage research and the emergence of hydrogen-related projects.

In its report on hydrogen, the French National Energy Regulator invited the French and European public authorities to support the manufacturers of electrolyzer components to maintain competitiveness with China and the United States.

Although China is the world’s leading producer of hydrogen, it is still lagging behind in the production of certain components, which it is forced to export.

Calls for projects or expressions of interest specifically dedicated to hydrogen have been launched in France.

Calls for projects **(CFP)** or calls for interest **(CFI)** are particularly suited to sectors that are not mature yet, such as hydrogen. These calls make it possible to provide the project managers with customized support that is perfectly adapted to the characteristics of the projects.

The French government has launched several CFPs/CFIs to stimulate and support research and the emergence of innovative projects related to hydrogen, which could be selected for the French hydrogen IPCEI

A hydrogen IPCEI conducted by Germany will support R&D and the industrialization of electrolyzers to produce carbon-free hydrogen and deploy these solutions on an industrial level. France will set aside €1.5 billion for it. The Commission should be notified of this IPCEI by the end of 2021, and other hydrogen related IPCEIs are expected to be initiated.

FIGURE 3

CFP Territorial Hydrogen HUB	CFP Technology bricks and demonstrators
Aimed at deploying large-scale territorial ecosystems concerning industry and mobility by bringing together local authorities and industrial solution providers to maximize economies of scale. This CFP will be endowed with €275 million by 2023.	Aimed at developing or improving components and systems related to the production and transportation of hydrogen and its applications. It can also support demonstration projects with significant value creation and allows the hydrogen sector to develop new solutions and structure the industry. This CFP will be endowed with €350 million by 2023.

France adopted the Hydrogen Ordinance, which outlines the main support mechanisms for developing the hydrogen sector. However, the regulations specifying the applications have not yet been adopted.

The first milestones of the French legal framework for hydrogen were laid with the Ordinance n° 2021-167 dated February 17, 2021. The Ordinance resulted in the creation of a new section in the French energy code. The government stepped in to define the framework of the support of renewable and low-carbon hydrogen.

The Ordinance distinguishes between renewable, low-carbon, and carbon-based hydrogen, and provides definitions based on the primary source used for hydrogen production. In France, public support exclusively concerns the production of renewable and low-carbon hydrogen.

The establishment of clear terminology is important for investors. **However, the sector's professionals are still waiting for the issuance of a decree of the French Ministry of Energy containing the thresholds above which hydrogen can be considered as renewable or low carbon.** The eligibility of projects for public support will depend on this qualification (Article L. 811-1, French energy code).

The Ordinance provides public support for the production of renewable or low-carbon hydrogen by electrolysis of water (Article L. 812-1, French energy code). This support is open to any person established in the territory of a member state of the Union or the European Economic Area. Depending on the case, t**his public support will take the form of:**

1. **Financial aid for investment**

2. **A combination of financial aid and operating aid**
   (Article L. 812-2, French energy code)

Clean hydrogen projects eligible for support will be selected following a tender procedure that complies with the principles of transparency and equal treatment, the terms of which will be specified by a decree of the conseil d'Etat (Article L. 812-3, French energy code).

The French National Energy Regulator, which was consulted to give its views on the Ordinance draft, expressed reservations about the use of calls for tenders to support renewable and low-carbon hydrogen produced by electrolysis.

The regulator questions the level of maturity of the hydrogen sector and its capacity to meet the prerequisites necessary for the proper functioning of a call for tenders, such as:

1. A sufficient number of projects to maintain the competitive pressure and the effectiveness of the tender
2. Knowledge of the operating costs of the projects, so public authorities can define the specifications and a suitable support mechanism

The operating aid granted will be subject to a contract with the state, with a maximum duration of 20 years, setting out the terms and conditions for the payment of the aid, its duration, the frequency of payments, and the conditions for receiving the aid (Article L. 812-4, French energy code).

To avoid reproducing the same situation as photovoltaic energy, which had such significant public support it led to a windfall effect, the Ordinance contains provisions to ensure hydrogen-related projects are not overly supported.

Two articles of the Ordinance provide mechanisms to avoid the risk of excessive remuneration of hydrogen project managers who benefit from operating aid:

- The amount of operating aid granted must not result in the total return on return on capital tied up exceeding a reasonable level, considering the risks inherent in the activities supported by the aid (Article L. 812-5, French energy code).
- The contract concluded with the French State may subordinate the benefit of the operating aid to the renunciation, by the producer, to some of his financial or taxation aids (Article L. 812-5, French energy code).

Moreover, since this support mechanism is transitory, the operating aid may be partially or totally suspended by the competent administrative authority if it no longer meets the objectives of the French Annual Energy Programs (Article L. 812-7, French energy code).

While the broad outlines of the French support system for the hydrogen sector have been outlined in the Ordinance, **the precise rules still must be specified** by a decree after the consultation with the conseil d'Etat.

Conclusion

The European Union and France, faced with the emergency of climate change, have fully seized the challenge of hydrogen.

They have set ambitious objectives and adopted the fundamentals of a legal framework that seems promising for a rapid and large-scale deployment of the hydrogen sector.

However, these legal frameworks are still in the process of being completed. Therefore, investors and hydrogen project managers are still waiting for the complete European legislation that will be adopted after the debates with the member states on the European Commission's strategy, as well as the French regulatory framework.

In addition, the implementation of support mechanisms for hydrogen projects is essential but not sufficient to guarantee a substantial take-off of the hydrogen sector. It is necessary to also put in place a coherent regulatory framework that offers visibility to investors apart from the financial circuit.

04

04 Climate Change & Energy Transition

04 Climate Change & Energy Transition

Commitments and Actions of States towards Climate Change

Christine Le Bihan Graff
Maxime Gardellin
Elisa Jeanneau

Commitments and Actions of States Towards Climate Change

At the international level, the parties to the Paris Agreement (COP21) committed to ambitious and legally binding objectives for climate change

The momentum gained in Paris appears to be continuing.

- Following the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, **the Paris Agreement (COP21) was adopted in 2015 by 196 Parties** and entered into force in 2016. Its target is to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels. There are currently 191 Parties to the Paris Agreement.

- Despite the withdrawal of the United States in 2017, the momentum gained in Paris appears to be continuing. In 2019, at the Climate Action Summit on the sidelines of the 74th General Assembly of the United Nations, **77 States committed to reducing their green house gas (GHG) emissions to zero by 2050, while 70 others announced their intention to strengthen their national action plan for reducing GHG emissions.** In 2021, the United States reinstated the Paris Agreement and set a goal of carbon neutrality by 2050. The world's largest emitter of GHG, China, also set a goal of carbon neutrality by 2060.

The Paris Agreement imposes binding and ambitious targets to its parties.

- Legally binding, the Paris Agreement works on a five-year cycle of actions carried out by the parties. Each party to the Agreement shall submit a national plan for climate action, known as a Nationally Determined Contribution (NDC), in order to achieve the **goal of limiting the global warming to 2°C, preferably to 1.5°C, compared to pre-industrial levels.** The parties to the Agreement shall submit new NDCs or updated NDCs by 2020 and every five years thereafter.

- NDCs submitted by some of the world's largest emitters of GHG detail the following pledges:
  - The United States initially committed to reduce its GHG emissions from 26% to 28% by 2025, compared to 2005 levels.
  - India committed to reduce its carbon intensity from 33% to 35% by 2030 compared to 2005 levels.
  - China, in 2016, committed to reduce its carbon intensity from 60% to 65% by 2030.

HOME

Setting legally binding obligations to the parties without a sanction mechanism for non-compliance in place, the Paris Agreement does not incentivize parties to take concrete actions in order to achieve climate targets.

The Paris Agreement does not provide sufficient incentives to the states for issuing and implementing their NDCs in order to achieve the goal of limiting the global warming

The Paris Agreement does not provide sufficient incentives.

- **The Paris Agreement does not provide a sanction mechanism** for countries that deviate from their commitments.

- **In the same way, the NDCs are not legally binding documents** since the provisions of the Paris Agreement do not provide that the parties to the Agreement shall implement their NDCs. Therefore, the implementation of the NDCs by the state is only on a voluntary basis.

In this framework, the NDCs submitted by the parties are not sufficient.

- In February 2021, **United Nations stated that the NDCs submitted by the parties to the Paris Agreement were not sufficient** to achieve the goal of limiting global warming. It asked the parties to submit news NDCs or updated NDCs. To date, 192 parties have submitted their first NDCs and only 110 parties have submitted their revised NDCs.

- As a result, **less than half of NDCs have not been revised** yet. Some countries (including Japan, Australia, and South Korea) revised their NDCs without strengthening their mitigation commitments. Others (like Brazil and Mexico) have declining commitments. Given the postponement of COP26, which was due to be held in Glasgow, Scotland in November 2021, and the impact of the COVID-19 pandemic on the NDC preparation process, the parties decided to revise their NDCs and announce concrete actions for their implementation ahead of COP26 next November.

According to the United Nations, in February 2021, initial NDCs submitted by 77 parties to the Paris Agreement “fall far short of what is required, demonstrating the need for Parties to further strengthen their mitigation commitments”. However, to date, only 110 of the 191 Parties have revised their NDCs.

1 Carbon Intensity is the measure of GHG per unit of economic activity, usually the GDP

At a regional scale, the European Union implements a proactive policy to achieve the climate targets

The European Union is the first regional area to have a legally binding target to reduce GHG emissions.

- In 2008, the European Commission (EC) implemented the Paris Agreement by adopting the **Energy-Climate Package** which defined:
  - **Three targets for 2020:** (i) reduction of GHG emissions to 20% compared to 1990 levels, (ii) increase of 20% of the share of renewable energy in the final energy consumption, and (iii) increase of 20% in energy efficiency.
  - **Two targets for 2030:** (i) reduction of GHG emissions to 40% compared to 1990 levels and (ii) increasing the share of renewable energy to 32% of the final energy consumption.

- In 2019, the EC revised theses targets by unveiling the **European Green Deal** which aims to ensure the European Union's carbon neutrality by 2050 and increase the reduction targets of GHG emissions to 55% by 2030 compared to 1990 levels (compared to 40% in the last target).

- In 2021, the European Union's general goal of carbon neutrality by 2050 and intermediate goal of reducing GHG emissions to 55% by 2030 compared to 1990 levels have been enshrined in the Regulation No. 2021/1119 of June 30, 2021[1], also known as the E**uropean Climate Law.** In contrast to a European Union directive, the regulation applies to the territories of the member states of the European Union without any national transposition measures. As a result, the European Union is the first regional area to have a legally binding target to reduce GHG emissions.

In order to achieve this objective, several ambitious measures have been presented or are expected.

- In order to achieve the latter goals, the EC unveiled **the Fit for 55 climate package** on July 14, 2021. It is a set of 12 proposals to revise and update European Union legislation or to put in place new initiatives in order to ensure that European Union policies are in line with the 2030 intermediate goal.

- The proposal includes: the creation of a **carbon tax** at the European Union's borders; the extension and strengthening of the European carbon market; an end to the sale of internal combustion cars by 2035; and the obligation to impose electric charging stations every 60 kilometers and hydrogen charging stations every 150 kilometers on major roads. It is also proposes to: renovate at least 3% of public buildings per year; decrease the European final energy consumption to at least 38% by 2030; and increase the share of renewables in the electricity mix to 40% by 2030, compared to 32% in the current targets. The proposal will also support reforestation, to benefit from the carbon sink effect of forests, by planting three billion trees by 2030.

- It will take between 12 and 18 months for the European Union institutions to approve the package submitted by the EC. Other proposals should be completed by the EC next December.

As the first region to have a legally binding target to reduce GHG emissions, the European Union is implementing a proactive policy to achieve this goal, as evidenced by the Fit for 55 climate package presented on July 14, 2021.

1 Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999

The historic European Union plan for the economic recovery after the COVID-19 pandemic will apply the climate targets set by the European Green Deal

Through the recovery plan, the European Union is strongly encouraging member states to promote the energy transition of their economies.

- In July 2020, the European Union adopted a historic **recovery plan of €750 billion** (€390 billion in grants and €360 billion in loans) to support the countries most affected by the COVID-19 pandemic.
- In this framework, **member states shall dedicate, at least, 37% of their national recovery plan to climate change and 20% to the digitization of the economy.**
- To ensure compliance with this obligation, member states must submit a **national plan** to the EC.
- **The EC assesses national plans** based on 11 criteria set forth in the Recovery and Resilience Facility (RRF) Regulation[1], such as devoting 37% of the expenditures to climate change.
- Member states should receive 13% of the funding and the rest of the funding is subject to the state's compliance with all commitments set by their own national plan.

As a result, member states have dedicated a significant part of their national recovery plan to climate change.

- To date, 25 of the 27 member states have submitted their national plans to the EC. **The plans of 18 member states have been validated by the EC** in June and July 2021. Other countries, including Hungary, Poland, Sweden, Romania and Finland, are still awaiting approval. Only the Netherlands and Bulgaria had not submitted their plans.
- Amongst the validated plans, the first beneficiaries, Italy (€68.9 billion of European Union funding) and Spain (€69.5 billion of European Union funding), have been reviewed in detail. Germany's plan has been criticized for recycling old projects, rather than focusing on new investments. The EC also requested the Czech Republic, Hungary, and Poland to provide more green measures in order to achieve the criteria of 37% of expenditures dedicated to climate change.
- Denmark (€1.56 billion of European Union funding) put 60% of the amount of its plan towards climate targets to help achieve the country's goal of a 70% reduction in GHG emissions by 2030 compared to 1990 levels, higher than the European Union target (55% by 2030). France (€39.4 billion of European Union funding) devotes 46% of the total plan budget to climate change.

According to the United Nations Secretary General's speech on April 2021, only 18% to 24% of public expenditures relating to the COVID-19 pandemic is expected to contribute to mitigating GHG emissions. Comparatively, European Union member states will devote at least 37% of their recovery plans to energy transition.

1 Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 establishing the Recovery and Resilience Facility

At the national level, France has set ambitious targets for combating climate change which have been translated into several binding measures for companies

France has set itself ambitious objectives to fight against climate change.

- **The Law No. 2015-992 of August 17, 2015, the Energy Transition Law for Green Growth** (LTECV), as revised in April 2020, sets the goal of (i) **reducing national GHG of 40% by 2030** compared to 1990 levels, and (ii) achieving **carbon neutrality** by 2050 by dividing GHG emissions by more than six compared to 1990 levels.

- Other tools have since been created to achieve this goal:
  - **The National Low-Carbon Strategy (SNBC)**[1] is a roadmap to reduce GHG emissions and integrate the issue into economic decisions. Revised in 2018-2019, the SNBC has two main goals: to achieve carbon neutrality by 2050 and reduce the carbon footprint of France. The SNBC defines the actions to be done in order to reduce GHG by 2050 and sets short- and medium-term objectives (carbon budgets).
  - **The Multi-Annual Energy Programs (PPE)**[2] set priorities for actions in the energy field. The PPE must be compatible with the SNBC.

To achieve these objectives, France imposes binding measures on its companies.

- To achieve the goal of carbon neutrality by 2050, several French environmental standards apply directly to companies, which shall adapt their production methods in order to comply with these standards. Accordingly, several recent French laws contain significant environmental provisions, such as the **Law No. 2020-105 of February 10, 2020, on the fight against waste and the circular economy**, which introduces strong measures, particularly relating to consumer environmental information.

- While some standards apply to all companies, others apply to companies only when a certain threshold of GHG emissions has been reached. This is the case **of the duty of vigilance, which imposes to the most polluting companies to prevent environmental risks linked to their operations and those of their subsidiaries.**

- Finally, other regulations are more sectoral. This is the case in the **automotive sector,** where current standards provide for a 37.5% reduction in GHG by 2030 compared to 2021 levels. Likewise, in the tertiary sector, the Decree n°2019-771 of July 23, 2019, on the obligations of actions to reduce final energy consumption in tertiary buildings, aims to reduce the consumption of these buildings by 40% by 2030.

French Law is constantly adapted in order to implement international and European commitments towards climate and to achieve climate objectives set at both European and international levels.

1 Stratégie Nationale Bas-Carbone (SNBC) in French
2 Programmations pluriannuelles de l'énergie (PPE) in French

While the French Administrative Supreme Court urged the French administration to justify its action in favor of energy transition, France's recent efforts, including its recovery plan and its Climate and Resilience Law, are an improvement

These ambitious targets are far from being met and the French government is currently being criticized by the French Administrative Supreme Court for its inaction.

- In July 2020, responding to applications lodged by associations and local authorities, the Conseil d'État ordered the French government to **take actions on air pollution (subject to a penalty of €10 million) in order to respect the climate targets dictated by national** law[1]. In November 2020, the Court ordered the French government to provide evidence within three months in order to justify that measures were taken to achieve the national climate targets[2].
- On July 1, 2021, **the Conseil d'État ordered the French government to take all appropriate measures before March 31, 2022 to achieve the objective resulting from the Paris Agreement** with the knowledge that current measures are not sufficient to comply with climate targets[3].
- In August 2021, the Conseil d'Etat considered that the government did not improve the situation and ordered it to pay **a fine of €10 million** for the first half of 2021 to several associations involved. It also decided to evaluate the actions of the government for the second half of the current year in early 2022 and decide whether the state must pay an additional fine[4].

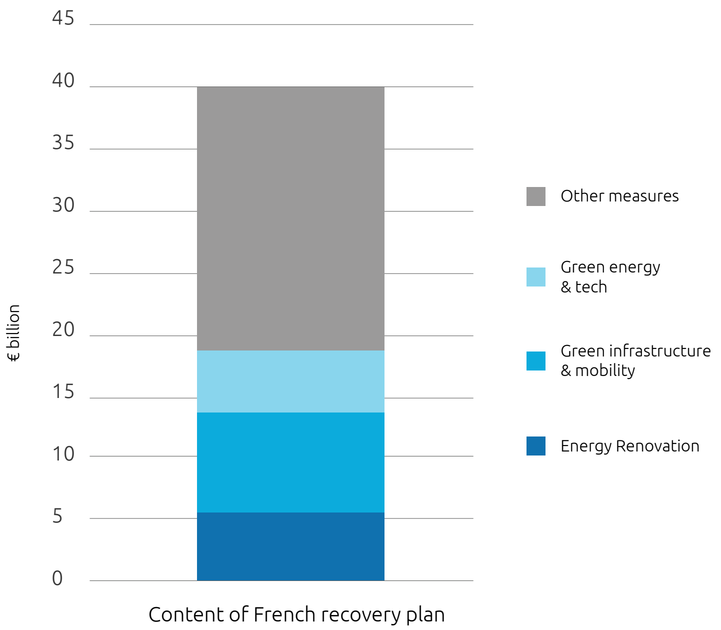
In this context, France's recent efforts, through its recovery plan and its Climate and Resilience Law, are an improvement.

- In September 2020, France launched a €100 billion recovery plan. This plan foresees that **€30 billion will be devoted to the financing of the ecological transition.** The ultimate objective is to become Europe's first decarbonized economy by achieving carbon neutrality by 2050.
- **Since the recovery plan was finally approved by the EC on June 23, 2021, France will receive €40 billion.** This recovery plan includes investing €5.8 billion in energy renovation, €7 billion in the construction of green infrastructures and mobility, and €5.3 billion for the development of green energy and technologies.
- **The Climate and Resilience Law** finally adopted by Parliament on July 20, 2021, already takes into account the climate targets resulting from the recovery plan. It includes: the creation of a national network of accompanying persons to advise and help with renovation projects for both companies and citizens; the prohibition of renting badly insulated housing as of 2025; the prohibition of domestic flights in the event of an alternative train journey of less than 2hrs and 30mins; and the mandatory carbon offsetting of all domestic flights by 2024.

1 Conseil d'État, November 19, 2020, Commune de Grande-Synthe, No 427301
2 Conseil d'État, July 10, 2020, Association Les Amis de la Terre, no. 428409
3 Conseil d'État, July 1, 2021, Commune de Grande-Synthe et autres, no. 427301
4 Conseil d'État, August 4, 2021, Association Les Amis de la Terre, no. 428409

FIGURE 1

Content of French recovery plan



Source: De Pardieu Brocas Maffei, European Comission (2021)

Conclusion

- According to the last Intergovernmental Panel on Climate Change (IPCC) report[1], **the effort of the parties to the Paris Agreement is not sufficient** to reach the goal to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels. It requires that the Parties submit new NDCs or updated NDCs in order to set more ambitious targets.

- However, since **the Paris Agreement does not provide a sanction mechanism** in case of NDCs which are not in line with the Paris Agreement's target, it is not possible to sanction states that do not implement concrete action plans in favor of climate change. Moreover, **the Paris Agreement does not provide that the Parties shall implement their NDCs.** The implementation of the NDCs, which are not legally binding documents, cannot be guaranteed nor controlled by the international community or by the United Nations General Secretary.

- In that context, the next **COP26** should be an important opportunity for the international community to strengthen the states' mitigation commitments and to respond to the IPCC report's conclusions on the implementation of the Paris Agreement.

- In Europe, expectations regarding actions in favor of energy transition are particularly high.

- Within **the Paris Agreement,** the European Union has decided to reach carbon neutrality by 2050 and reduce their GHG emissions to 55% by 2030 compared to 1990 levels. While the historic **European Union recovery plan of €750 billion** is subject to a transition energy criterion, **the package of measures** to achieve the intermediate target (reducing the GHG emissions to 55% by 2030) that the European Union has committed to achieve has not been adopted yet. The adoption of this package may also require national transposition measures. As a result, the implementation of the measures may take several years.

- In France, **the French Administrative Supreme Court urged the French government to take additional and stricter measures** in order to achieve the target of reducing national GHG by 40% by 2030 compared to 1990 levels – a national law that exceeds the target set by the EU. In order to respond to the court's order, the French government shall justify the appropriate measures taken before March 31, 2022. The **Climate and Resilience Law and the French recovery plan,** are a first sign of improvement in this respect.

1 Intergovernmental Panel on Climate Change (IPCC), Climate Change 2021, The Physical Science Basis, August 7, 2021.

05 Infrastructure & Adequacy of Supply

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Decarbonizing the electricity mix: How the European Union (EU) power mix is expected to evolve to reach 2030 climate target

The EU is divided on the way to reach the decarbonization of its power mix.

- EU has strengthened its climate ambition. The Green Deal, adopted at the beginning of 2020, introduced the objective of carbon neutrality by 2050, with reinforced milestones in 2030 to reduce carbon emission by 55% (compared to 1990) vs. 40% initially targeted. In July 2021, to support its carbon neutral ambition, the EU Commission also reinforced the renewables ambition to target 40% of renewable share in the energy mix by 2030 vs. 32% initially planned[1]. As power generation represents a major source of EU carbon emission, decarbonizing the power mix is a major step towards achieving carbon neutrality.

- Despite that common ambition, EU members failed to build a unified plan to decarbonize the power mix and are opposed on the technology to promote. Although most countries have planned their coal phase-out before 2030, a few members like Germany or Poland remain reticent to exit coal too fast or even plan a phase-out.

This two-tier phase-out threatens the ability of Europe to reach the Paris Agreement, which requires the completion of coal phase- out by 2030[2].

- Despite increasing capacities, renewables are not able to fully replace coal yet, mainly due to their insufficient growth and their still unsolved intermittence.

- As a consequence, to support renewables growth and coal phase-out, nuclear energy and gas are the two main options. However, they are at the heart of political opposition between members, especially concerning their place in the green taxonomy.

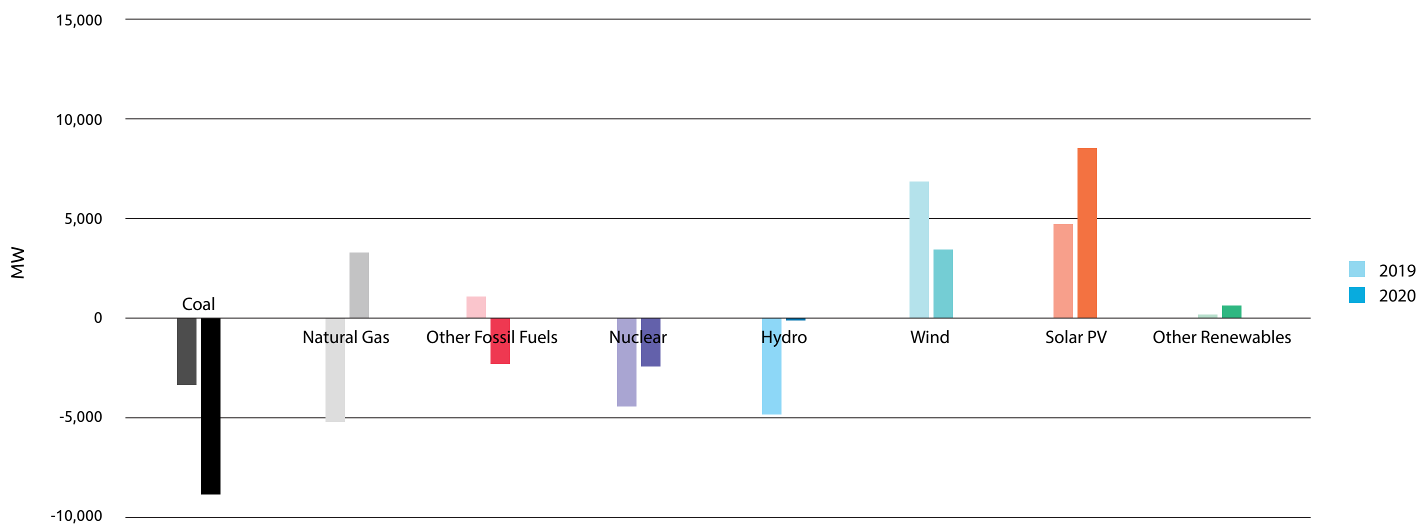
- Nuclear energy is promoted by France (and the U.K. before their withdrawal from the EU) and the Visegrad group (Poland, Hungary, Czech Republic, and Slovakia) as a decarbonized energy, which saves half a billion tonnes of CO_2 emission each year[3] in Europe. On the other hand, few countries, like Germany and Austria, strongly oppose nuclear energy citing safety, waste management, and cost issues.

1 https://www.reuters.com/business/environment/eu-unveils-plan-increase-renewables-share-energy-mix-40-by-2030-2021-07-14/
2 https://beyond-coal.eu/2021/03/23/europes-coal-phaseout-were-halfway-there/
3 https://world-nuclear-news.org/Articles/EU-Commission-will-not-hinder-pro-nuclear-countri

- Eastern and southern members, such as Poland and Greece[1], are banking on gas to replace high carbon coal plants. They are currently blocking green taxonomy negotiations to include gas as a transitional technology without using carbon capture, utilisation and storage (CCUS) systems to master the electricity price and ensure grid stability. On the other hand, Spain, Austria, Denmark, and a few others, strongly oppose, arguing it will weaken the taxonomy and endanger the green deal target's achievement[2].

FIGURE 1

Evolution of the capacity mix in the EU 2019-2020 [MW]



Sources: ENTSO-E 2021

1 https://www.euractiv.com/section/energy-environment/news/brussels-postponed-green-finance-rules-after-10-eu-states-wielded-veto/
2 https://www.euractiv.com/section/energy-environment/news/leak-eu-considers-expanding-role-of-gas-in-green-finance/

1. Coal phase-out is accelerating in the EU thanks to economic and regulatory conditions. However this trend varies significantly according to each member's power mix.

As economic and regulatory conditions are no longer favorable to coal, EU members are accelerating their coal phase-out by either closing or converting their plants.

- EU recently passed an important milestone toward decarbonization, as half of its coal power plants will close by 2030[1]. This happened after 2020 when coal experienced an unprecedented decline. As a result, 8.5 GW of coal-fueled capacities were decommissioned, almost three times more than in 2019. Coal-fueled power generation dropped by 22% compared to 2019, representing only 12% of the power mix. For instance, coal based power generation decreased by 22% in Germany, the EU's largest coal generator.

- New European air pollution standards were applied in Q3 2020 and forced the decommissioning of several plants. Spain shut down eight of its 15 remaining plants, accounting for 5.1 GW[2].

- In many countries, coal has not been able to compete with gas as carbon prices rose (from €25/t in Q4 2019 to €30/t in Q4 2020 and almost €50/t in Q2 2021) and gas prices[3] drastically dropped. The lockdowns and sanitary measures caused a 4% decrease in power demand which fell below 2500 TWh – a level never reached in the last decade – making coal capacities underused and less profitable. It forced operators to close their coal power plants sooner than planned. This enabled countries like Sweden to exit coal two years earlier than expected. Similarly, Portugal's last coal power plant closed in July 2021, though its phase-out was initially planned for 2023. Spain could follow the same path and exit coal before its 2030 deadline.

- On the other hand, several operators, such as Greece[4] or Poland[5], are converting their existing plants to gas.

- In Germany, hard coal plant operators can bid at public auctions to decommission their plant in exchange for financial compensation, which is a very successful compensation mechanism. The first auction, which took place in November 2020, decommissioned 4.8 GW far below the price cap whereas 4 GW were initially targeted by the public authorities.

Despite that positive momentum, some barriers remain, preventing the EU from fully exiting coal.

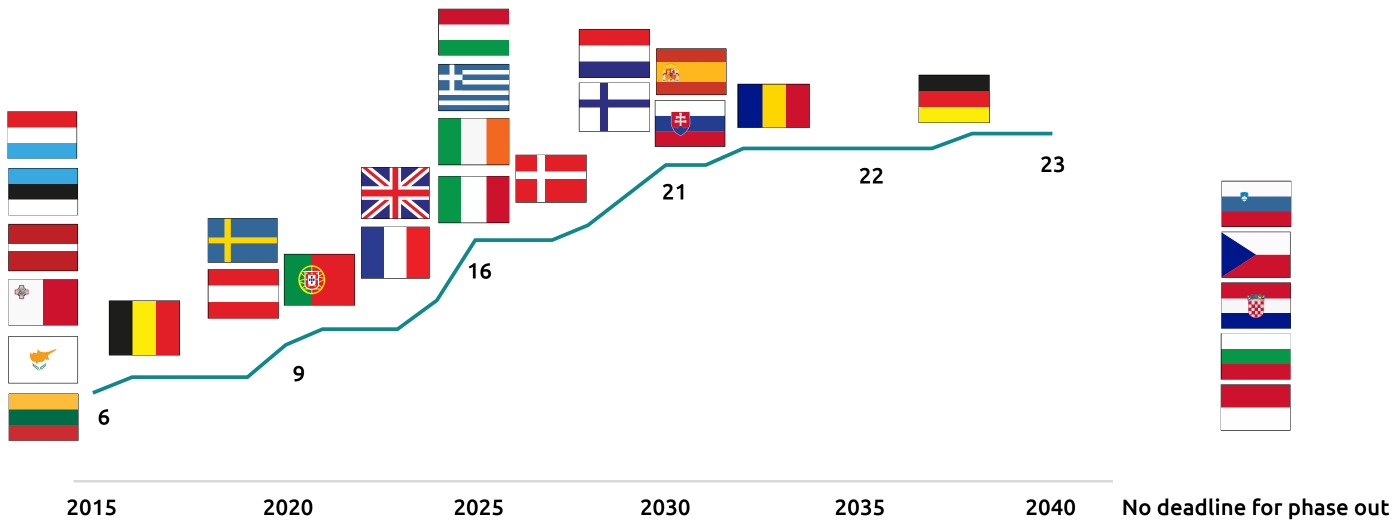
- Some countries are still reticent to exit coal too fast or discuss a deadline. For example, Germany will not phase out coal before 2035 or discuss a deadline. Poland, whose economy, power supply, and grid stability remain highly coal-dependant (74% of Poland's generation mix) is in a similar position. Others are facing delays in achieving their ambition, such as France, which postponed its phase-out from 2022 to 2024-2026. Its last power plant will remain online to ensure regional grid stability until the Flammanville nuclear power plant is commissioned.

At this rate, 21 countries are expected to be coal-free within the EU by 2030. But, as carbon price is expected to at least triple over the next decade, coal phase-out could be faster.

1 Euractiv
2 Electrek
3 Eurostat
4 Power-ENG
5 Reuters

FIGURE 2

Coal phases out timeline and number of coal-free countries within EU under current announcements and latest news on plant closure[7]



World Energy Markets Observatory 2021

By 2030, 21 European countries are expected to phase out coal according to their government's commitment. But, as regulation and economics become increasingly binding for power production, coal phases out can happen earlier than expected if countries manage to accelerate the development of renewables, gas and nuclear to ensure sufficient power supply and grid stability.

2. Renewables pursue their development in the power mix, but regulatory issues must be addressed quickly to fully unlock the EU's potential

The global COVID crisis demonstrated renewables' resilience and accelerated long-term shifts. Contrary to other energy sources, new renewable installed capacities in 2020 equal 2019 levels and represent an increase of 9.3% for wind and solar (+29GW).

- Among the 8 GW newly installed, Netherlands and Germany drove wind farm capacity by adding 2 GW mainly offshore and 1.4 GW mainly onshore, respectively. In the meantime, exceptional warm and windy meteorological conditions led to a new wind generation record in February 2020 (21 TWh onshore and offshore in the EU27)[1].
- Solar capacity increased by 11% compared to 2019, at 18.2 GW, the second biggest increase after 2011 with 21.4 GW installed[2]. Germany remains the largest solar market in Europe (4.8 GW), before Netherlands and Spain with 2.8 GW and 2.6 GW, respectively. Poland doubled its solar capacity from 2019 to reach 2.2 GW and transform its coal-based generation mix. Solar also broke record highs in Q2 2020, generating 9 TWh (a 21% YOY increase)[3].
- Finally, hydroelectric power capacities did not evolve since most hydro potential is already exploited in the EU. Hydroelectric power generation slightly increased due to recovered hydro volume (mainly in France, Italy, Spain, and Portugal)[3].
- As a result, at the end of 2020, renewables overtook fossils in the EU27 energy mix generation, representing 41% and 34%[3] respectively.

Despite increasing capacities for both wind and solar energies, two distinct trends emerge. On one hand, new installed wind capacities are slowing.

- In 2020, new installed wind capacity growth decreased by 6%. The number of wind projects is at its lowest level since 2010 in Germany.
- The COVID crisis slowed down project commissioning by 22% (on-shore wind farm).
- Renewable capacity projects also suffer from complex authorization procedures and legislations (for construction and electricity generation).
    - Permit delays exceed 3 years in average. Those delays discourage investors as well as long impact studies on biodiversity. For instance[4], one year may be required to analyze wind turbine compliance with environment protection during all seasons[3]. The construction of Borssele Wind farm offshore started in 2020 in the Netherlands, more than 3 years after the concession was awarded.
    - Wind farms also meet strong community opposition, enhancing delays and legal complexities.

On the other hand, solar capacities pursue their accelerating growth.

- Despite impacts of COVID, the solar sector demonstrated good resilience and new installed capacity increased by 32% in 2020[3].
    - In 2020, 5 markets (Germany, Netherlands, Spain, Poland and France) were responsible for 74% of

1 WindEurope.org
2 SolarPowerEurope.org
3 ec.europa.eu
4 windpowermonthly.com

new installed capacities, 5% less than in 2019. Moreover, 22 out of 27 countries in the EU doubled their solar capacities from 2019[1]. This implies a broadening adoption of solar capacities across the EU.

- In 2020 in Germany, the most powerful solar plant in the country (187 MW) started to produce its first electron. In the Netherlands, a 110 MW plant (Groningen) also became operational[1].

- Poland encouraged solar development through a dedicated policy for prosumers. As a result, 350,000 micro-generation installation (less than 1 MW) were installed by the end of 2020[1].

- EU solar dynamic will be strengthened with the ability to optimize surface utilization. In the Netherlands, rooftops represents 50%[1] of the PV market share. This is an example of solar potential capacities to be exploited across Europe.

- While solar also faces legal complexities, it takes advantage of better public opinion and investors' confidence as compared to wind energy.

Legislation simplification and homogenization at the European level will be essential to keep the pace for wind and solar development.

- By mid-2021, the new EU Renewables Directive is to be translated at a national scale to homogenize regulations, impose a two-year deadline, and create one-stop shops for wind permit decisions (responsible for commissioning and repowering)[1].
- Permitting rules also impact wind farm repowering projects. Their fluidification and homogenization will be a key driver for the future of wind. By 2025, 38 out of 220 GW will reach more than 20 years of operation and require repowering, life-time extension, or full decommissioning. At present, 9.4 GW could be decommissioned and only 2.4 could be repowered. Germany will lead the repowering market, followed by Spain, Denmark, Italy, and the Netherlands[2].

- Repowering wind farms could reduce turbines by a third while tripling the electricity output thanks to technological improvements. Austrian Puspök Group's current repowering project in Burgenland is an illustration of that technological progress. It represents a great opportunity for the EU to harness renewables and zero-emission objectives[3].

While renewables capacity has increased (51 TWh of wind and solar in 2020), improving EU's regulations is now a key step to reach the target of 100 TWh/year average growth between 2020 and 2030.

Focus on demand: In 2020, experts forecast a unique decrease in a 2015-2030 period of demand growth.

Strong turbulences shook energy consumption during the COVID crisis peak, but pre-crisis levels were quickly restored by the end of 2020.

- 2020 was a special year regarding energy consumption. Over the whole year, consumption dropped by 4%[3] compared to 2019.

- The COVID crisis had the most impact during the outbreak peak and global lockdown measures in April 2020. Consequently, Q2 2020 recorded a consumption decrease of 11% compared to the same quarter a year earlier[4].

1 SolarPowerEurope.org
2 WindEurope.org
3 ec.europa.eu
4 ec.europa.eu

- Meteorological conditions also influenced energy consumption. The pandemic followed a warm winter requiring less heating. In Q1 2020, energy consumption decreased by 3% compared to Q1 2019, a decline led by France (5.4%), Italy (4.5%), and Germany (2.4%)[1].

- With the ease of lockdown restrictions and despite second-wave threats, EU27 saw a strong recovery with an economic rebound. Consumption, which was 3% down compared to Q3 2019, rebounded in Q4 2020 close to pre-crisis levels[1].

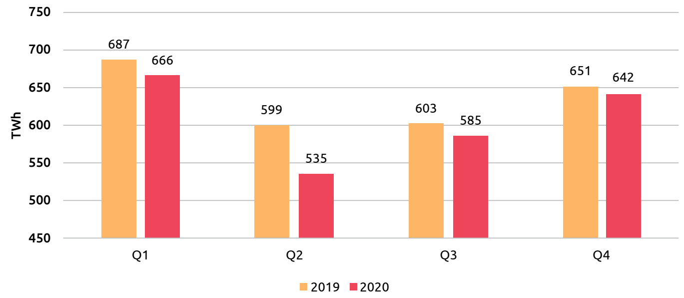
Post-pandemic will see energy consumption on the rise again to meet growing electrification needs.

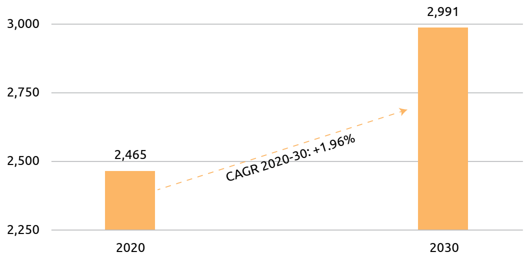
- With pandemic controls and the subsequent economic recovery, pre-crisis consumption levels may be rapidly exceeded. Meteorological conditions were colder in Q1 2021, implying a clear rupture of the energy consumption trend in 2021 and after.

- In the 2020's, energy consumption is expected to grow by 1.39% every year, to meet growing economic and demographic needs. That sustained growth implies numerous opportunities and challenges for energy sources and infrastructures including network reinforcement, storage, dynamic forecasting, and interconnection.

FIGURE 3

Electricity consumption in the EU





Sources: Eurostat 2021, European Commission 2018

3. Nuclear and gas: Two main options for the EU to manage coal phase-out and renewables growth while maintaining grid stability and flexibility

As the EU members progressively phase out coal, nuclear power and gas become key controllable sources of energy to replace it while managing renewables intermittence.

Gas is on the way back to growth as many countries consider it an economically viable alternative to coal production.

- After a 6 GW drop in the installed capacity in 2019, installed capacity increased by 3 GW in 2020 and more than 60 GW of gas plant projects were announced by developers across Europe's five largest power markets (United Kingdom, Italy, Spain, Germany, and France). The U.K, Germany, and Italy[1] are set to add 32 GW, 10 GW, and 9 GW, respectively. Eastern and southern EU operators, such as Enel and PGE, announced massive conversion of coal power plants to gas. Greece's Public Power Corp. announced the conversion of its 660 MW under construction coal power plant by 2025, three years earlier than initially planned. As a result of this coal-to-gas transition in the power sector, gas has become the top power sector emitter in 11 EU countries[2], including Spain, Italy, and France.

- In 2020, gas became much more competitive than coal benefiting from a drastic 50% drop in gas prices (from €10/MWh in Q3 2019 to €5/MWh in Q3 2020)[3] and from a lower exposure to carbon price rise due to its lowest carbon intensity (450 kg CO_2/MWh for gas vs. 1000 kg CO_2/MWh for coal).

Nuclear capacity is still decreasing, but is considered by some countries to be a key energy to decarbonize the power mix. This is creating a deep division within the EU.

- Nuclear capacity experienced a 3 GW drop in 2020 mainly driven by Fessenheim units 1 & 2 decommissioning in February and June 2020. This downward trend is expected to be confirmed in the coming years following the phase-out of Belgium (2022) and Germany (2025), which will lead to the decommissioning of 6 GW and 8.5 GW[4], respectively.

- However, according to the long-term vision of the European Commission's Clean Planet for All, nuclear is part of the EU's low carbon strategy. Europe will need around 120 GW (vs. 115 GW in 2020[5]) of nuclear capacity by 2050. Accordingly, historical nuclear countries like France, U.K., Finland, and Slovakia are currently building new generation reactors accounting for 7 GW to be progressively commissioned by 2026. Others, like Poland, will enter the market and commission 6 to 9 GW of nuclear capacity from 2033 to 2040, an investment of $40 billion[6].

- As nuclear energy can help decarbonize the EU's power mix, pro-nuclear countries are struggling to include it in the green taxonomy and give it a positive signal for investors to strengthen its development. It is facing strong opposition by a German group arguing it will decrease the taxonomy credibility.

1 S&P Global Market . Intelligence
2 Ember Climate
3 Eurostat
4 World-Nuclear.org
5 NTSO-E
6 World Nuclear News

Although the interest in gas and nuclear has risen in the EU, they must overcome industrial challenges to keep a significant place in the power mix.

- Gas will have to face the expected rise of carbon price during the 2020s, which will negatively impact its competitiveness and plant profitability. This will require operators to reduce their emissions, investing in carbon capture usage and storage systems.

- In the next decade, the nuclear industry will have to face two main challenges. First, managing the end of life of 90 out of 107 nuclear plants that are currently more than 31 years old. Nuclear reactors were designed for an average lifetime of 40 years and will require the industrialization of dismantling or significant investment to expand their lifetime. The second challenge will be to secure the building of a next generation of nuclear power plants in due time and costs. It's currently far from being achieved considering reactors under construction like Flamanville 3 face a 10-year delay. The plant is expected to be commissioned in 2023 but was initially planned in 2012, and the cost increased to €19 billion from the €3.5 billion initially planned[1]. This will require product standardization and process industrialization to fully benefit from the economy of scale.

1 French Court of Audit report

Despite internal opposition within the EU, gas and nuclear are the two main energy sources to support the development of renewables. Nevertheless, they must limit their carbon price exposure, decrease their carbon emissions, and master their building costs and delays to remain competitive and maintain their status

4. Renewables will reshape the EU power paradigm in the 2020s

- Considering the current trends in power production, what will the future of the EU power mix be by 2030? The 2010s was the decade of the maturation of renewables, the 2020s is the decade when renewables will definitively outperform fossil fuels and totally reshape the power supply.

Development of renewables is expected to accelerate driven mainly by solar and wind power generation.

- Renewables' capacity will rise sharply to reach 975 GW by 2030, which is 70% of the capacity mix vs. 530 GW in 2020. This growth, which represents almost 45 GW of additional capacities each year, will be mainly driven by solar and wind technology. The share of renewables in the generation mix will also increase to reach 65% by 2030 vs. 40% in 2020.

- U.K. and Germany are expected to be wind market leaders offshore and onshore. 18 GW of additional yearly capacity is expected by 2025 and will cut European carbon emissions by 55% to follow National Energy and Climate Plans. This will need the full commitment of the members to remove the administrative barriers that slow down wind development.

- Solar energy will experience higher growth than wind with 230 GW of additional capacities planned between 2020 and 2030. Mainly driven by Germany, Spain, and Netherlands, solar energy will accelerate its development thanks to its low and still decreasing levelized cost of energy (-7% between 2019 and 2020 to reach $0.04/kWh[1]). This makes solar energy especially competitive for a neutral energy tender and corporate power purchase agreement.

Nevertheless, to ensure the grid can accommodate this huge amount of additional intermittent capacities, investments will be needed to strengthen the grid and to develop storage capacities.

Other energy sources will decline, but gas and nuclear will maintain a strategic place in the EU power mix, limiting their decrease.

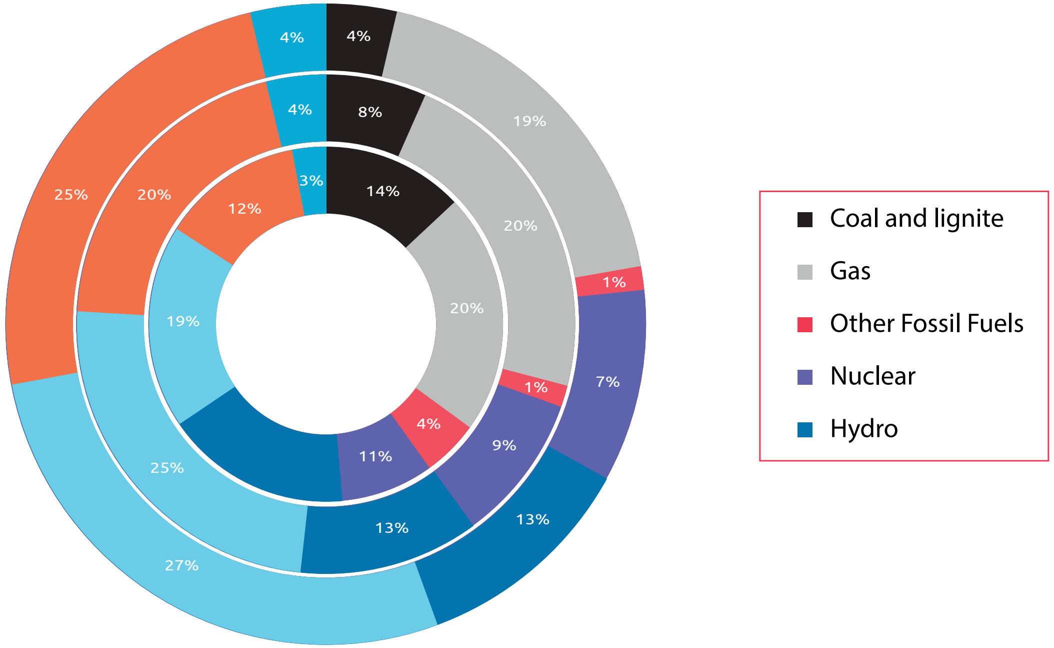
- Nuclear energy share in the power mix will decrease during the next decade due to plant decommissioning (nuclear phase-out in many countries and end of life of many plants), despite the commissioning of the next generation of reactors, especially in France. The share of nuclear in the capacity and generation mixes is expected to fall at 7% and 16%, respectively. But as new countries, like Poland, plan to enter the nuclear market and build new reactors after 2030, this trend could balance out during the 2030s.

- Coal and other fossil fuels will continue to sharply decline following the multiple phase-outs which will occur during the next decade. To compensate while maintaining network flexibility, and to face intermittent renewables fast growth, gas capacity will rise. However, this will not be enough to maintain its share in the capacity mix, which will decline from 21% to 14%. As renewables generation increases, gas competitiveness is expected to decrease, driven by the rising carbon price, which is expected to at least triple by 2030, reaching €90/t[2]. Gas generation will decline from 19% to 13% to mainly cover consumption peak and compensate for a production drop in renewables.

1 Solar Power Europe
2 Euractiv, ICIS

FIGURE 4

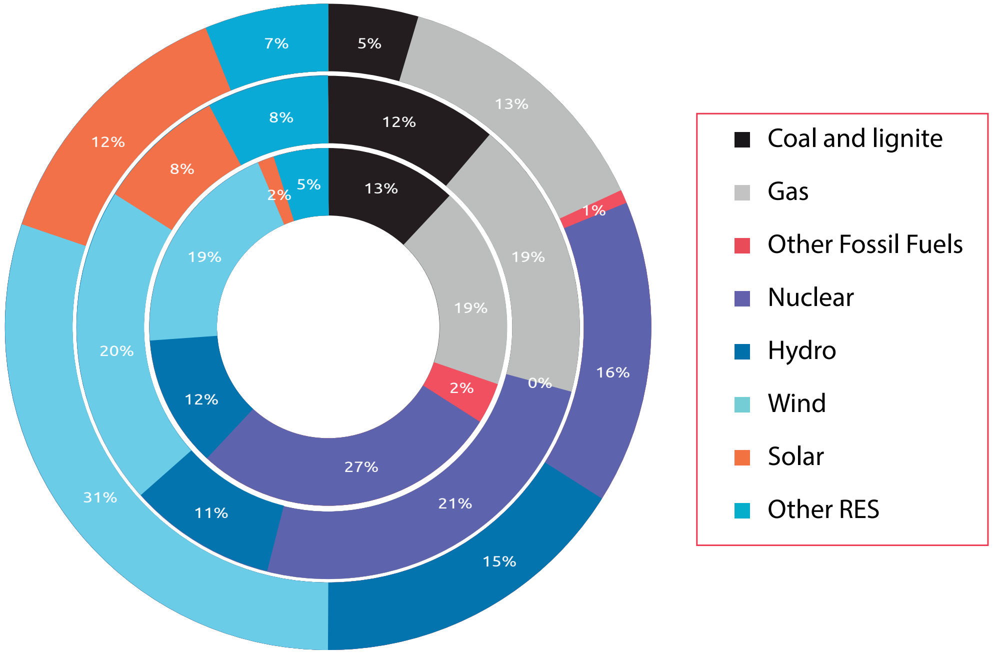
Forecast of the European Capacity Mix 2020 – 2025 – 2030



Sources: ENTSO-E 2021

FIGURE 5

Forecast of the European Generation Mix 2020 – 2025 – 2030



Sources: ENTSO-E 2021

Focus on spot prices: 2020 power spot prices were strongly impacted by the COVID-19 pandemic and the resulting decrease in demand

Day-ahead electricity prices decreased significantly in 2020 compared to 2019.

- European day-ahead electricity prices decreased on average by 26% in 2020 compared to the previous year[1]. It was mainly due to a strong decrease in power demand along with low fuel prices.
- Important disparities have emerged in the European spot price evolution with northern countries seeing a significantly stronger decrease than others. Norwegian spot prices saw the largest decrease with 76% while Polish prices decreased by only 12%.
- Electricity spot prices have also seen a significant number of negative prices in 2020[1]. European countries had negative day-ahead prices 0.8% of the time on average in 2020, doubling the 2019 mark[2].
- Countries with a high intermittent renewable generation share were more exposed to such negative prices. With a high wind generation share and only few interconnections to continental Europe, Ireland was the most exposed to the increase of negative prices (+209% compared to 2019). Poland and Norway were not impacted as they rely more on homogeneous and controllable production sources[3].

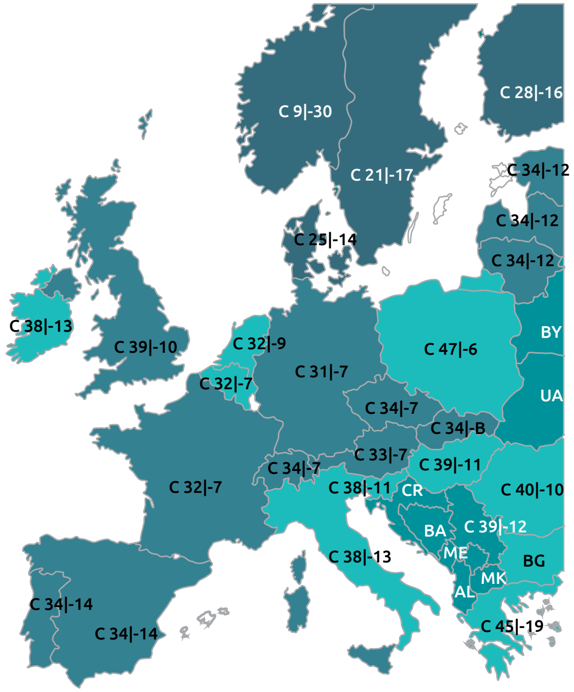
2021 spot prices will rocket as a result of economic recovery[4]

- Electricity day-ahead spot prices are soaring in 2021. This could weigh on European economic recovery.
- The historical increase in gas prices is the main reason for such an evolution. While European countries rely more and more on gas to replace coal and nuclear phasing-out, European spot prices are even more strongly affected.
- As European countries drew deeply into their gas reserves during the 2020-21 winter, European spot prices should continue to rise as we approach the 2021-22 winter.In case of a cold winter, European electricity prices could increase by up to 20%[5].

1 https://www.ffegmbh.de/kompetenzen/wissenschaftliche-analysen-system-und-energiemaerkte/strommarkt/1041-european-day-ahead-electricity-prices-in-2020
2 Wind Power Monthly
3 https://www.powerengineeringint.com/world-regions/europe/three-quarters-of-2020-see-negative-power-prices-in-europe/
4 https://www.nytimes.com/2021/09/08/business/europe-natural-gas-prices.html
5 https://www.capital.fr/votre-argent/gaz-electricite-vos-factures-pourraient-augmenter-de-20-cet-hiver-1413619

FIGURE 6

Average day-ahead prices in the EU 2019-2020



2020 price | Change from 2019

- < 30 €/MWh
- 35-30 €/MWh
- ≥ 35 €/MWh

Sources: ENTSO-E, FFE
World Energy Markets Observatory 2021

5. Cross-border interconnections are recognized as a requirement in order to secure European targets

To keep supporting the upswing of renewables in the decade to come, cross-border interconnection capacities is an opportunity to maximize use of renewable energy during low consumption periods/hours[1] and to keep supporting the upswing of renewables in the decade to come.

To support security of supply purposes (power plant failures, extreme weather condition, etc.), the European Commission set a 10% interconnection target to be reached by each member country by 2020[2]. Each country should be able to allow at least 10% of its electricity production to be transported through cables toward neighboring countries.

At the end of 2020, Spain was the only member unable to meet the target reaching only 5% of interconnected power capacity[3]. According to the European Network of Transmission System Operators for Electricity (ENTSO-E), the Spanish situation remains a critical concern and is due to unique technical challenges. However, ENTSO-E expects Spain to meet its target by the middle of the decade[4]. By 2030, European countries are expected to meet a 15% target.

Major interconnection projects are being developed to ensure European security of supply.

- NeuConnect, a privately financed interconnection project – the first in Europe – which aims to link the U.K. and Germany, went into the permitting phase in 2021. Its construction should start in 2022 and be commissioned by 2023-2024[5].
- With the Interconnexion France-Angleterre 2 (IFA2) interconnector (France-U.K.) commissioned in 2021, NeuConnect is part of the U.K.'s objective to become a net-exporter by 2040 and encourages privately financed projects[5].
- In addition to NeuConnect, Nordlink (Germany-Norway), which was inaugurated in May 2021, is also part of Germany's energy strategy. It allows the export of renewable surplus toward Norway while importing Norwegian hydraulic power when necessary[6].

Some challenges must still be overcome to ensure a proper development of interconnection capacities.

- Beyond the opposition frequently observed during the development of big infrastructures (airports, railroads, highways, etc.), interconnection developers face energy sovereignty opposition. Some would rather not share their energy surplus with other countries – such comments were observed in Norway following the commissioning of Nordlink[5].
- Still, to protect internal markets, limitations of interconnection capacity have also frequently been observed in some countries[5] – pushing the Agency for the Cooperation of Energy Regulators (ACER) to force an opening of at least 70% of their interconnector capacity for members.

1 IRENA
2 European Commision
3 Red Electrica de Espana
4 ENTSO-E
5 https://www.cleanenergywire.org/news/new-cable-between-germany-and-uk-advances-europes-integrated-power-system
6 https://www.usinenouvelle.com/article/l-image-du-jour-nordlink-l-immense-cable-qui-aidera-l-allemagne-a-decarboner-son-energie.N1097944

FIGURE 7

Map of interconnections in Europe

Level of interconnections (2020)

- ≥ 5% & < 10%
- ≥ 10% & ≤ 15%
- > 15%
- Cross-border interconnection projects under construction
- Cross-border interconnection projects in permitting
- Priority electricity corridors from the Trans- european Networks for Energy (TEN-E) strategy

Sources: ENTSO-E TYNDP
World Energy Markets Observatory 2021

6. In Europe, other capacity mechanisms tend to strengthen security of supply

Involvement of European countries in security of supply mechanisms is growing.

While western European countries were more active in capacity mechanisms in the past, they are progressively joined by more countries[1].

- Switzerland and France were involved in the five mechanisms in 2020.
- 11 countries are part of four mechanisms in 2020 (vs. 6 before).
- Southeastern European's involvement grew significantly, as evidenced by several newcomers.

For more details on capacity mechanisms, please refer to Topic Box 3.1 from WEMO 2018.

After several reports, European capacity mechanisms have passed significative milestones.

- The establishment of a common European imbalance netting (IN) platform was achieved on June 21, 2021, enabling transmission system operators (TSOs) from 24 countries to avoid simultaneous activation of frequency restoration reserves in opposite directions[2].

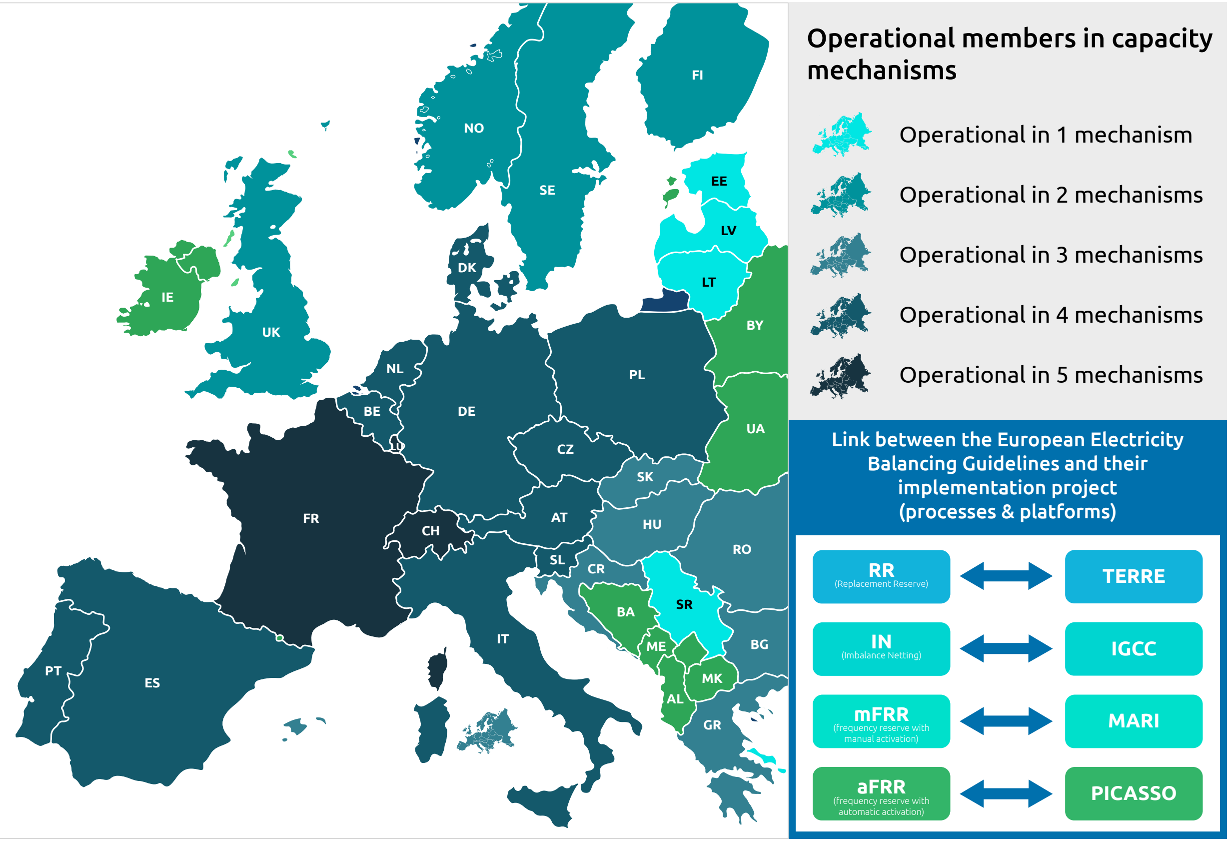
- A year after its entry into operation, the Trans European Replacement Reserve Exchange (TERRE) is one step closer to real time bidding. On January 13, 2021, the balancing energy gate closure time shifted from 60 to 55 minutes before period activation[3].

- After a go-live in January 2020, TSOs from Western Denmark and Slovenia have now joined the frequency containment reserve (FCR) platform. FCR is still the capacity mechanism gathering fewer members with only eight countries joining[4].

1 ENTSO-E
2 ENTSO-E
3 ENTSO-E
4 ENTSO-E

FIGURE 8

Map of Capacity Mechanisms in Europe



Sources: ENTSO-E 2021

7. In line with capacity mechanisms, market couplings are still growing, despite the U.K. leaving the day-ahead market coupling zone

Day-ahead market coupling: In pursuance of the development despite BREXIT complications

- According to latest announcement[1] and following recent delays, the integration of DE-AT-PL-4MMC countries (Germany, Austria, Poland and Czech Republic, Hungary, Romania and Slovakia) was being assessed. A go-live was planned for June 10, 2021[2].
- As announced in our last edition, Greece has successfully joined single day-ahead coupling (SDAC) in the second half of 2020[3] through the Italian-Greek high voltage direct current (HVDC) connection.
- In contrast to these extensions, following Brexit, the United Kingdom no longer participates in the Union's dedicated platforms. Therefore, Great Britain's borders were removed from SDAC at the end of 2020.

1 https://www.epexspot.com/en/news/updated-test-planning-de-pl-4m-mc-interim-coupling-project
2 No announcement (to confirm or infirm the scheduled go live date) has yet been realised
3 Source: ENTSOE

Intra-day: Three new integration waves to come

- In contrast with its SDAC integration, Greece will only join single intraday coupling (SIDC) from 2022 (vs. initially being scheduled in 2021).
- However, Italy is still scheduled to join the intra-day market coupling area.
- In addition, a fifth integration wave (perimeter to be confirmed – Slovakia is a prospective candidate) is foreseen, although its exact date has not been confirmed yet.

FIGURE 9

Market Coupling in Europe (2021)

Coupling areas

SDAC (Single Day-Ahead Coupling)
Coupling under study

Day Ahead coupling projects

Entry Date	Coupling region
Nov 2010	CWE (Central Western Europe)
Feb 2014	NWE (North Western Europe)
May 2014	SWE (South Western Europe)
Nov 2014	4 MMC (4 Makets Market Coupling)
Feb 2015	IBWT (Itallian Borders Market Coupling)
FB May 2015	Core FB MC (Core Flow Based Market Coupling) 1st wave- CWE FB
Jan 2018	wb6 (Western Balkan)
FB Q2-Q3 2021	Core FB MC (2nd wave)

Intra day coupling proect

Go-live date	Coupling project
SIDC 2018	SIDC (Single IntraDay Coupling, 1st wave)
GB-I-SEM 2018	GBISEM
SIDC 2 2019	SIDC (2nd wave)
SIDC 3 2021	SIDC (3rd wave)
SIDC 4 2022	SIDC (4th wave)
SIDC 5 TBD	SIDC (5th wave)

Source: Power exchanges and various industry
World Energy Markets Observatory 2021

05 Infrastructure and Adequacy of Supply

05

05 Infrastructure and Adequacy of Supply

Europe Gas
Adequacy of Supply

Erwan Masse-Guillaume
Alain Pasqualini
Mikaël Lefevre
Mohammed Badr Labraiki

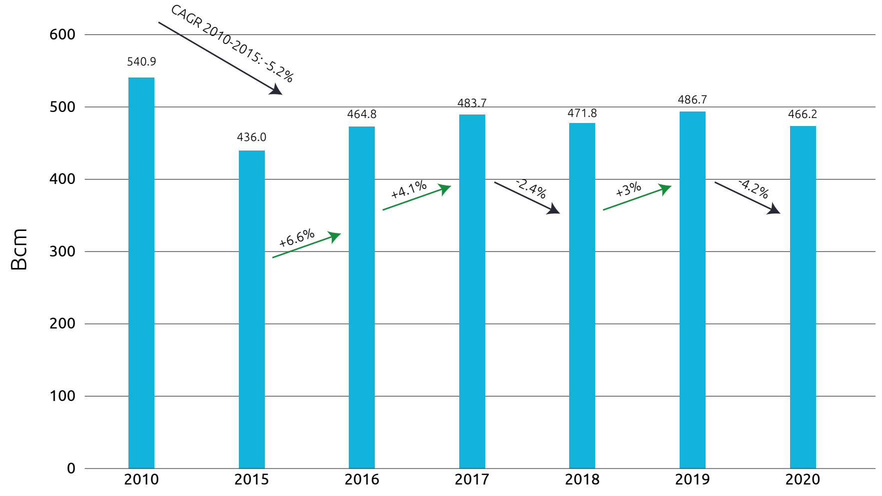
Infrastructure & Adequacy of Supply Gas Europe

A challenging decade ahead for the European gas market: Expected decrease in demand, evolutions in supply, and adopting green tech

Newly signed policies to decrease future gas demand

FIGURE 1

EU27+UK gas demand (bcm):



Sources: Eurostat 2021

The gas demand in 2020 was impacted by Covid lockdowns and their economical impacts (-4.2% vs 2019). However, we observed a rebound. Since September 2020, the monthly gas consumption of the European Union countries (EU27) has been on par with 2019 levels[1].

However, over the next decade[2], the International Energy Agency (IEA) expects EU gas demand to decrease by 7% (compared to 2019), due to several factors:

1 Eurostat Data
2 IEA, stated policies scenario

- **Stricter emissions regulations**, impeding the appeal of gas-fired electricity (which accounts for about 20% of the current EU mix). For instance, Taxonomy Regulation promotes a threshold of 100gCO_{2eq}/kWh[1]. By comparison, gas-fired electricity not backed with carbon capture, emits 490gCO_{2eq}/kWh_{elec}. Unless a new delegated act[2] releases natural gas from this threshold constraint, natural gas will not be labelled as sustainable, making it more difficult to finance.

- **New regulations and initiatives in housing and construction** are expected to lead to a decrease in heating demand. While many energy efficiency schemes will decrease energy consumption, other bills will altogether ban the use of natural gas in new construction. For example, in 2021, France banned[3] the use of natural gas in new houses and will restrict its use in new collective housing by 2024.

- **Concerns over supply security encourages investors and governments to divest from natural gas.** Since European domestic gas production passed its peak beginning in 2017 (depending on the country), external supply is also a source of tension – examples of which include the U.S. issuing sanctions regarding the NordStream II Russian pipeline and dependency on Russian gas, etc.

Over the next decade, EU gas demand is expected to decrease by 7% (compared to 2019), due to:

- **Stricter emissions regulations**
- **New regulations and initiatives in housing and construction**
- **Concerns over supply security, which may encourage investors and governments to divest from natural gas.**

Evolutions in supply: Dwindling domestic production

EU28 (European Union + United Kingdom) natural gas production fell for six consecutive years (-14%)

In 2020, a decrease in natural gas production was seen in all major EU28 except the United Kingdom (U.K): Netherlands (-28.5%), Italy (-16.4%) and Germany (-15.9%).

Since 2017, the U.K has been the largest gas producer in EU28, overtaking the Netherlands. U.K production is still stable, despite Brexit and Covid-19 (-0.4%), with newer assets compensating for the decline of older ones. For example, while the U.K's new asset – Culzean – entered production in Q2 of 2019, 19 historical assets in the North Sea including pipelines, topsides, storage tanks, and subsea installations were decommissioned[4].

A series of earthquakes in 2018 and 2019 drove the Netherlands to accelerate the shutdown of Groningen field operated by Shell and ExxonMobil. A decision was made by the Minister of Economics to let the production fall to zero by mid 2022[5]. However, due to the importance of this field - which still accounts for 11.8 bcm or half of the Netherland's production - the Dutch government wants to keep the field operational until 2026, to mitigate possible shortfall of gas supplies.

Norway will keep its leading position in Europe despite difficulties

Despite a natural gas production that stalls (-4.6% decrease since peak), Norway remains, by far, the main gas producer in Europe: 116.2 bcm. That is more than the entire EU28 gas production.

The Norwegian Petroleum Directorate, expects natural gas production to remain stable or rise until 2024 despite 2019 and 2020 numbers[6].

1 TEG final report on the EU taxonomy Link. And signed Delegated Act
2 Press release from EC
3 "RE 2020" bill
4 Eurostat
5 https://www.gov.uk/guidance/oil-and-gas-decommissioning-of-offshore-installations-and-pipelines#history
6 https://www.arctictoday.com/norway-pushes-forward-on-more-oil-and-gas-production/

However, hope for renewing gas reserves through high-impact wells (especially in the Barents Sea) is diminishing as the number of exploration wells drilled is set to halve from 2019 and no major gas discoveries were made in Norway.

The Eastern Mediterranean is emerging as hope for Europe to develop its indigenous gas production, and reduce reliance on Norway and Russia

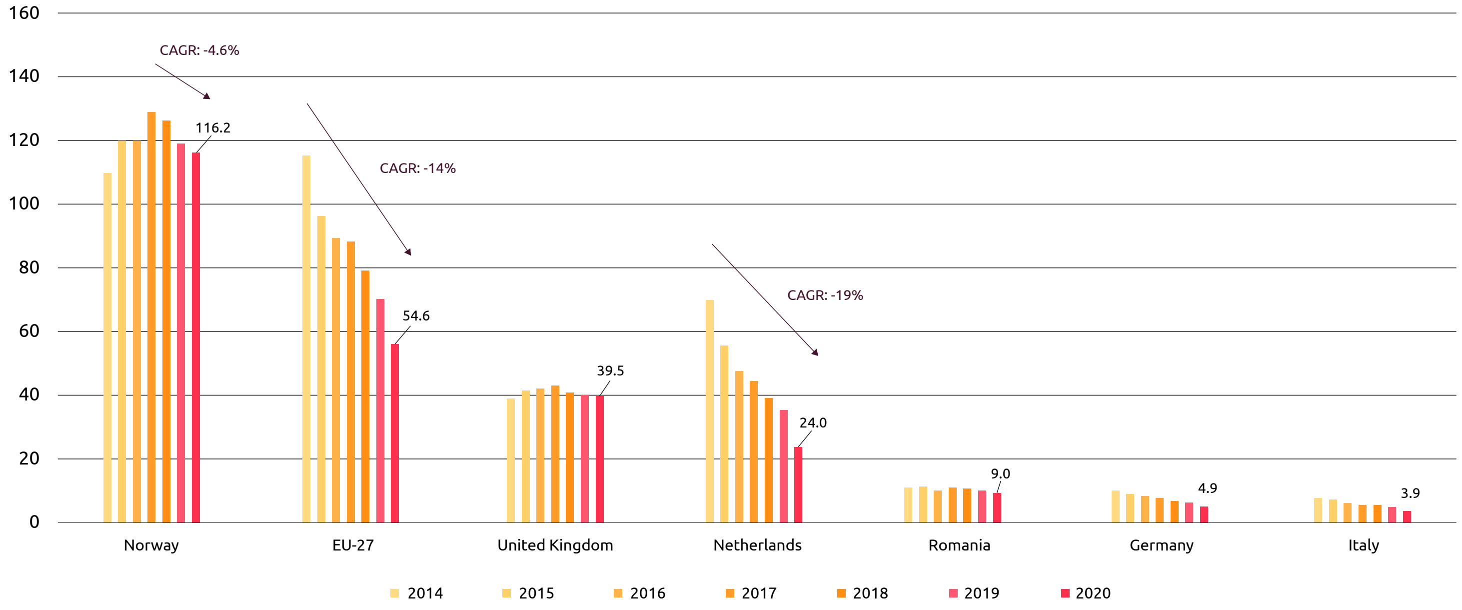
The Eastern Mediterranean has held many opportunities since the discovery of the giant Zohr gas field in offshore Egypt.

ExxonMobil and Eni evaluated discoveries of Glaucus (Cyprus) and Nour (Egypt) to 109 and 19 bcm respectively in 2019. However, natural gas discoveries in the Black Sea (Sakarya) and seismic data acquisition made by Turkish vessels in Greek waters impede the reliability of the Eastern Mediterranean becoming a gas exporting province.

- **EU28 production continues to decrease (-14%), and Netherlands' production may be cut by half in 2022 with the Groningen shutdown.**
- **Norway's production stalls (-4.6% behind the 2017 peak), yet remains the largest producer in Europe.**
- **Eastern Mediterranean is a promising exploration area with large discoveries. However remains crossing interests between Turkey, Greece through their proxy conflict on Cyprus.**

FIGURE 2

European Domestic Gas Production over time (bcm)



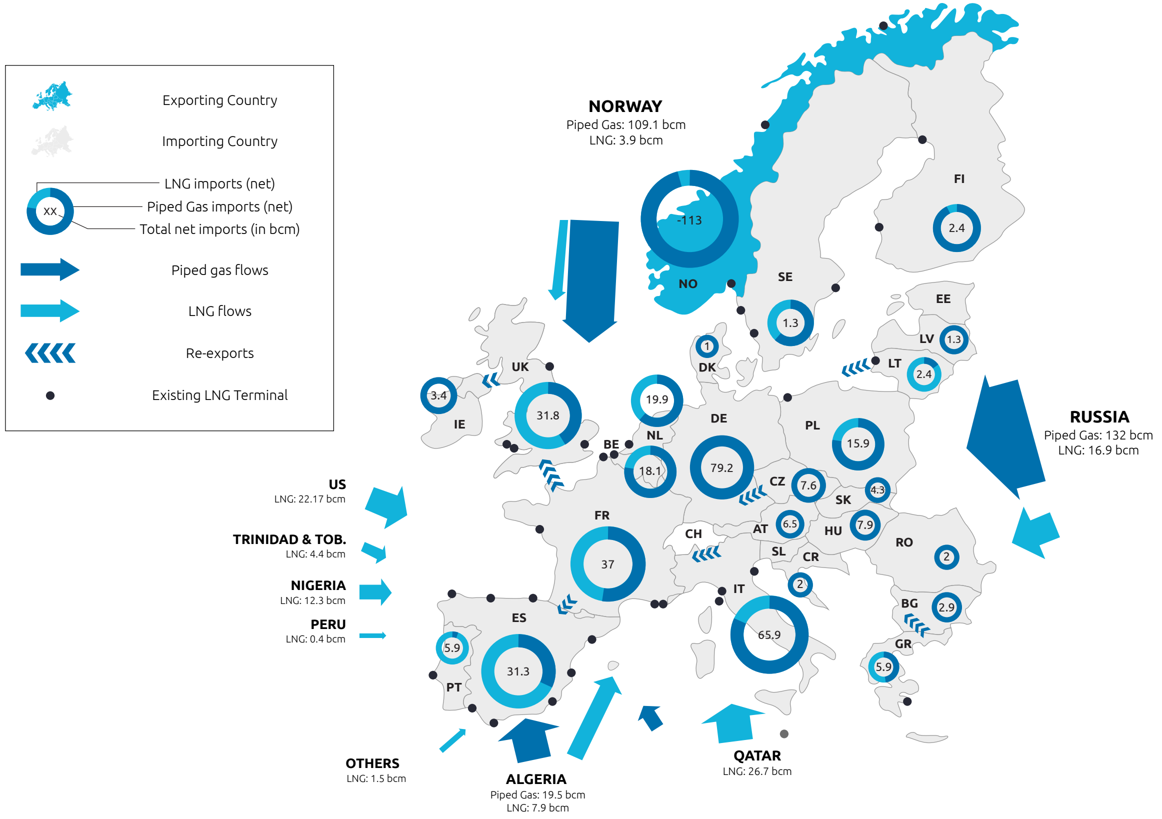
Sources: Eurostat 2021

Evolutions in supply: All EU countries are now importing gas

- **Denmark, the last gas exporting country of EU27, is now a net gas importer.**
- **The EU27 import bill is estimated at €36.5 billion1 for 2020 (-39% vs 2019) due to lower gas prices and demand.**
- **There are several trends in the supplying countries:**
- **In 2018, the U.S started exporting to Europe, and is already its 5th most important supplier two years later.**
- **Norway's supply to Europe evolved with its production, which peaked in 2017.**
- **Algerian supply halved over the past decade.**
- **Qatari and Russian exports have been stable for the past decade.**

FIGURE 3

Map of gas imports (bcm):



Sources: Eurostat 2021, GIIGNL, European Commission gas market quarterly reports

Evolutions in supply: The shift towards LNG

LNG supply in EU27 and U.K has grown steadily over the years (+3% compound annual growth rate (CAGR) between 2011 and 2020)

LNG accounted for 21% of EU (27) and U.K. gas consumption, totaling 96,18 bcm of net imports to the EU and U.K. during 2020.

Several factors can explain this trend:

- Due to the flexibility of LNG cargo, investors worldwide favor[1] new LNG projects over new long-distance pipelines. One can divert cargo towards the best offering gas market, but one cannot do so with a pipeline.
- Europe mostly relies on Russia for piped gas imports, which is a source of tension considering the diverging political views between the two blocs. Therefore, diversification of supply is a sensible approach.

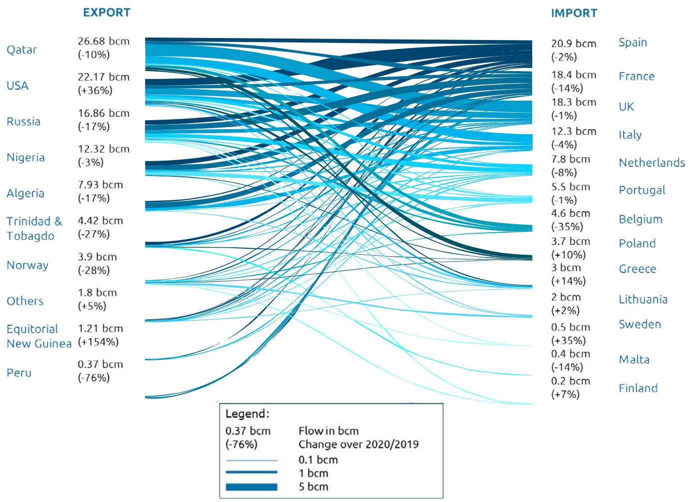
The EU27 and U.K regasification capacity stood at 218 bcm/year[2], meaning regasification assets were utilized at 44% of their yearly capacity in 2020. In addition to this capacity, planned projects (+62 bcm by 2027) show that LNG imports to Europe may increase further.

Two-thirds of the LNG supplied to Europe comes from Qatar, United States, and Russia.

In 2020, the rivalry between the U.S and Russia continued. U.S market shares are now second only to Qatar. U.S supply grew by 36% year-over-year, enabled by the commissioning of new liquefaction trains (Cameron LNG trains 2 and 3, Corpus Christi LNG train 3, Freeport LNG trains 2 and 3[3]).

FIGURE 4

LNG Imports to Europe (bcm):



Sources: GIIGNL 2021

Meanwhile, the NordStream II Russian pipeline, perceived by the U.S as competition[4] for their LNG, was delayed by sanctions, which are soon to be waived.

- **While EU27 and U.K gas consumption has decreased, LNG imports to the bloc grew steadily (+3% CAGR) between 2011 and 2020.**
- **Two-thirds of the LNG supplied to Europe comes from Qatar, U.S., and Russia.**

1 The Oxford Institute for Energy Studies, 'Does the Portfolio Business Model Spell the End of Long-Term Oil-Indexed LNG Contracts?', figure 1 and associated text
2 GLE investment database
3 GIIGNL annual report
4 Reuters. Article 'Blinken: U.S. able to mitigate Nord Stream 2 pipeline effects

Besides profound changes in consumption and supply, gas will need to adapt to new technologies

The Energy Information Administration (EIA) forecast that in 2021 CO_2 emissions will decrease by 7%[1] (323 million metric tons) over 2020. Even before the effects of COVID-19 became obvious in mid-March, the EIA anticipated a decline in 2020 energy-related emissions. This is generally consistent with the trend of lower CO2 emissions since they peaked in 2007.

Due to the economic revival and the easing of business and travel restrictions, the EIA forecast that energy-related CO2 emissions will increase in 2022 by almost 1.5%[12] as compared to 2021.

Thanks to new technologies, natural gas could play a major role in energy transition. Currently, 95%[3] of hydrogen production comes from fossil fuels and produces more greenhouse gases. This issue could remain thanks to the production of blue hydrogen through gas recapture.

1 https://www.eia.gov/environment/
2 http://www.chem4us.be/energie/h2/
3 BoilingCold

05 Infrastructure and Adequacy of Supply

05

05 Infrastructure and Adequacy of Supply

North America
Adequacy of Supply

Alexander Rodriguez
Nupur Sinha
Aditi Ghosh

U.S. electricity use growth: Electricity use is projected to grow at a modest rate from 2020 to 2050

Annual average electricity growth rate in the U.S. is less than 1% from 2020 to 2050.

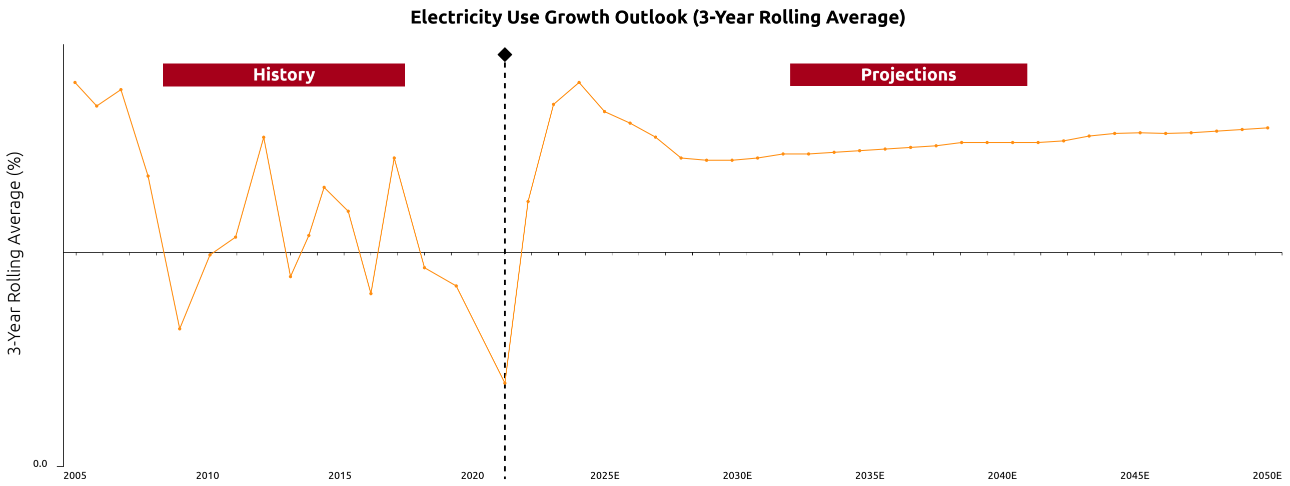
- In the short-term, demand for electricity may fluctuate as a result of year-to-year weather changes, but EIA projects with long-term trends in electricity demand are driven by economic growth, and are somewhat offset by efficiency improvements.
- Although shifting weather patterns and efficiency improvements explain some of the near-term changes in electricity demand, the COVID-19 pandemic and associated economic downturn has a role as well, resulting in a near-term decline in electricity demand.
- EIA expects that electricity demand is largely going to return to 2019 levels by 2025.
- Before 2025, higher residential sector demand partially offset lower electricity demand from the commercial and industrial sectors.

The amount of electricity Electric Vehicles (EVs) use is of significant consequence to electric utilities as that decides whether they have enough generation to supply the growing number of EVs.

- U.S. sales of plug-in light duty electric vehicles in 2020 totaled 296,000 units, which was down significantly from the 331,000 in sales in 2019 due largely to the coronavirus pandemic.
- However, the amount of electricity used to power the country's EV fleet came to 4.68 TWh in 2020, an increase over 2019 of 21.3% due to an increase in the number of charging stations.
- According to Platts Analytics Future Energy Outlooks' report (2021), it may take until 2022 and 2023 to break out of the coronavirus sales slump, and sales by 2025 will finally break the one million mark.

FIGURE 1

US ~ Electricity Use Growth Outlook, 2005-2050E



Source: US EIA Annual Energy Outlook, 2021
Link: https://www.eia.gov/outlooks/aeo/

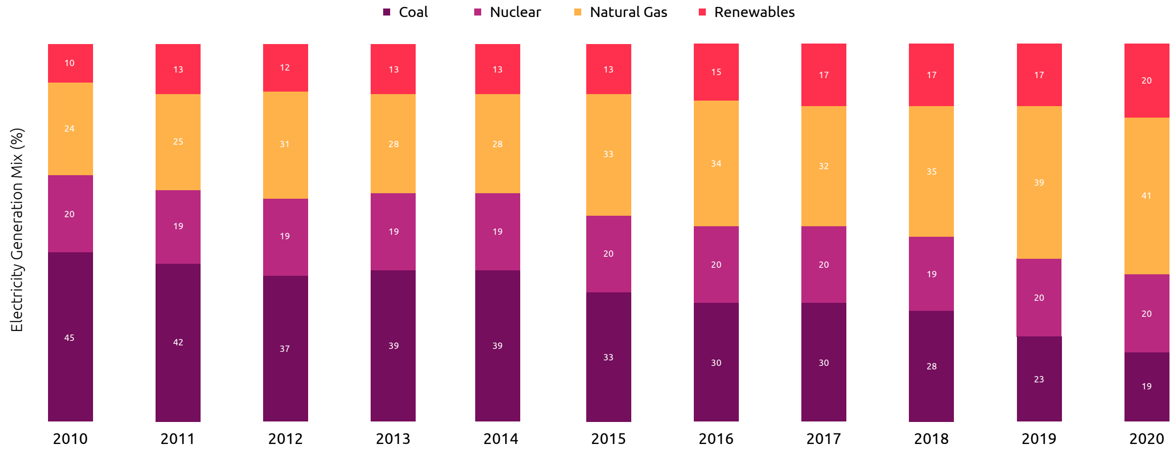
U.S. electricity generation: Natural gas-fired electricity is rising while coal-fired electricity generation is falling

Natural gas remains the largest source of power generation in the U.S. However, the year-over-year rate of expansion between 2019 and 2020 was down, as compared to that of 2018 and 2019.

- Gas accounted for 41% of generation, or 1,641TWh in 2020. That's a 2.19% increase in its contribution from 2019 despite the dips in 2020 demand. This is due to low 2020 fuel prices and the new gas-fired power plant builds.
- Renewable power generation's contribution grew 11% year-over-year in 2020 (also mirroring power plant build), with a 15% jump in output from wind and solar, as well as a 5% increase in hydropower generation.
- In absolute terms, renewables generation rose 79TWh to land at 799TWh, or 20% of the total.
- Coal's role waned further in 2020, dropping to only 19% of the mix.

FIGURE 2

US ~ Historical Electricity Generation Mix ~ Evolution, 2010-2020 (percent)



Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#

- In total, coal produced an estimated 751TWh, the least in absolute terms since 1979 and a 22% decline from 2019.
- Despite continuing financial troubles and the closure of the Indian Point, Duane Arnold, and Davis Besse stations, nuclear's contribution to U.S. power generation declined only slightly by 2.1%, accounting for 20% of the total share.

The energy generation mix varies throughout the U.S. with different power-generating technologies contributing various amounts in different power markets.

- Major trends over the last 10 years have included the rise of natural gas-fired generation and the fall of coal-fired generation in the Southeast, Midwest and mid-Atlantic regions, as well as the growth of renewables – particularly wind and solar – in Texas and California.

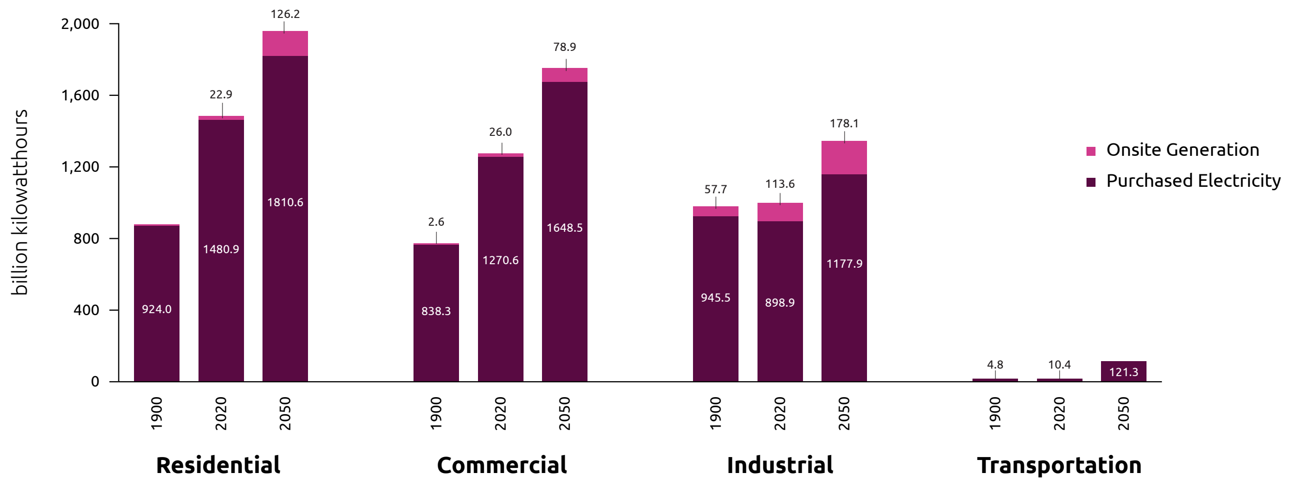
U.S. electricity generation: The share of on-site electricity generation is projected to increase in 2050 across non-transportation sectors

Electricity demand in transportation remains low.

- Although the greatest potential for increased electricity demand is within the transportation sector, electricity demand from this sector remains low.
- Current laws and regulations are not projected to induce much market growth, despite continuing improvements in electric vehicles (EVs) through evolutionary market developments.
- Both vehicle sales and utilization would need to increase substantially for EVs to raise electric power demand growth.

FIGURE 3

US ~ Electricity Use By End-Use Sector, 1990, 2020, 2050E (billion KWh)



Note: Onsite generation is electricity produced onsite for own use.

Source: US EIA Annual Energy Outlook, 2021
Link: https://www.eia.gov/outlooks/aeo/

There is a reduction in electricity sales from vendors and growth in on-site electricity generation.

- The growth in electricity sales from vendors has lessened due to significant growth in on-site generation in the residential, commercial, and industrial sectors.
- Installation of rooftop photovoltaic (PV) systems, primarily on residential and commercial buildings, and combined heat-and-power systems in industrial and some commercial applications, will account for more than 7% of total electricity generation by 2050, almost doubling the 2020 share of on-site power generators.

U.S. electricity generating capacity: Renewables account for most of the projected capacity additions from 2020 to 2050

Renewable electric generating technologies account for almost 60% of the approximately 1,000 gigawatts of cumulative capacity additions in the U.S. projected by EIA from 2020 to 2050.

- The large share is a result of declining capital costs, as well as increasing renewable portfolio standard (RPS) targets and tax credits.
- Although wind contributes to renewable electric generating capacity additions, it is on a much smaller scale compared with solar capacity, which builds steadily throughout the projection period.
- Pairing renewable energy power plants with energy storage is a trend of increasing importance as the cost of energy storage declines.
- By December 2023, 2.3 gigawatts (GW) of the 4.9 GW (47%) of operating battery storage is planned to be paired onsite with renewable generation.

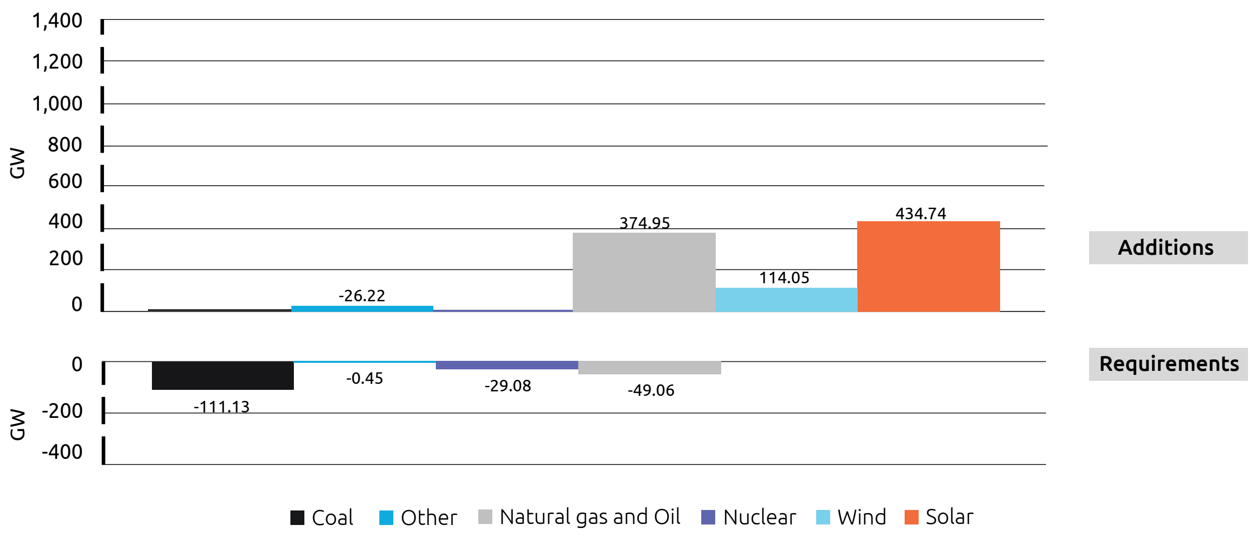
Natural gas continues to be the fuel of choice for fossil-fuel capacity additions.

- Although renewable electric generating technologies account for about 60% of cumulative capacity additions throughout the projection period, natural gas-fired generators account for almost the entire remaining balance of additions—about 40% through 2050.

Coal-fired generating unit retirements will largely take place by 2025.

FIGURE 4

U.S. cumulative electricity generating capacity addition and retirements, 2021-2050E (GW)



Source: US EIA Annual Energy Outlook, 2021
Link: https://www.eia.gov/outlooks/aeo/

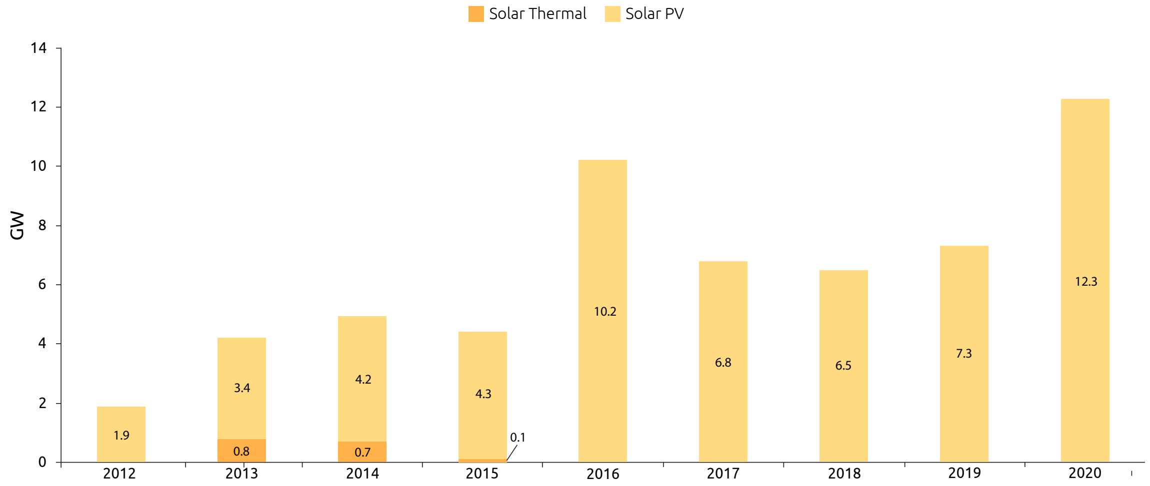
U.S. large scale solar addition: 2020 witnessed the highest level capacity additions of the last decade in solar PV

The COVID-19 pandemic had little to no impact on construction activity of solar PV, but subdued the availability of tax equity.

- Utility-scale installations rose to 12.3GW in 2020. This brought capacity additions to their highest level ever, beating the former peak of 10.2GW in 2016.
- Solar thermal build remained non-existent.
- As economic activity stalled, the amount of taxes owed to the government slowed as well, and major tax equity providers had limited clarity on their tax appetite over the duration of the year. However, projects that had secured their finances in advance were not affected. Commissioning activity ramped up in response to the anticipated phase-out of the tax credits.
- Projects that began construction by 2019 had until 2023 to commission and safely retain their credits.
- As part of end-of-year legislation passed to stimulate the economy, tax credits for solar projects were extended for two more years at the 26% level. Projects that commence construction in 2021-2022 can secure 26% of the project's costs as a credit.
- Tariffs on bifacial panels were alternately removed and reapplied, leading some developers to procure large volumes of bifacial panels during the periods when they were not subject to tariffs.
- The tariffs on imported solar panels are expected to end in February 2022.
- **California, Texas and Florida are the top states for annual solar capacity additions.** California has the largest solar market in the U.S. because of the many economic and environmental benefits it provides.

FIGURE 5

U.S. large scale solar build deployment



Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#

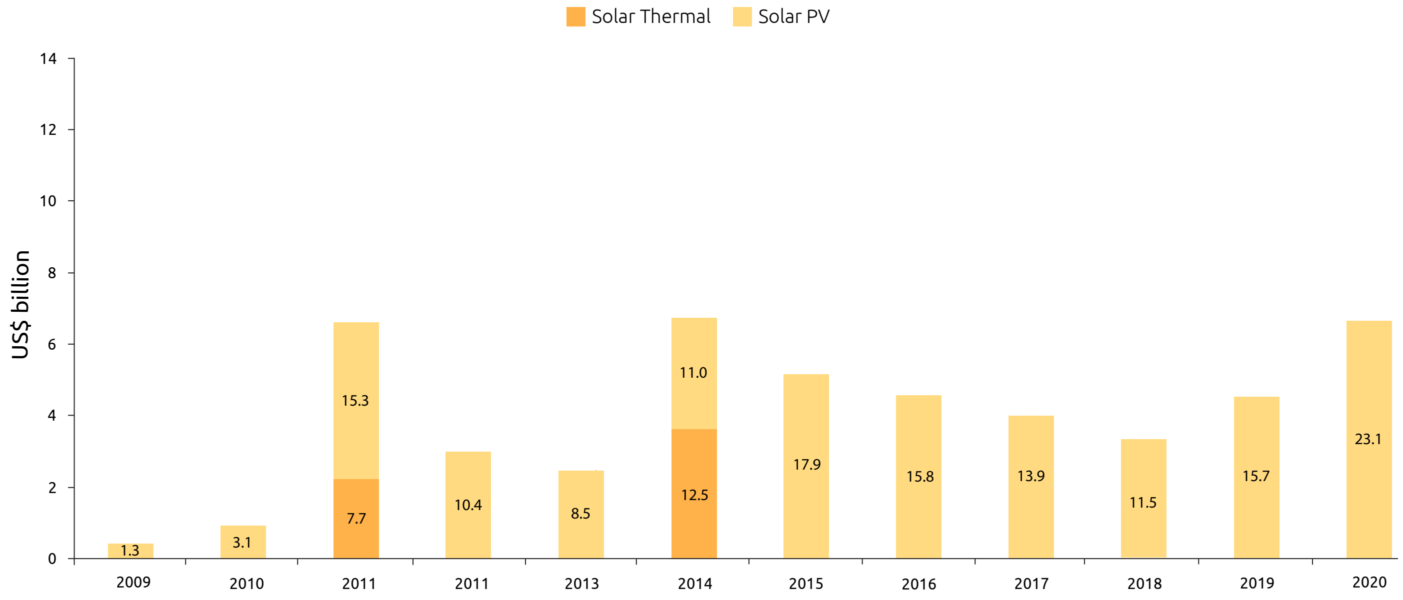
U.S. asset finance for large solar projects: In 2020, asset finance for U.S. solar projects rose to the highest level in the last decade

The U.S. onshore wind sector showed remarkable resilience in the face of the pandemic and posted 17GW of installations in 2020.

- Asset finance activity for new build solar rose to the highest level of the last decade, reaching US$ 23.1 billion in 2020, up from US$ 15.7 billion in 2019. This represents new investment in solar build across various forms of debt and equity.
- As assets are typically funded a year before commissioning, the investment volumes indicate record commissioning activity ahead.
- As technology costs fall, the same dollar value of investment supports a higher GW capacity of projects commissioned in the future.
- Acquisition activity also rose from 2019 to 2020, driving more funds into the sector.

FIGURE 6

U.S. asset finance for large scale solar projects by technology



Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#

U.S. large scale wind addition: The U.S. onshore wind sector posted its highest-ever year of installations in 2020

The U.S. onshore wind sector showed remarkable resilience in the face of the pandemic and posted 17GW of installations in 2020.

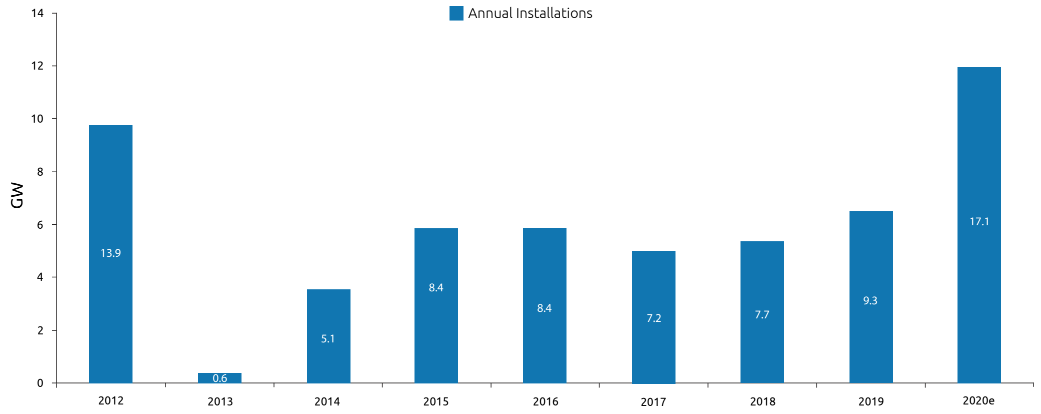
- During 2020, some major U.S. onshore wind developers faced construction delays. However, many projects made up for lost time and came online by the end of 2020.
- Developers had fortunately started construction early, as they raced to meet a deadline for the production tax credit (PTC) by year end.
- After intense industry lobbying, the Internal Revenue Service also extended the commissioning deadline for projects that started construction in 2016 and 2017 from four to five years.
- The extension has reduced pressure on the sector, which was already facing a shortage of cranes, trucks, and construction crews before the pandemic.
- On December 22, 2020, Congress extended the PTC by one additional year. The PTC is on a step-down schedule, and 2020 had been the last year projects could qualify.
- As a result of the action by Congress, projects that qualify in 2021 and commission by the end of 2025 will receive the credit at 60% of its original value of US$25/MWh or US$15/MWh.

Texas installed the most capacity in 2020 with 4,137 MW, while sixteen states exceeded 10% wind energy penetration as a fraction of total in-state generation.

- Texas also remained the clear leader on a cumulative basis, with 32,686 MW of capacity.
- Notably, the wind capacity installed in Iowa supplied 57% of all in-state electricity generation in 2020, while Kansas (43%), Oklahoma (35%), South Dakota (33%) and North Dakota (31%) were all above 30% by this metric.
- Within independent system operators (ISOs), 2020 wind penetration (expressed as a percentage of load) was 31.3% in SPP, 22.7% in ERCOT, 11.0% in MISO, 6.6% CAISO, 3.4% in the PJM, 3.0% in ISO-NE, and 2.9% in NYISO.

FIGURE 7

U.S. large scale wind build deployment



Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#

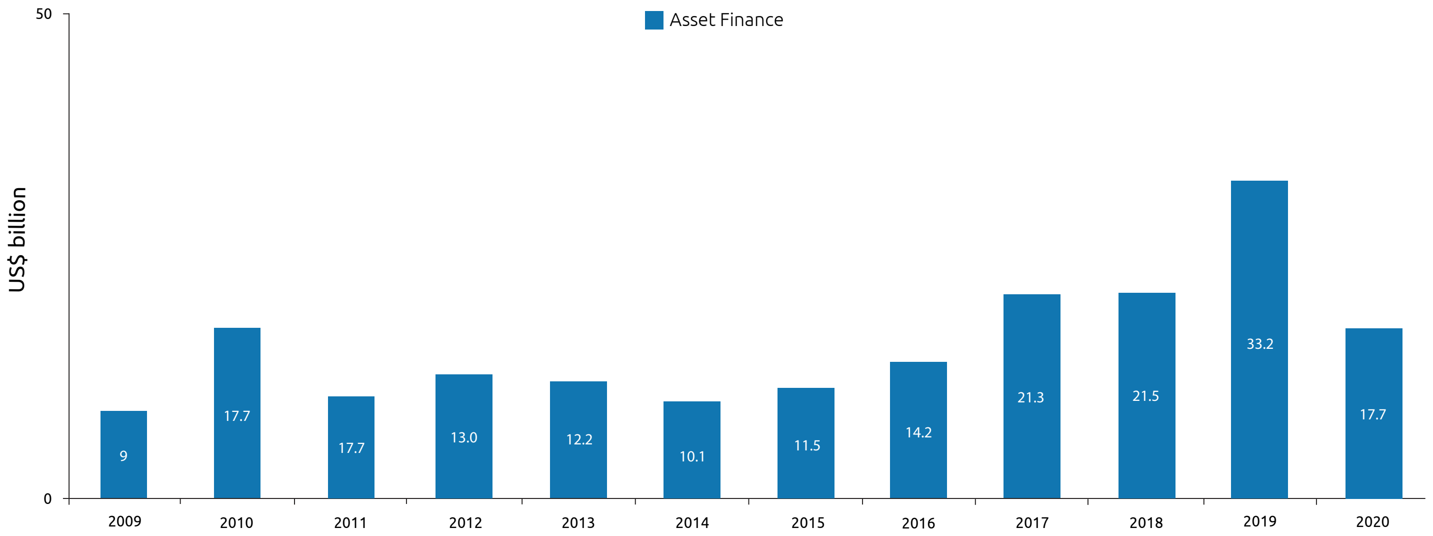
U.S. asset finance for large wind projects: There was a dip in asset financing for U.S. onshore wind projects in 2020 compared to 2019

Wind projects worth US$ 17.7 billion were financed in 2020, representing just over half of the 2019 total of US$ 33.2 billion.

- Asset financing has tracked closely with the status of the PTC, which has expired and has been retroactively extended multiple times since 2012.
- The final chance to receive the full value of the PTC was for projects financed and under construction in 2016.
- The U.S. set a new wind installation record in 2020 as developers raced to commission these projects and qualify for the subsidy.
- This build rush, along with the time lag between a project securing funding and coming online, explains the large financing figure in 2019.
- Projects that qualified for the PTC in 2017 and later will receive a phased-down credit. It is expected that there will be lower installations in 2021 and 2022, meaning a dip in investment in 2020. Projects that qualify for the PTC after 2021 (and come online after 2025) will receive no federal support.
- Strengthening asset finance over a longer time period is reducing costs. Since 2009, global turbine prices have fallen 58% to US$ 700,000/MW.

FIGURE 8

U.S. asset finance for large wind projects



Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#

U.S. electric transmission investment: There is a gradual upswing in electric transmission investment aiming to provide clean, reliable, and affordable power

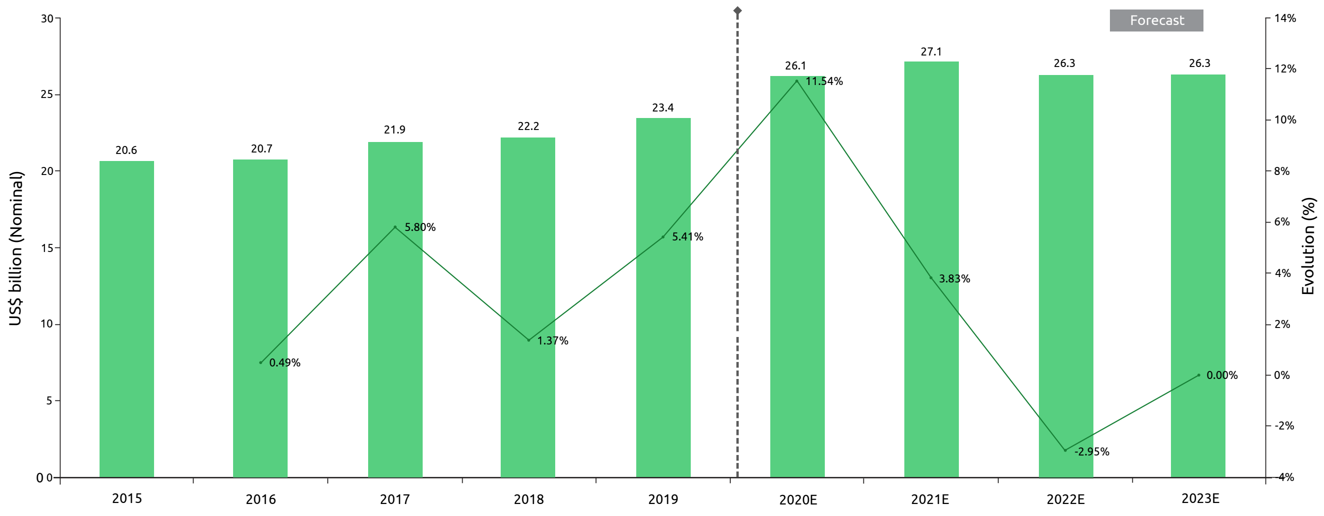
According to estimates from Edison Electric Institute, electric transmission investment likely jumped 12% in 2020 to US$ 26.1 billion.

- Investor-owned utilities and independent transmission developers spent a record $23.4 billion on electric transmission in 2019.
- This figure is up 5% from 2018 and 14% from 2015.
- Based on company reports, investor presentations and surveys, transmission investment likely jumped 12% in 2020 to $26.1 billion.
- Current CAPEX plans suggest that investment will peak in 2021 and slow thereafter.
- However, future-year budgets are not yet finalized, and these numbers may be revised upward.

- The electric transmission investment upswing is driven by a number of factors, all of which concern the utility's fundamental aim to provide reliable, affordable, increasingly clean and safe power.
- These investment initiatives include the need to replace and upgrade aging power lines, resiliency planning in response to potential threats (both natural and man-made), the integration of renewable resources, and congestion reduction.

FIGURE 9

U.S. electric transmission investment by investor-owned utilities and independent transmission developers, 2015-2023E



Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#

U.S. offshore wind capacity: Offshore wind farms are expected to be rolled out faster in the U.S. with the new Biden administration

The Biden administration announced plans on March 29, 2021 to install 30GW of offshore wind capacity in the U.S. by 2030.

- This is a move that will have a major impact on the speed of existing development efforts along the East Coast. Twelve of the fourteen East Coast states were already working on installing almost 29GW of offshore wind capacity over the next 15 years, with upward of 6.5GW of that total expected online by 2025.
- This will have a major impact on future generation needs in coastal states.
  - In New England, projects with a capacity of 4,044MW have been contracted and are in various stages of development. It is likely all will be in commercial operation by the mid-2020s. That new capacity will have the ability to generate at least 16,000GWh annually.
  - The latest forecast from ISO New England projects that total demand in the region will climb from 124,184GWh in 2020 to 128,781GWh in 2029, a 10-year increase of roughly 4,600GWh. In other words, the new offshore wind will be able to meet that demand increase and much more. This extra wind capacity will also undercut any need for new fossil fuel generation in the region, while also vying for market share with existing fossil fuel generators.
- Additional projects with at least 7,000MW of planned capacity are in varying stages of development in New York, New Jersey, Delaware, Maryland, Virginia, and North Carolina.
- Offshore wind is still relatively expensive, but the costs have come down significantly in recent years; new work by the U.S. Department of Energy should help spur continued reductions.
- Another benefit that will drive costs down is the first-time extension of the investment tax credit to offshore wind farms. This provision, included in the December 2020 budget reconciliation bill, provides developers a 30% tax credit through the end of 2025.

The administration's 30GWh by 2030 plan indicates that offshore wind will have a major impact on the grid in the eastern U.S. over the next decade. This clean electricity needs to be considered by utilities and regulators looking at projected generation resource expansion in the mid-to-late 2020s.

Canada renewable energy infrastructure: Renewable energy is gaining traction into Canada's energy infrastructure, a market traditionally dominated by oil & gas

According to Preqin which provides financial data and information on the alternative assets market, renewables accounted for 46% of total energy infrastructure investment in Canada in 2020, a huge increase from 16% on a larger amount in 2019.

- Clean energy infrastructure has seen a steady stream of private capital investment over the past decade in Canada.
- Since 2011, US$ 24 billion in clean energy infrastructure deals have closed in Canada. This is much less than US$ 63 billion investment on non renewables.
- Wind power has been the dominant asset in clean energy, with about US$ 11 Billion invested over the past 10 years. This is despite interest in the space waning recently, and wind power accounting for only a small portion of Canada's total energy production.

- Preqin data shows five wind-power-related deals closing in 2020.

- Montreal-based Axium Infrastructure has been one of the most active managers in the Canadian renewables space.
    - The firm has been involved in 68 deals since 2012, most of which have been investments in solar and wind power.
    - Till June 2021, Axium has acquired six renewable energy assets from CPP Investment Board, four of which are wind power farms, and the remaining two are solar power facilities.

U.S. natural gas demand: Total demand for U.S. natural gas decreased in 2020 for the first time since 2009 due to the COVID-19 pandemic

After a decade of growth, total demand for U.S. natural gas declined for the first time since 2009 due to the COVID-19 pandemic.

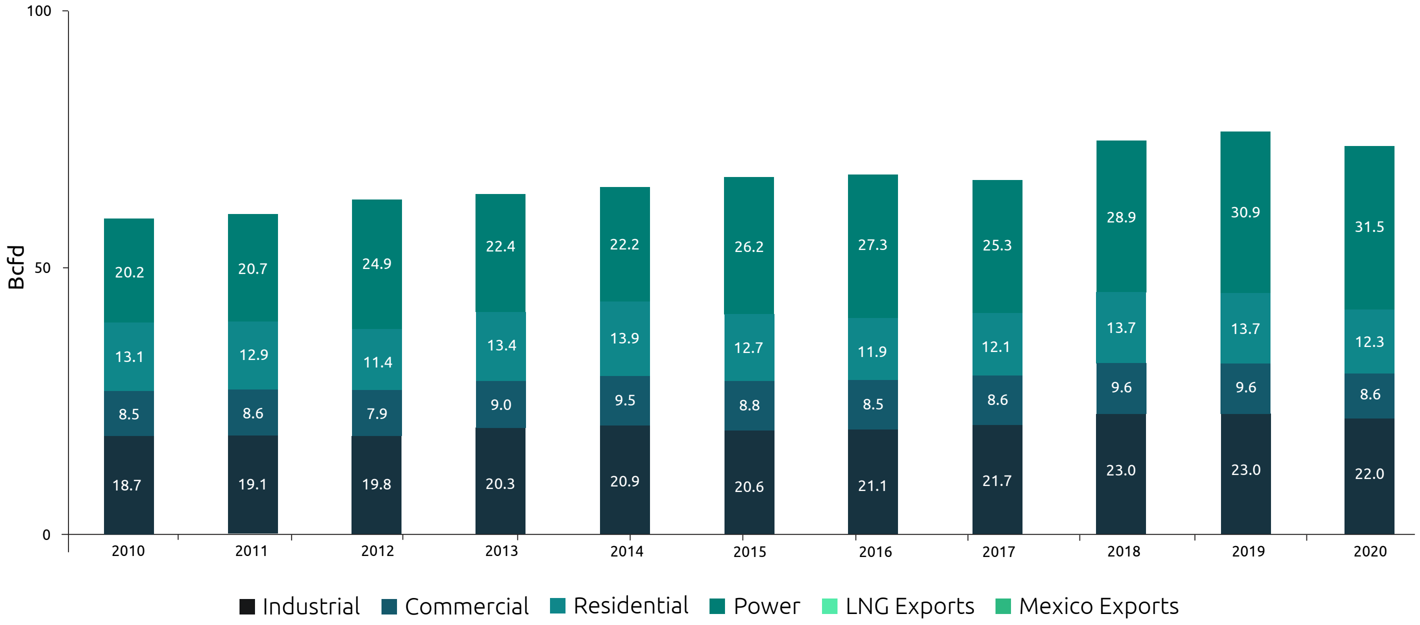
While overall load fell, gas demand for power generation grew by 0.6Bcfd due to lower year-over-year gas prices and continued coal-fired power plant retirements.

- LNG exports also grew significantly due to new liquefaction capacity coming online via multiple export facility projects.

- Industrial, residential, and commercial heating demand decreased 4.2%, 10.5%, and 10.2%, respectively.

FIGURE 10

U.S. natural gas demand by end use



Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#

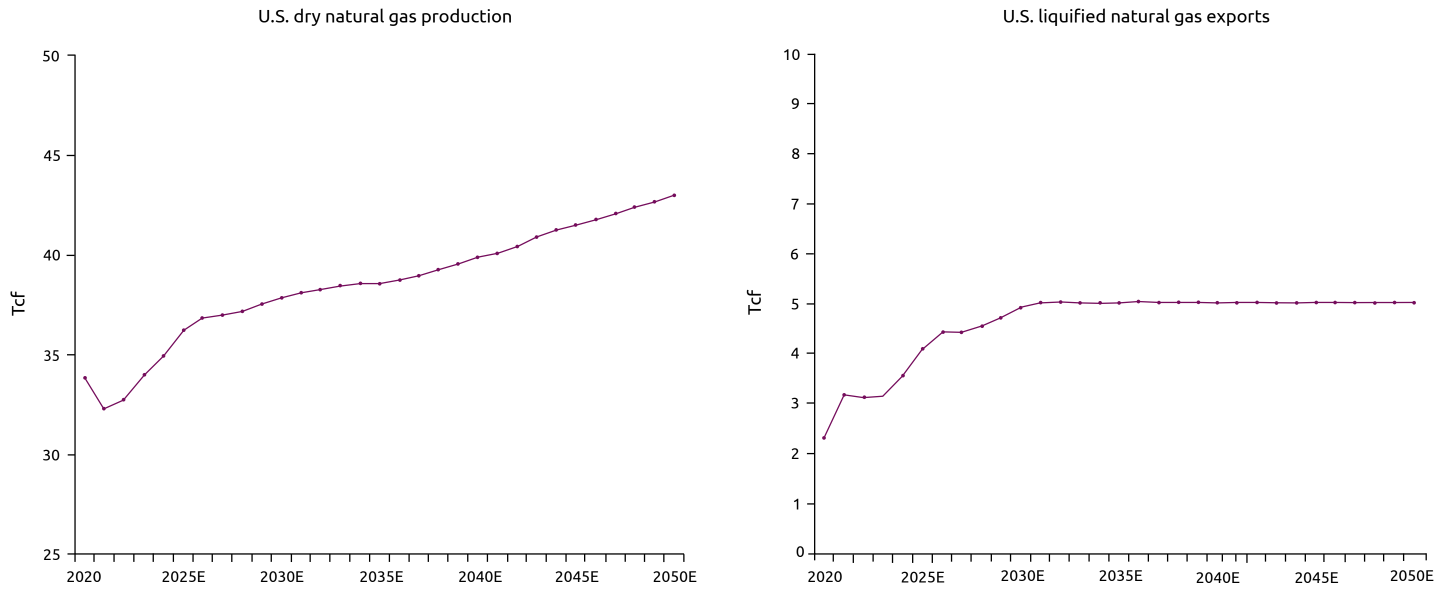
U.S. natural gas production: Natural gas is projected to grow in the long term as driven by end use consumption and opportunities to sell natural gas internationally through LNG exports

Domestic natural gas production is expected to return to pre-pandemic levels starting in 2023.

- More than half of the growth in shale gas production between 2020 and 2050 will come from shale gas plays in the Appalachian Basin in the East region; most of the remaining growth will come from plays in the Gulf Coast and Southwest regions.
- Due to the drop in crude oil production, associated natural gas (natural gas produced in primarily oil formations) also decreased in 2020 because of the relatively low crude oil and natural gas prices.
- EIA projects that natural gas will return to 2019 levels in 2024 and then steadily increase at a modest rate through 2050, primarily driven by increased drilling in the Permian Basin.

FIGURE 11

U.S. projected natural gas production, 2020-2050E (trillion cubic feet)
U.S. projected liquified natural gas exports, 2020-2050E (trillion cubic feet)



Source: US EIA Annual Energy Outlook, 2021
Link: https://www.eia.gov/outlooks/aeo/

Canada carbon capture, utilization and storage (CCUS) projects: Canada continues to advance its role as a leader in CCUS with recent announcements of governmental support at the federal and provincial levels for projects

Canada is a leading player in CCUS with a number of operating projects and decades of experience in the technology

- **In Canada, the federal and provincial governments support the use of CCUS to meet Canada's international GHG reduction commitments, balancing the importance of energy to the Canadian economy with the need to protect the environment.**
    - In August 2021, The Canadian Government called for an expression of interest to support CCUS developments across the country as it strives to achieve net-zero emissions by 2050.
    - Although Canada already stands as a leader in CCUS technologies, the Federal Government said it would invest US$ 319 Million into research, development and demonstrations to advance the commercial viability the technology as part of its 2021 budget.
- Canada sees CCUS as one of the main technologies available to mitigate GHG emissions from extensive fossil fuel use and to assist with the transition to more sustainable energy systems.
- The successful development of CCUS technologies requires knowhow and experience, appropriate legal and regulatory systems, favourable geology, and money.
- Canada has seven large sedimentary basins for permanent geological sequestration of captured CO2.
- Canada has a stable legal and regulatory system which has been specifically amended to consider and approve CCUS projects.
- Canada has significant experience in drilling wells and injecting substances into geological formations for storage or disposal. Canada's first CO2 enhanced oil recovery (EOR) scheme started in 1984 with CO2 sourced from a petrochemical facility, and in 1990 the world's first acid gas injection operation was commenced in Alberta.
- **With three projects already up and running - Boundary Dam (2014), Quest (2015) and Alberta Carbon Trunk Line (2020) – Canada has been leading in CCUS projects for a while.**

In fact, Canada is second to only the U.S. in operational projects to date. Yet, these facilities capture about 7 Mt annually, roughly 1% of total emissions.

- In 2019, Canada produced 730 megatonnes (Mt) of carbon dioxide. To meet Canada's most recent obligations under the Paris Agreement, the country needs to cut this volume by 40-45% over the next nine years.
- CCUS will be integral to cut this emissions volume. Current policies are projected to reduce emissions by ~30%, and CCUS is one of many levers driving this reduction. Strategic investments in large-scale CCUS projects could play a major role in closing the remaining 10-15% gap.

05 Infrastructure and Adequacy of Supply

05

05 Infrastructure & Adequacy of Supply

South East Asia
Adequacy of Supply

Nupur Sinha
Ankita Das

Improved performance in energy access and the security of Southeast Asia is driving the region in energy transition

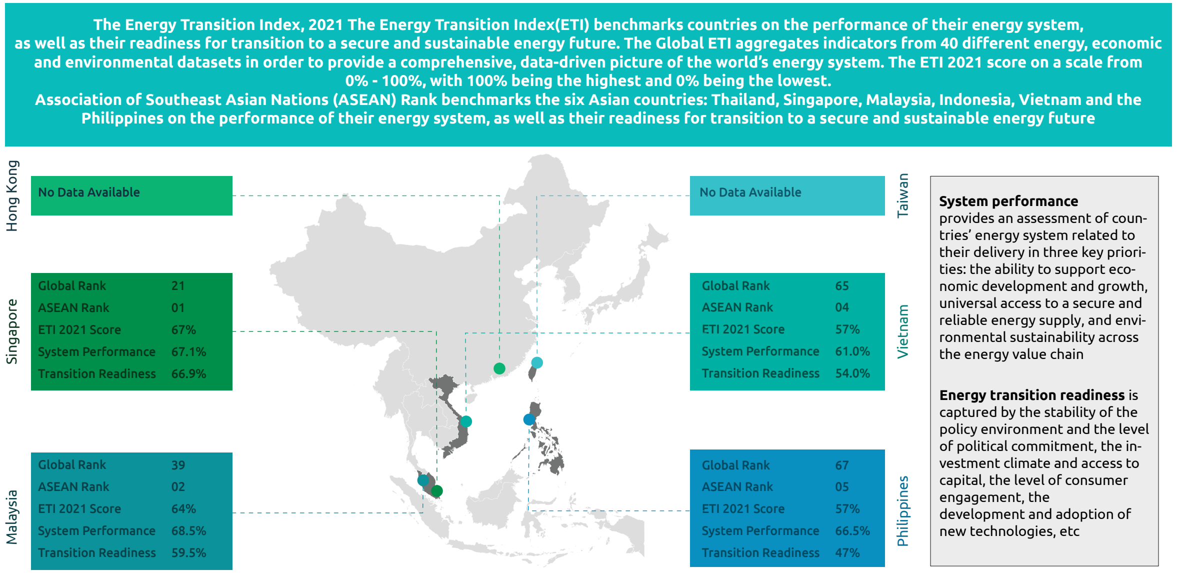
According to the 2021 World Economic Forum's Energy Transition Index (ETI), Asia has improved at the fastest rate, boosting its ETI index score by 6% in the past decade. This is driven by significant improvement in the region's performance in energy access and security.

- Singapore has a high ETI ranking of 21, as driven by stable guidelines, establishments, governance framework, and transparency, along with a culture of innovation and contemporary infrastructure.
  - The aggregate score for Singapore has remained consistent over the past six years, demonstrating the strength of its energy system.
  - As a major refining hub and emerging center of global liquefied natural gas (LNG) trade, Singapore plays a significant role in the global energy system. The fossil fuel industry is a major economic driver in Singapore.
  - Malaysia also has an ETI ranking of 39 due to its high electrification rate, low usage of solid fuels, diversity of its fuel mix, and high quality of electricity supply.
- The Philippines has a low ETI rank of 67, which has declined from the previous year.
- Vietnam has a low ETI rank of 65 due to weaker institutions, a low level of investment freedom, and a low quality of transportation infrastructure.

Note: *2021 World Economic Forum's Energy Transition Index (ETI) benchmarks 115 economies on the current performance of their energy systems across economic development and growth, environmental sustainability and energy security and access indicators and their readiness for transition to secure, sustainable, affordable and inclusive energy systems.*

FIGURE 1

Energy Transition Ranking in Southeast Asia, 2021



Source: World Economic Forum, 2021
Link: :http://www3.weforum.org/docs/WEF_Fostering_Effective_Energy_Transition_2021.pdf

Southeast Asian countries have improved in the 2020 Energy Trilemma Index due to enhanced energy policies for better energy transition

Southeast Asia is one of the most dynamic and diverse regions in the world in terms of energy transition. In the 2020 World Energy Council's Energy Trilemma Index, Southeast Asian countries are among the top and bottom ranks.

- Energy equity scores have generally increased, primarily due to successful deployment of modern and affordable energy across the region.
- Southeast Asia remains the largest energy importer in the world and its energy security is expected to become even more challenging.
- The region presents dramatic improvements in sustainability. Governments are investing in the transition to clean energy, increasing private competition, and incentives in the renewable sector.
- The COVID-19 crisis could have negative and positive effects on the energy systems of the region, which will be explored further.

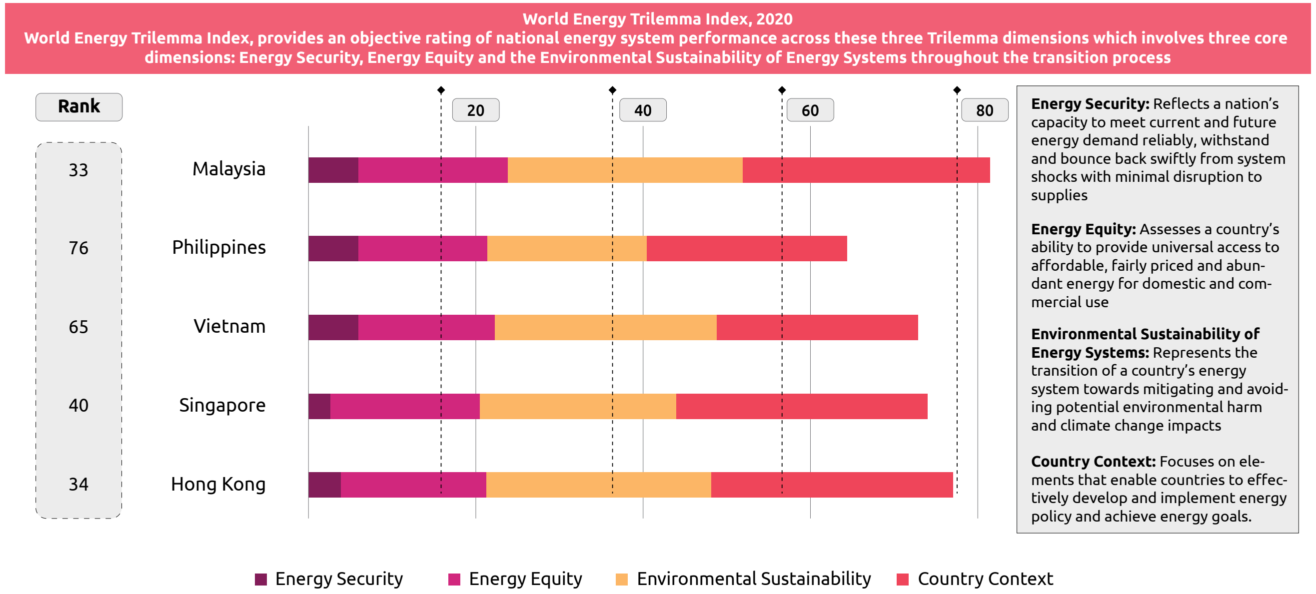
Improvement trajectory for each country varies in Southeast Asia:

	2020 Rank	2019 Rank	Rank Changes
Malaysia	33	51	▼
Philippines	76	94	▼
Vietnam	65	91	▼
Singapore	40	43	▼
Hong Kong	34	34	No Change

Note: *The World Energy Council's Energy Trilemma Index tool, produced in partnership with Oliver Wyman, ranks countries on their ability to provide sustainable energy through 3 dimensions: Energy security, Energy equity (accessibility and affordability), Environmental sustainability*

FIGURE 2

Southeast Asia Trilemma Index, 2020



Source: : World Energy.org, 2021
Link: https://www.worldenergy.org/assets/downloads/World_Energy_Trilemma_Index_2020_-_REPORT.pdf

South-East Asia represents a key growth region for natural gas for the next few years

Oil, Coal, and natural gas continue to be the dominant sources of energy in primary energy consumption mix in 2020.

- Oil continues to hold the largest share of the energy mix (44.5%). Coal is the second largest fuel in 2020, accounting for 30% of total primary energy consumption.
- The share of both natural gas and renewables(including hydroelectricity) rose to record highs of 17.5% and 6.5% respectively.
- Renewables has now overtaken nuclear which makes up only 1.5% of the energy mix.

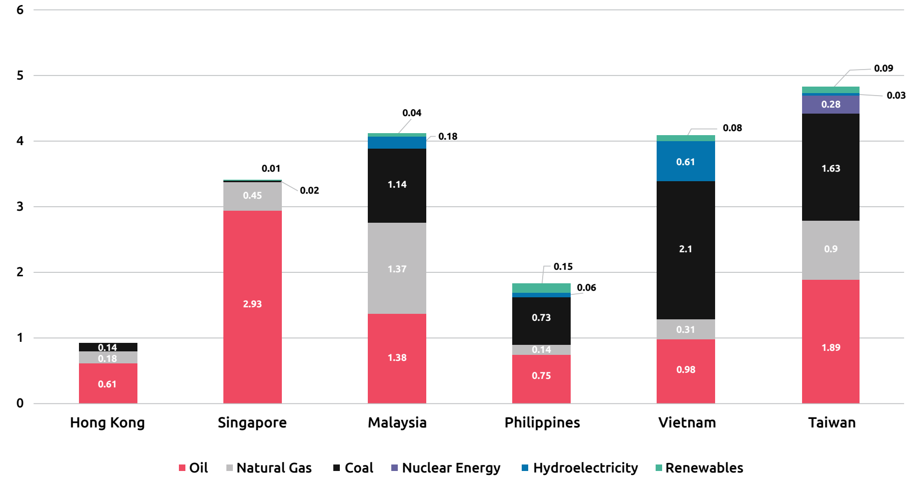
Southeast Asian countries are set to expand imports of liquefied natural gas as the depletion of domestic gas reserves looms, setting the stage for a realignment in the global LNG market

- Given the increasing gas demand and declining domestic supply, countries in South-east Asia are bracing themselves to become net gas importers and are studying ways to enhance their security of supply.
- In the Philippines, major power utility First Gen begins construction on a US$ 300 million offshore LNG intake terminal this month in Batangas, a port city in the southern portion of the main island of Luzon. The large-scale project is the first of its kind for the nation.
- Although Vietnam has yet to import LNG, the Petrovietnam group, the largest state-owned oil company, plans to start up an LNG terminal in the southern province of Ba Ria-Vung Tau as early as 2022.

The Covid-19 pandemic has dented the gas demand growth in the region. This will ultimately create short term headwinds for gas projects under development in the region and the pace of gas demand recovery. However, this is unlikely to change the longer-term trajectory of gas consumption in the region and the importance of LNG will become ever stronger as a result.

FIGURE 3

SEA~ Energy Mix by fuel (Exajoules), 2020



Source: BP Statistical Review of World Energy, 2021
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

05 Infrastructure and Adequacy of Supply

05

05 Infrastructure & Adequacy of Supply

Australia
Adequacy of Supply

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Australian electricity generation remains largely unchanged since 2019, at 265,232 GWh in 2020

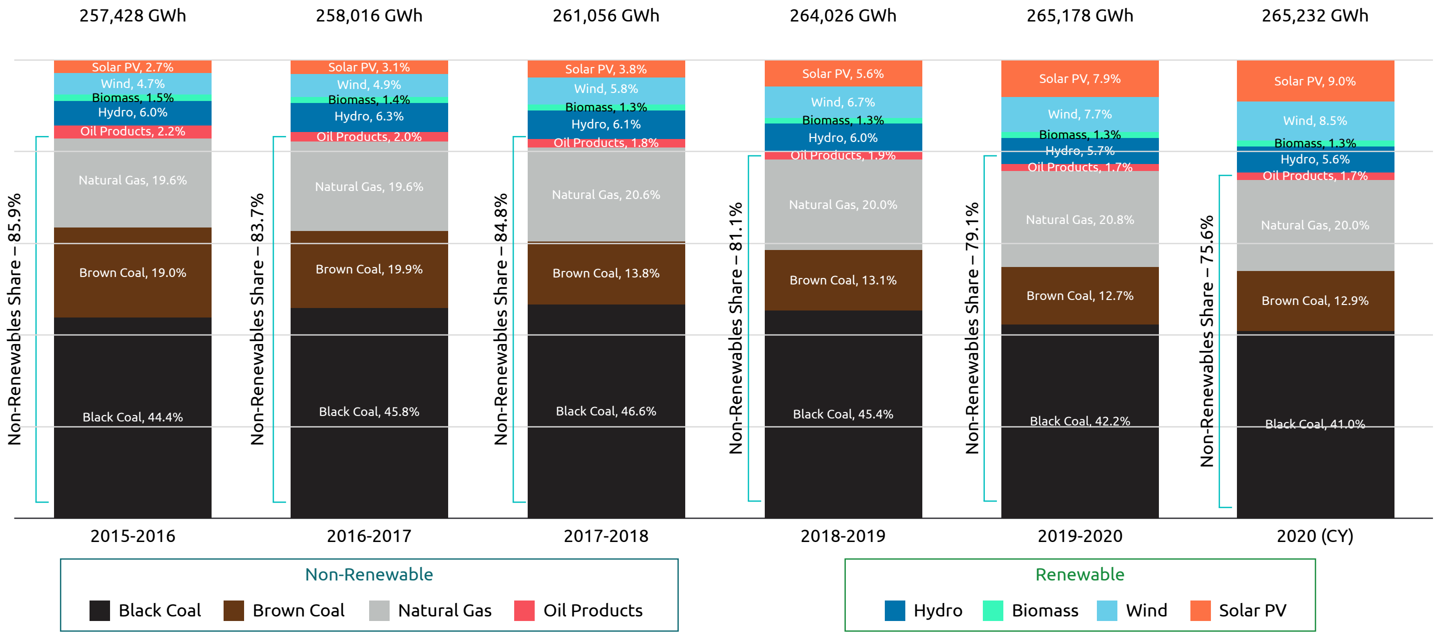
The Australian electricity system is organised into two physical electricity systems and wholesale market constructs, an eastern states energy system and a separate system comprised of Western Australia and the Northern Territory. The eastern states system is the largest interconnected energy system of its type in the world.

Organisation of Australia's Physical Energy System and Wholesale Energy Market

- The National Electricity Market (NEM) is comprised of five physically connected regions on the east coast of Australia: Queensland, New South Wales (NSW) (which includes the ACT), Victoria, Tasmania and South Australia. It generates around 200 TWh of electricity annually, supplying around 80% of Australia's electricity demand.
- Both the physical electricity system and the electricity market are regulated by the three energy market bodies, each with specific responsibilities:
  - Australian Energy Market Commission (AEMC) make rules for the energy system and markets.
  - Australian Energy Market Operator (AEMO) controls operation of the energy system and markets
  - Australian Energy Regulator (AER) monitors and regulates the energy markets.
- Western Australia and the Northern Territory are not connected to the NEM. They have their own electricity systems and separate regulatory arrangements. The AEMC also has a role in the Northern Territory.

FIGURE 1

Electricity Generation Mix in Australia



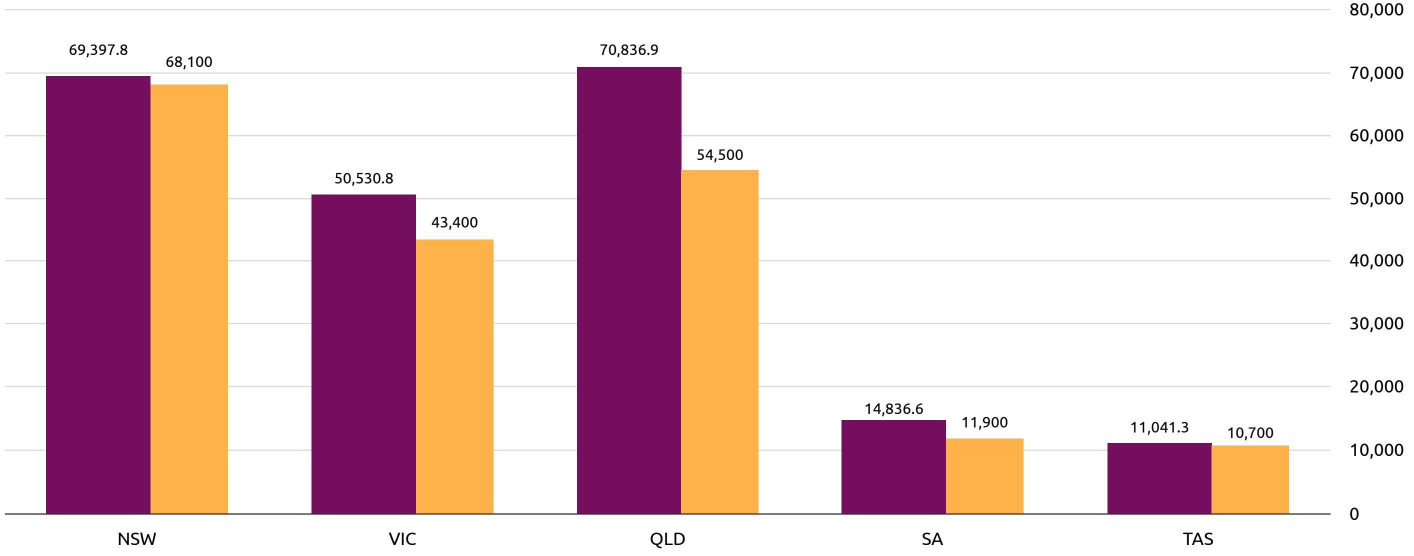
Source: Australian Energy Statistics by Department of the Environment and Energy, Australian Energy Statistics, Table O, March 2019; Australian Energy Statistics, Table O Electricity generation by fuel type 2019-20 and 2020; Australian Energy Update 2020 Link: https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2018-19-and-2019 ; https://www.energy.gov.au/government-priorities/energy-data/australian-energy-statistics

Electricity Generation and Supply

- Total electricity generation in Australia was estimated at 265,232 GWh in 2020, remaining materially unchanged since 2019.
- Overall electricity consumption decreased slightly in 2020 to 203 TWh. Consumption rose from 2014 to 2019, reaching 206 TWh in 2019 after 5 years of steady growth.
- As captured in the AER's State of the energy market 2021 report, in 2020-21 the NEM saw:
    - Electricity consumption by more than 10.3m residential and business customers
    - More than 3,700 MW of large-scale solar and wind generation capacity enter the NEM, mostly in NSW and Victoria.
    - Record investment in rooftop solar photovoltaic (PV), with almost 2,500 MW of new capacity installed across the NEM in 2020. This activity drove record levels of wind and solar generation, accounting for over 19% of total electricity generation.
- For the first time in several years, AEMO did not forecast any supply shortfalls for the 2020-21 summer, despite maximum demand forecasts being similar or only slightly lower than in 2019-20.
- The major factor in the improved outlook was the more than 5 GW of new renewable energy generation that entered the market, easing the supply shortages of previous years.

FIGURE 2

NEM Electricity Generation vs NEM Electricity Consumption by state, GWh 2020



Source: Australian Energy Statistics, Table O Electricity generation by fuel type 2019-20 and 2020
Link: https://www.energy.gov.au/publications/australian-energy-statistics-table-o-electricity-generation-fuel-type-2019-20-and-2020

Australia's 2020 Integrated System Plan (ISP) identifies opportunities and transmission investments that are required to ensure grid reliability and security

The ISP is a whole-of-system plan that provides an integrated roadmap for the efficient development of the NEM over the next 20 years and beyond.

The ISP Process

- AEMO published the first ISP in 2018. The ISP will be updated every two years based on extensive stakeholder engagement, and internal and external industry and power system expertise.
- The primary objective of the ISP is to maximize value to end consumers by designing the lowest cost, secure and reliable energy system capable of meeting any emissions trajectory determined by policy makers at an acceptable level of risk. It fully utilizes the opportunities provided from existing technologies and anticipated innovations in Distributed Energy Resources (DER), large-scale generation, networks and coupled sectors such as gas and transport.
- The ISP identifies the optimal development path to assist in planning regulated assets. It highlights development opportunities and complementary market and regulatory reform needed to meet future power system needs efficiently and sustainably.
- The ISP modelling identifies investment portfolios that can minimize total resource costs and the required targeted transmission investment.

The 2020 ISP provides an actionable roadmap for eastern Australia's power system.

- The 2020 ISP was released on 30 July 2020, providing a blueprint that maximizes consumer benefits through a transition period of great complexity and uncertainty.
- The key objective for the 2020 ISP is to deliver both power system and broader policy needs in the long-term interests of electricity consumers.
- Transmission investment recommended for immediate action in this ISP was estimated to be between AUD$450 million and AUD$650 million.

Committed 2020 ISP projects, already underway:

- **South Australia system strength remediation**, on track to be completed in 2021.
- **Western Victoria Transmission Network Project**, on track to be completed in two stages, by 2021 and 2025.
- **QLD-NSW (QNI Minor)**, on track to be completed in 2021-22.

Actionable ISP projects:

- **NSW – HumeLink** (A 500 kV transmission upgrade to reinforce the NSW southern shared network and increase transfer capacity between the Snowy Mountains hydroelectric scheme and the region's demand centers) expected to be completed by 2025-26.

In October 2020, AEMO commenced work on the 2022 ISP

- The initial focus is to consult and agree with stakeholders on the inputs, assumptions and scenarios that AEMO proposes to use in its 2021-22 forecasting and planning activities, including the 2022 ISP.

- AEMO has commenced consultation to develop the ISP Methodology, in accordance with the Australian Energy Regulator's (AER's) forecasting best practice guidelines and cost benefit analysis guidelines, providing stakeholders with multiple opportunities to contribute.

"The Australian Energy Market Operator's $25 billion Integrated System Plan to build up the power grid is a real milestone in energy policy and evidence AEMO is stepping up to the plate to be a real force in the design of the energy system through and post the transition"

Matt Rennie,
Energy Magazine, 2020

FIGURE 3

Key Projects for the 2022 ISP	State	Status	Responsible TNSP(s)
Eyre Peninsula Link	**SA**	Committed	ElectraNet
Project EnergyConnect Anti	**SA**	Anticipated	ElectraNet and TransGrid
Central West Orana REZ Transmission Link	**NSW**	Anticipated	TransGrid
Queensland to New South Wales Interconnector (QNI) Minor	**QLD-NSW**	Committed	Powerlink and TransGrid
Victoria to New South Wales Interconnector (VNI) Minor	**VIC-NSW**	Committed	AEMO (Victorian TNSP) and TransGrid
VNI System Integrity Protection Scheme (SIPS)	**VIC**	Committed	AEMO (Victorian TNSP)
Western Victoria Transmission Network Project	**VIC**	Anticipated	AEMO (Victorian TNSP)

The Australian Government is focusing on new and emerging technologies to improve grid security and efficiency, however not with the required urgency to effectively respond to and manage market disruption

Australian energy suppliers and regulators are taking positive steps to drive key initiatives. For example, across DERMS, cyber security, AI and digital twins. However, suppliers' and regulators' technology transformation plans, and actions, generally have not addressed the necessary scale and urgency. They must enable autonomous, dynamic, and intelligent renewable, grid and customer environments.

Recent examples of Australian digital technology investments and initiatives intended to deliver efficiencies and security to the electricity system, are highlighted below.

Distributed energy resources management system (DERMS)

DERMS software systems are a critical capability to support management of reliable, efficient and dynamic grids. Australian utilities are in the early stages of framing their approaches and progressing their DERMS investments. Slow progress has been made to operationalize and scale implementations.

- In June 2021, Horizon Power, in partnership with PXiSE Energy Solutions and SwitchDin, successfully deployed a DERMS solution and powered Onslow with 100% renewable energy as a demonstration of advanced microgrid technology. In a complex and technically challenging endeavor, the hydrocarbon-free operation was achieved for 80 minutes orchestrating traditional energy sources with customer and utility solar and battery solutions. Horizon Power will continue further DERMS testing ahead of commissioning the project later this year.

- In 2020 CitiPower & Powercor selected mPrest to leverage their utility orchestration and optimization platform called mDERMS to manage DER while optimizing dispatch and resolving system constraints. It was one of the first Grid Operators to deploy a DERMS solution locally. The solution was live for the important summer period in December 2020.

Artificial Intelligence

- In August 2021, Australian renewables developer Edify Energy, and U.K-based investor Octopus Group, deployed Fluence's AI-powered trading platform. It optimizes the trading of the 333 MW Darlington Point Solar Farm in southwestern New South Wales.

- In May 2021, the Federal Government announced it will further develop Australia's capability in Artificial Intelligence with AUD$124.1 million in initiatives. That includes a National Artificial Intelligence Centre led by CSIRO, supported by a network of AI and Digital Capability Centers to drive adoption of AI across the economy.

- In 2020, Origin Energy developed a world-first AI driven production optimization tool. The tool takes data such as pump speed and flow rates and decides which of the company's 2,000-plus gas wells can be turned down and turned back on again with the lowest probability of failure. This allows Origin to reduce the number of workovers, extend the life of each well, and reduce flaring emissions.

- In September 2020, Microsoft partnered with AEMO on its nationally important digital transformation. It is designed to drive efficiency and consumer value in a transitioning the energy market. AEMO is exploring the use of AI and machine learning to enhance its analytics capability and build new classes of digital tools. This includes a next-generation simulator to provide near real-time support for system security challenges in a rapidly evolving power system.

- In October 2018, Australian Renewable Energy Agency (ARENA) launched a project in collaboration with Monash University's Grid Innovation Hub, Worley, and Palisade Energy. It applies machine learning to predict wind and solar power. It aims to securely integrate them into the national electricity grid. In July 2021, the forecasting algorithm had achieved a 45% improvement in the power output predictions in the 130.8 MW Waterloo Wind Farm (WWF) in South Australia, and the 11 MW Ross River Wind Farm (RRWF) in Queensland. Further research is needed in relation to solar.

Digital twins

- The digital twin technology is developed by CSIRO's Data61. It is the digital specialist arm of Australia's national science agency.

- NSW Department of Customer Service's Spatial Services launched its Spatial Digital Twin in early 2020. It is a virtual 4D (3D + time) model of the Western Sydney's built and natural environments. The technology will allow planners, developers and policymakers to make more informed decisions, saving costs and creating efficiencies for utilities including for energy and power.

- The Victorian government announced AUD$35 million to build a statewide spatial digital twin to inform planning decisions and investment. The platform is planned to be widely accessible from late 2021. It will be used to transform planning and unlock efficiencies from the start to finish of infrastructure projects. It will also monitor real-time feed data such as renewable energy capacity.

Funding aimed at improving the cyber resilience of the electricity, gas and liquid fuel industries

- In the federal budget 2020-2021, the Australian Government announced AUD$4.9 million funding over two years to build, consolidate and strengthen cyber security capability in the energy sector. It will deliver a range of discrete uplift support measures across the electricity, gas, and liquid fuel industries. Cyber security will become increasingly critical as physical assets are a target of attacks, particularly for operational systems and connected equipment.

Australia Institute's Energy Policy and Regulatory Lead, Dan Cass, said the latest research showed that renewable energy was capable of providing sufficient system security to support the grid and Australians were "ready for that transition to take place".

"Australians have embraced new energy assets such as rooftop solar and batteries (known collectively as DER) at a high rate, with the country having the highest per capita uptake in the world…This need requires a plan to integrate DER and operate Virtual Power Plants (VPPs) now—so speed to market is key."

- ARENA

Security of electricity supply remains a top priority for Australia

Australia's coal-fired generation fleet is ageing, and operational challenges are causing more frequent and longer unplanned outages for energy infrastructure managers. This is resulting in higher operating and maintenance costs for the existing fleet of coal-fired assets.

Unplanned Outage and Reliability Challenges in Australia

- In 2020, AEMO reported rising forced outages among fossil fuel plants due to breakdowns and more frequent, longer planned outages for maintenance and repairs.
- Reliability concerns tend to peak over summer when high temperatures spike demand and increase the risk of system faults and outages.
- In recent years, both brown and black coal has increased rates of forced outages with reliability falling to historically low levels in 2019-20 for NSW coal plants.
- Brown coal forced outages exceeded long term averages and there was a sharp increase in outages across black coal plants in NSW and Queensland in 2019–20.

- A September 2020 Australia Institute study found that some of the country's newest gas and coal-fired power stations were among the least reliable. It showed that Australia's newest coal-fired power station, Kogan Creek, was the most unreliable single generating unit in the National Electricity Market.

- According to AEMO, the reliability outlook in NSW for the 2022–23 summer and beyond has improved with the planned upgrade of the QLD–NSW interconnector, and the development of 900 MW of renewable generation. NSW will be dependent on this investment and remains vulnerable to high demand, generation outages, and low renewable generation.

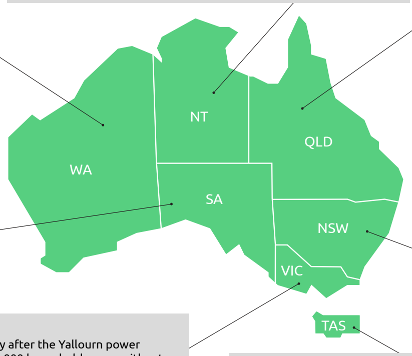
FIGURE 4

Electricity Supply security issues by state

- In April 2021, Western Power confirmed that 29,500 homes and businesses remained without power in the mid West and Central Wheatbelt regions, with at least 75 transmission poles damaged across an area spanning 700 kms long and 150 kms wide. The outage lased for several days.
- In January 2020, a mass blackout caused 100,000 homes to lose power across the state. The outage was caused when a Kwinana generator failed, with a smoking turbine at the Leath Road power facility reported just before 9pm, with two failures at Badgingarra Wind Farm and Worsley Power Station ensuing.

- In November 2020, a massive power outage affected properties across Darwin and Katherine, including two hospitals, after a key power station went down. NT Power and Water confirmed the issue was caused by a gas supply interruption to the Channel Island Power Station.

- In May 2021, an explosion at a central Queensland coal-fired power station occurred that triggered mass power outages statewide, from the NSW border to north of Cairns, disrupting power to more than 470,000 customers. AEMO reported the incident interrupted multiple transmission lines and power stations at Gladstone, Stanwell, Yarwun and Mackay, resulting in about 3,100 megawatts disappearing from the Queensland power grid.
- In April 2021, a power outage in north-west Queensland left the city of Mount Isa and four outback towns without electricity for five hours. In total, almost 10,000 customers were affected by the outage, which was caused by an issue with the Diamantina Power Station complex which triggered an interruption to power supply to Mount Isa and surrounding regions.



- In July 2021, Adelaide faced electricity outages amid winter storm.
- In Feb 2021, a growing colony of grey-headed flying foxes caused an increasing numbers of power outages in Adelaide and nearly 2,000 homes at Klemzig were without power after one became entangled in power lines.

- In November 2019, more than 25,000 households were without power across Sydney after an intense burst of wild weather caused large blackouts.
- An unplanned outage at the Liddell coal-fired power plant in late December 2020 highlighted the unreliability of Australia's ageing fossil fuel generation fleet.

- In June 2021, the Victorian government has declared a state energy emergency after the Yallourn power station and coal mine, in the Latrobe Valley, was damaged in flooding. About 7,000 households were without power, and 3,000 of them have been told to prepare to be off supply until July 10.
- In January 2020, Southwestern Victoria faced transmission towers collapse in Moorabool – Mortlake and Moorabool – Haunted Gully 500kV transmission lines due to a severe convective downburst during thunder-storm activity. This resulted in the separation of the Mortlake Power Station, the APD Portland aluminium smelter and South Australia from the rest of the NEM for 17 days.

- In June 2021, almost 2000 residents were left without power across the northern suburbs of Launceston on a Saturday evening due to a power outage. Total of 1874 residents across Mowbray, Mayfield, Newnham and Rocherlea were impacted.
- Basslink, high voltage direct current electricity interconnector also experienced unplanned outages during 2019-20, which lasted from 25 August 2019 to 29 September 2019.

Electrification, population growth, and electric vehicle potential is putting pressure on the grid

Australia is on the cusp of significant disruption to its energy value. That is driven by global changes including net-zero strategy execution, electrification, population growth, electrical vehicle growth, accelerating rooftop and large scale solar adoption, and small-scale battery storage. These will affect power demand, demand profile, and critically, how the grid must be managed.

Electricity demand is forecast to rise in Queensland, South Australia and New South Wales, while remaining relatively stable in Tasmania.

According to the AER's State of the Energy Market 2021 Report:

- Minimum demand fell in every NEM region in 2020. The greatest falls were in South Australia and Victoria, where new minimum demand records were set.
- AEMO forecasts that all regions will experience a decline in maximum demand in 2020–21. That is due to COVID-19, including affects on economic activity, changing daily demand profiles, and reduced output of some large industrial customers in response to economic conditions.
- Maximum demand over the next 10 years is forecast to: rise in Queensland, South Australia, and NSW; and remain relatively stable in Tasmania. Demand in Victoria will be flat before slightly increasing 2026-27 onwards.
- Low grid demand contributed to low prices. The NEM experienced unusually mild summer conditions and high levels of rooftop solar PV generation over the 2020–21 summer. Mild conditions also resulted in few reliability concerns.
- New technologies are providing opportunities for smaller scale distributed energy resources to offer demand response in the wholesale market, and grid stability services.
  - Initiatives include virtual power plant trials and a proposed AEMO-operated platform on which participants can contract for electricity in the week leading up to dispatch, to enable enhanced demand response.

Rooftop solar PV systems are changing the size and profile of grid-supplied electricity demand. This is expected to change further with accelerated battery adoption.

- Output from rooftop solar PV systems met 6.4% of the electricity needs in the NEM in 2020, up from 2.5% in 2015.
- It is anticipated that in coming years, customer battery storage of surplus energy from solar PV systems will increase and reduce reliance on the grid in peak demand periods.

Solar PV generation has led to lesser electricity demand during the day.

- This reduces wholesale prices and revenues for generation for day times.
- The South Australia Government is targeting 100% coal-fired net renewable energy generation by 2030. It has also announced plans to achieve renewable energy of more than 500% of current local grid demand by 2050. SA plans to become a green energy exporter nationally and internationally.

Industrial companies are using more electricity as their power source for physical plant and equipment

- The energy transition in Australia is characterized by an acceleration in variable renewable energy (VRE) together with an increase in electrification.
- Good planning and technology transformation is required to effectively manage system reliability and supply adequacy as these changes take affect.

- A shift is underway towards electrifying certain aspects of industrial operations.
- Many companies have published sustainability reports, detailing their strategies for increasing energy efficiency, reducing landfill waste, and lowering greenhouse gas (GHG) emissions. Examples include:
  - AGL, through its virtual power plants (VPP) program, is encouraging renewables integration and electrification measures among its customers, by providing behind-the-meter storage. In collaboration with the NSW State Government, AEMO, and ARENA, AGL is pioneering new financial incentives for customers to reduce energy use during peak demand periods.
  - Rio Tinto is developing an AUD$98 million solar plant at its new Koodaideri iron ore mine. The 34 MW facility will deliver 100% of the site's electricity requirements during peak generation hours, and approximately 65% of the mine's average electricity demand. It will be supported by a lithium-ion battery storage system, and is predicted to reduce Koodaideri's annual CO2 emissions by ~90,000 tonnes.
- According to the REmap decarbonization scenario of the International Renewable Energy Agency (IRENA), electrification initativeis are expected to increase the share of electricity in final energy consumption for all energy applications from 20% today, to 49% in 2050.
- According to the Australian Government, electric vehicles are expected to constitute ~26% of new car sales by 2030, with 1.3 million in use by then. Charging profiles of EVs will affect power flows in a similar way to batteries. Price incentives that discourage customers from charging during peak demand periods will ease potential strain on the power system.

Research conducted by Evenergi as part of the Strategic Regional EV Adoption Program highlights that current adoption rates suggest personal electric vehicles will not have significant implications on grid performance between now and 2025, and that EVs potentially offer an opportunity to improve network asset utilization.

The pandemic impacted the profile of energy use across the network. Electricity usage increased for residential customers and decreased for small businesses.

The COVID-19 pandemic affected all aspects of society in 2020. In 2021, it will continue to impact electricity consumption and expenses.

- Residential customers, spent more time at home and increased their electricity use. As a result, residential electricity bills increased. Overall, residential customers used 10% more electricity in 2020, with an average bill increase of 7%.
  - 2019 to 2020 regional comparisons show that the median quarterly usage for residential customers increased the most in New South Wales (13%) and Victoria (12%), and the least in South Australia (6%) and south-east Queensland (6%).
- Small business customers used less electricity. That reflected government restrictions, reduced onsite business activity, and staff working from home. With decreased usage of 17% overall, small business electricity bills decreased by 16% overall.
  - For small business customers, median quarterly usage decreased the most in Victoria (25%) and New South Wales (17%), and the least in South Australia (4%) and south-east Queensland (6%).

- Households with solar panels increased their use of grid electricity in 2020.
- Small businesses with solar panels decreased their use of grid electricity.
- According to AEMO, overall grid demand of the NEM decreased by 313 MW, or 1.4% in 2020 compared to 2019, as opposed to comparable countries.
- That was due to increased solar feed-in supply from solar customers, and a decrease in underlying demand from businesses, due to Covid-19.
- Victoria is the only reference state in Australia that can be used to measure COVID-19 energy usage impacts. It provides reliable analysis due to its 99% smart meter penetration.
- Victoria's Stage 4 restrictions reduced commercial demand for grid electricity by approximately 15% and increased residential demand by around 10 to 15%.
- The primary reason for the decrease in demand is that Australian households consume far more energy than their European counterparts, due to their size and uneconomical energy usage.

The energy transfer from commercial to residential highlights an underlying equity problem of sustained lockdowns, transferring the cost of energy used as a productive business input onto households. With demand moving, the biggest risk may come from overloading parts of the network without network providers having visibility of demand.

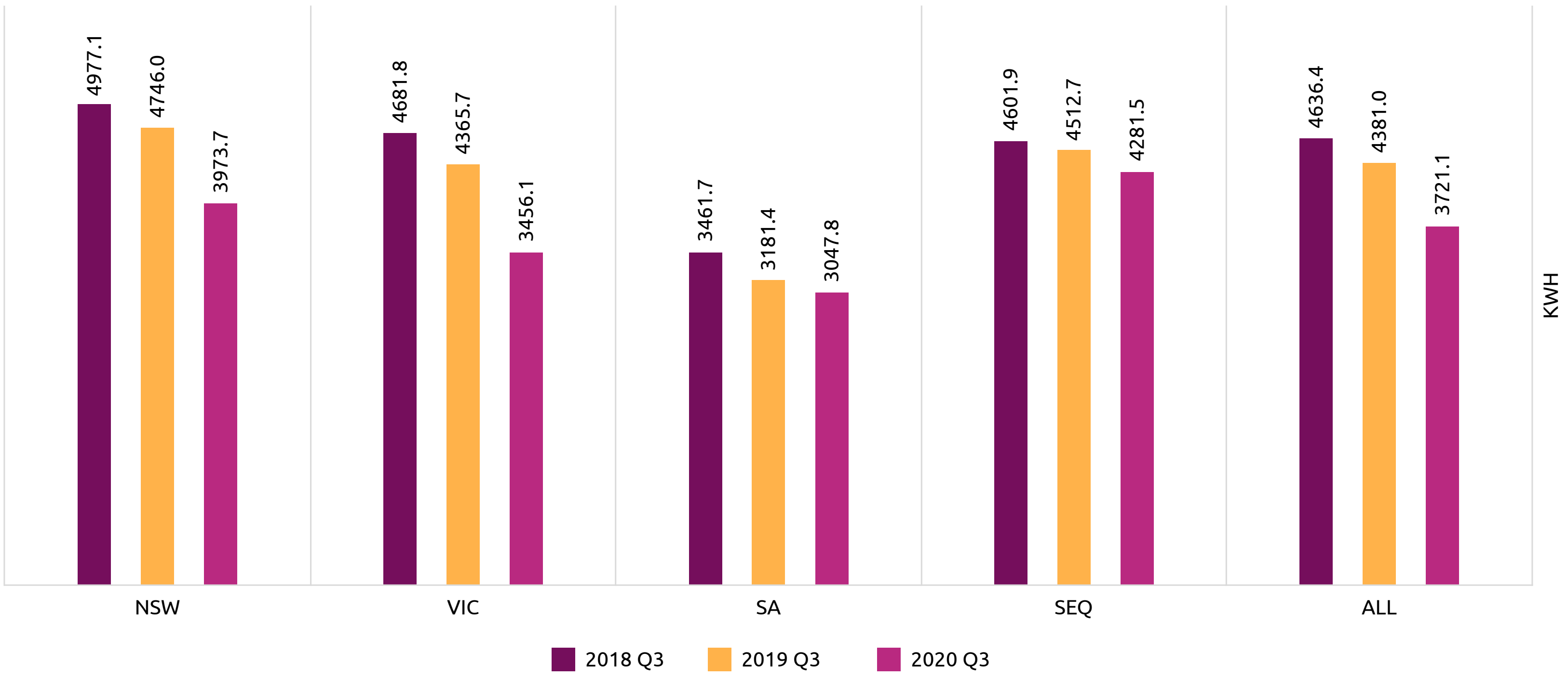
FIGURE 5

Quarterly grid usage by residential customer

Source: ACCC - Inquiry into the National Electricity Market
Link: https://www.accc.gov.au/system/files/Inquiry%20into%20the%20National%20Electricity%20Market%20-%20May%202021%20report%20v2.pdf

FIGURE 6

Quarterly grid usage by small business customers



Source: ACCC - Inquiry into the National Electricity Market
Link: https://www.accc.gov.au/system/files/Inquiry%20into%20the%20National%20Electricity%20Market%20-%20May%202021%20report%20v2.pdf

Australia's average wholesale electricity prices plummeted to the lowest levels in 9 years

The beginning of 2021 saw lower energy demand and therefore wholesale prices. That was caused by mild weather, and an increasing proportion of lower cost energy production in the generation mix. We are starting to see dynamic management of the grid in response to weather, environment and demand drivers. For example, in South Australia, rooftop solar was turned off to stabilize the grid and increase demand for power from centralised sources.

The NEM produced ~204,081 GWh of electricity between September 2020 and September 2021.

- The generation mix included fossil fuels, renewables and batteries (discharging). Fossil fuel contributed the vast majority at 70.1%.

The AER's Q1 2021 Wholesale Markets Quarterly found average electricity prices across the NEM are at their lowest first quarter levels since 2012.

Prices are typically higher in Q1 due to summer demand. In Q1 2021:

- This did not occur due to mild weather, low demand, and increased low-cost generation.
- Volume weighted average (VWA) prices in all regions were lower than expected. They ranged from AUD$27/MWh in Victoria to AUD$53/MWh in South Australia.
- There were a high number of negatively priced trading intervals - especially in Victoria and South Australia
- There was the lowest number of prices above AUD$300/MWh in a Q1 since 2012.
- Reduced output and cheaper prices resulted in very low NEM turnover.

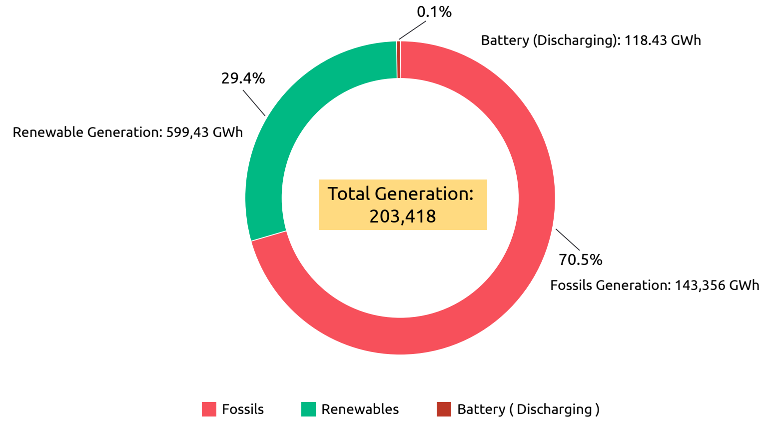
These prices are expected to continue, with contract prices for the next 2 to 3 years remaining below AUD$60/MWh in all regions.

"In summer, and particularly Q1, wholesale electricity prices are usually higher with hot weather prompting more use of air conditioners, and higher demand for electricity pushing up prices, but Q1 this year was different… But equally low demand can impact the stability of the network, which we saw in South Australia in March 2021 when for the first time the market operator needed to use new powers to help stabilize the network by turning off some rooftop solar to increase demand."

-Clare Savage, AER Chair

FIGURE 7

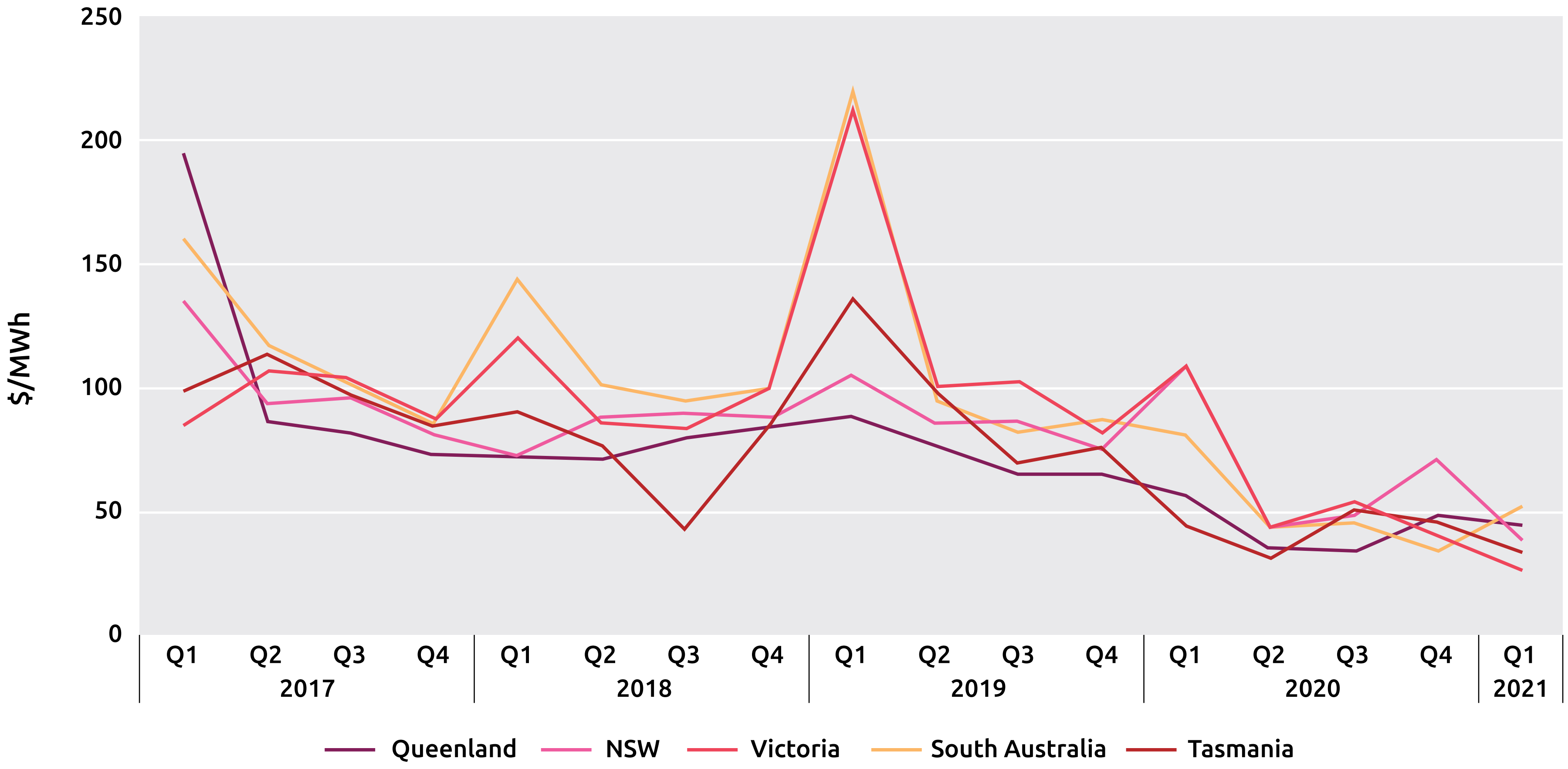
NEM Market – Electricity production (Aug 2020 – Aug 2021)



Source: NEM open data (Aug 2020 – Aug 2021)
Link: https://opennem.org.au/energy/nem/?range=1y&interval=1M

FIGURE 8

Average quarterly spot prices (Volume weighted average)



In 2020, Australian coal exports declined by 4%, largely due to the fall in Chinese demand. Correspondingly in March 2021, YoY coal exploration expenditure declined by 32%.

Australian thermal coal had a difficult 2020. That was due to a shift in demand, and China's ban of Australian coal imports. It resulted in the largest decline in coal demand since World War II. However, coal demand is expected to remain stable over the coming years as Asia's demand for low-cost energy to support economic growth will continue.

In 2020, Australian coal decreased ~4% in exports, ~6% in production, and ~3.5% in consumption.

- China's import restrictions contributed to the decline in exports, from 213 million tonnes in 2019-20, to 198 million tonnes in 2020-21.

Australia's coal markets continue to adjust to China's import restrictions, and metallurgical coal mining firms are benefiting from the surge in world steel production.

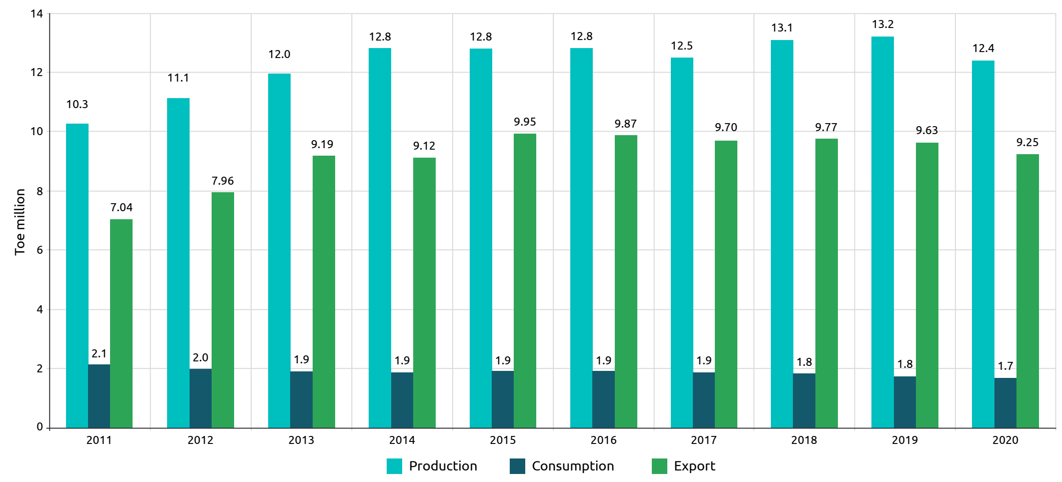
- Australian exporters of premium thermal coal are enjoying multi-year price highs.
- However, producers of mid-calorific thermal coal and metallurgical coal have taken longer to pivot from China to other markets.
- Prices are expected to be firm in 2021–22, as ex-Chinese usage recovers further. Thermal coal prices have risen, with premium Australian coal hitting its highest level in more than ten years.
- Metallurgical coal trade is also anticipated to face ongoing uncertainty. That is due to the COVID-19 pandemic, with new waves of infection spreading across India (a large steel producer), and potentially elsewhere in Asia.
- Australian Government figures show there was a 0.7% decrease in both coal mining and oil and gas output, leading to declines in exports of 8.3% in coal, and 1.7% in other mineral fuels.

"While hard coking coal exports to China have diminished since mid-2020, increased exports to India, Japan and South Korea have offset some of the fall"

– Australian Bureau of Statistics, 2021

FIGURE 9

Australian Coal Production and consumption (2015 – 2020) in Exajoules



Source: BP Statistical Review 2021
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

Australia's coal exploration expenditure decreased by 32% year-on-year to AUD$51 million in the 2021 March quarter. That likely reflects uncertainty over thermal coal markets, and recent volatility in prices.

- Australia had an 8.8% drop in fugitive emissions, partly due to reduced coal production.
  - Fugitive emissions occur during the production, processing, transport, storage, transmission, and distribution of fossil fuels, including coal, crude oil and natural gas.
  - Coal production declined by 5.0 per cent in the 2020 December quarter, contributing to the overall decrease in fugitive emissions.

Battery investment is accelerating, however, battery generation still only contributes a minuscule portion of the generation mix with 595 MW of new capacity added in 2020

While a critical part of the energy mix, battery generation still has a lot of growth potential in Australia.

Through funding mechanisms and reforms, the Australian Government is enabling new generation capacity and storage to meet short term needs for reliability and security.

- In May 2021, Australian Government confirmed it will spend up to AUD$600 million to build a new 660 MW gas-fired power station in Kurri Kurri in the Hunter region of NSW. The plant is scheduled to come online in the summer of 2023-24 to replace the coal-fired Liddell power plant that will close in 2023.
- In June 2021, Queensland Government-owned energy company "Stanwell" announced its plans to install a 300 MWh battery plant in Queensland.
- In May 2021, the New South Wales Government entered into a services agreement to underpin development of a 100 MW battery in the southwest of the State. The agreement forms part of a long-term retail contract with Shell Energy to provide electricity for government-run facilities.
- In November 2020, the Victorian Government secured the plan for Victorian Big Battery. The 300 MW battery will be installed near the Moorabool Terminal Station, just outside Geelong, and will be ready by summer 2021-22.
- In 2020, ARENA partially funded a trial led by Tesla, to deploy 3,000 household solar and battery storage systems on Housing SA-owned residential properties.

  This is part of a larger project to connect 50,000 solar and battery systems across South Australia to form the world's largest VPP.
- In 2020, AEMO on behalf of the Victorian Government, procured 250 MW from Neoen's 300 MW battery to increase the capacity of the VIC-NSW Interconnector. That is to service unexpected network outages in Victoria from November 2021.

According to the Clean Energy Council's 2021 Clean Energy Australia Report, 16 large-scale batteries were under construction at the end of 2020, representing more than 595 MW of new capacity.

- Several notable utility-scale battery projects were announced in 2020, including the NSW Government committing to build four new large-scale batteries under its Emerging Renewables program.
- AGL plans to build several big batteries on the sites of its existing fossil fuel power station assets.
- The Western Australian Government is tendering for a 100 MW battery, the first to be built on the State's main grid.
- In South Australia, 7,152 new household batteries were installed in 2020, the most in Australia. That was due to strong uptake of the SA Government's Home Battery Scheme.

- In New South Wales, 6,264 new household batteries were installed following the NSW Government's Empowering Homes battery loan program.

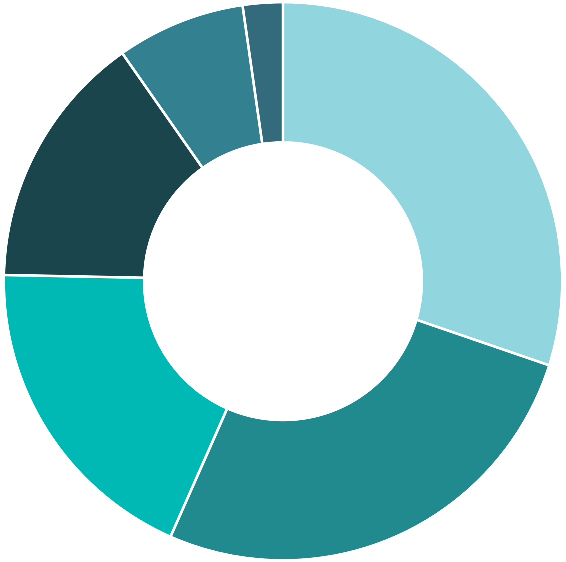
Hydro storage:

- Battery of the Nation is a Hydro Tasmania project. It proposes to draw upon more than 2,500 MW of new pumped hydro as energy storage for the NEM. In December 2020, Hydro Tasmania selected Lake Cethana from its three shortlisted pumped hydro sites to progress to final feasibility. The other sites were Lake Rowallan and Lake Tribute.

- The Snowy Mountains Scheme is a hydroelectricity and irrigation complex in southeast Australia. It was constructed in 1974. Snowy 2.0 is an expansion of the Snowy Mountains Hydroelectric Scheme that will increase the capacity of the system by almost 50%. The existing 4,100 MW of fast-start dispatchable generation capacity will be expanded to 6,100 MW. The scheme is expected to be progressively commissioned from 2025.

FIGURE 10

Number Of Small Behind-the-meter Battery Systems Installed In 2020



State	Systems	Capacity (MWh)
SA	7,152	71.5
NSW	6,264	62.6
VIC	4,476	44.7
QLD	3,576	35.8
WA	1,788	17.9
TAS	540.0	5.4
TOTAL	23796.0	237.9

Source: Clean Energy Australia Report 2021
Link: https://assets.cleanenergycouncil.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2021.pdf

Australia commits ~AUD$45 million to boost gas supply and mitigate domestic shortfall

The Australian Government is focused on ensuring there is no domestic gas shortfall.

- **Wholesale gas markets:** The AEMC makes National Gas Rules which apply to three types of wholesale gas markets: gas supply hubs (located in Wallumbilla, Queensland and Moomba, South Australia); short term trading market hubs (in Brisbane, Sydney and Adelaide); and the declared wholesale gas market in Victoria.

- **East coast gas market:** An interconnected gas grid connects Australia's eastern, northern and southern states and territories. This market has undergone structural change as the Queensland gas export industry developed. The Australian Government is undertaking a range of reforms to improve the functioning of the market and to implement measures to deliver affordable and reliable gas.

- **National Gas Infrastructure Plan:** The interim report released by the Government on 7 May 2021, identifies the priority infrastructure developments necessary to alleviate forecast near-term southern gas supply shortfalls.

- **Australia's Gas-Fired Recovery Plan:** On 15 September 2020, the Government announced funding of AUD$52.9 to implement the Gas-Fired Recovery Plan. It is designed to ensure the Australian gas market is working to benefit all Australians. It addresses energy affordability as part of the Government's JobMaker Plan.

- **Energy National Cabinet Reform Committee:** The Government is working to consider new measures that will require greater transparency across the gas market, including from gas producers and LNG exporters on prices, reserves and resources. The purpose is to ensure the gas market operates with accountability and transparency.

- **Gas Supply Outlook 2022:** The outlook for 2022 is finely balanced. A shortfall of 2 PJ could arise across the entire east coast gas market next year, driven by a shortfall of up to 6 PJ in the southern states, if LNG producers export all of their surplus gas.

- **Australian East Coast Domestic Gas Supply Commitment:** On 21 January 2021, the Australian Government announced a Heads of Agreement with East Coast Liquefied Natural Gas (LNG) Exporters. Under that, LNG exporters must offer uncontracted gas to the domestic market on internationally competitive terms before it is exported. They must also provide relevant material to the ACCC to demonstrate compliance.

In May 2021, in its 2021-22 budget, the Australian Government made a commitment of AUD$58.6 million to boost gas supply, storage and pipeline capacity. This was made up of:

- Up to AUD$38.7 million to support critical gas infrastructure projects to alleviate forecast gas supply shortfalls.

- AUD$5.6 million to further strengthen the Government's gas system planning framework through delivery of the National Gas Infrastructure Plan.

- AUD$6.2 million to design, consult and implement reforms to accelerate the development of the Wallumbilla Gas Supply Hub.

- AUD$4.6 million to develop initiatives that empower gas reliant businesses to negotiate competitive outcomes in their gas supply agreements.

- AUD$3.5 million to design and implement a framework to facilitate Commonwealth support for medium to long-term gas infrastructure to secure Australia's future gas supply.

This spending fits with the Government's push for a gas-fired economic recovery from the COVID-19 pandemic. It aims to boost gas supply, drive down prices for manufacturers, and avert a looming shortfall in the country's southern states.

- The funding is designed to help the projects reach final investment decisions quicker, so they can be built in time to address potential gas shortages.
- The Minister for Energy and Emissions Reduction, Angus Taylor said, "the Budget is supporting the Government's responsible and pragmatic approach to energy policy and emissions reduction, setting Australia up for a prosperous future as the economy continues rebuilding from the COVID-19 pandemic."
- These investments are anticipated to create more jobs across the country, grow the economy, and ensure Australia continues to meet and exceed its emissions reduction target.

"The precarious supply situation for next year highlights the importance of the new Heads of Agreement that the Australian Government signed with LNG exporters in January 2021"

-Rod Sims, ACCC Chair

2020–21 gas prices fell in all regions compared to the previous financial year except in Queensland. There were low prices across all markets through mid-2020.

- Gas production was at near record levels (5,478 TJ/day) in Q2, driving record levels of spot trade (28.6 PJ). Spot prices declined 7%, AUD$5.60-AUD$6.54/GJ, across markets.

The east coast region witnessed an increase in gas demand and the region's gas production increased by 17.2 PJ compared to Q2 2020

In 2020, gas demand declined in response to COVID-19, and then gas demand rebounded strongly in Q2 2021.

- International gas markets were particularly impacted by COVID-19 in Q2 2020. That led to lower gas prices and lower LNG exports. While gas powered-generation demand only slightly increased (+2 PJ), there were significant increases in late May and June due to Callide and Yallourn outages.
- Total east coast gas demand in Q2 2021 increased by 4% compared to Q2 2020. That was mostly due to increased Queensland liquefied natural gas (LNG) demand.
- The large increase in Queensland LNG exports continued recent trends, influenced by strong Asian LNG demand and high prices. Despite a 21 PJ decrease from Q1 2021, Q2 2021 delivered the fourth highest quarter, and the highest Q2 export quantity on record.
- Compared to Q2 2020, Australia Pacific LNG (APLNG) recorded the largest increase of 20.3 PJ. Gladstone Liquefied Natural Gas (GLNG) increased by 6.2 PJ, and Queensland Curtis LNG (QCLNG) decreased by 7.3 PJ.
- On 25 May 2021, QCLNG experienced an unplanned production interruption related to the Callide incident. Its production decreased from 1,706 TJ to 1,076 TJ, and Curtis Island flows decreased from 1,368 TJ to 919 TJ. APLNG and GLNG production was also affected but to a lesser extent. While production dropped, flows to Curtis Island also decreased, and no additional gas volumes flowed into the domestic market.
- As reported by AEMO, in line with increased gas demand, east coast gas production increased by 17.2 PJ compared to Q2 2020.

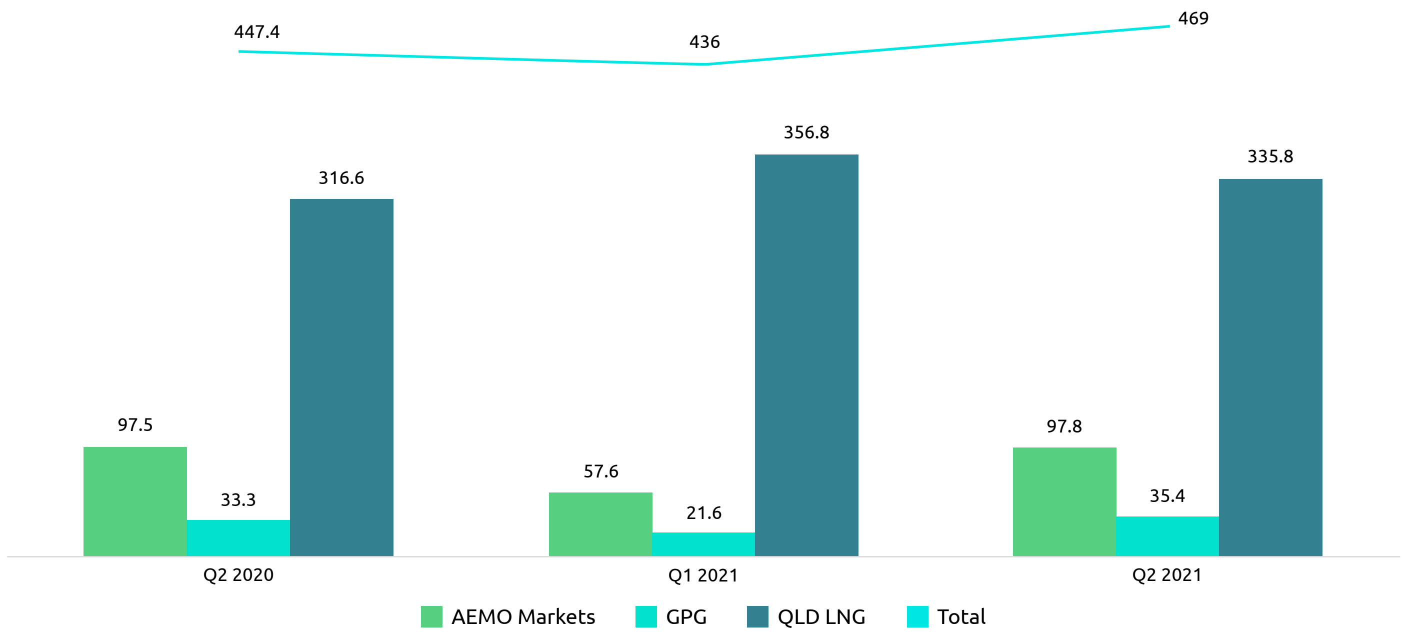
- According to the AER's State of the Energy Market 2021 Report, in 2020, eastern Australia produced almost 2,000 PJ of gas. The majority (68%) was exported as LNG, supplied predominantly by Queensland's Surat–Bowen Basin (76%), and the remainder was sold to the domestic market.
- The Gippsland Basin is the most significant of the 3 producing basins in Victoria, meeting 13% of demand in 2020.
- The Cooper Basin in central Australia accounted for 5% of eastern Australian gas production in 2020.

Storage facilities are becoming more important to manage supply and demand

- AER reported that average storage levels in 2020 were higher than in 2019. That was despite slight depletion in late 2020 due to record LNG export demand.
  - Since LNG operations commenced, effective storage has been important in managing supply and demand. Storage levels at the Roma underground, Moomba, and Silver Springs facilities have been consistently drawn down to meet LNG export demands.
- According to AEMO, during Q2 2021, there was rapid emptying of Iona UGS facility. That facility finished the quarter with a gas balance of 14.3 PJ, 3.6 PJ lower than at the end of Q2 2020.

FIGURE 11

Gas demand – Quarterly comparison (PJ)



AEMO Markets demand is the sum of customer demand in each of the Short Term Trading Markets (STTMs) and the Declared Wholesale Gas Markey (DWGM) and excludes GPG in these markets.;
GPG – Gas powered generation
Source: https://aemo.com.au/-/media/files/major-publications/qed/2021/q2-report.pdf?la=en

LNG exports earnings are stable. Earnings were 2.2% lower QoQ in Q1 2021, and are expected to rebound in 2021-22.

In Q1 2021, Australia's LNG exports totaled 20.1 million tonnes, 2.2% lower quarter-on-quarter, and 0.1% lower year-on-year.

- Production at Chevron's Gorgon project has been limited since May 2020. Technical issues were detected in the heat exchanger of Train 2. Due to some phased shutdowns, Gorgon has been operating well below its nameplate capacity of 15 mtpa since May 2020.
- Prelude FLNG has also experienced significant production disruptions. It was offline between February 2020 and January 2021. Although production has increased in subsequent months, Prelude FLNG is yet to produce at its full nameplate capacity of 3.6 million tonnes after it shipped its first cargo in June 2019.
- In January 2021, Santos announced an FID for an infill drilling program in the Bayu-Undan field. Its first production is expected in the 2021 September quarter.

In 2020–21, Australian LNG export volumes are estimated to fall marginally to 79 million tonnes, reflecting the technical issues at the Gorgon and Prelude LNG plants.

For 2020–21, Australian LNG exports are estimated at AUD$32 billion, down 32% from 2019–20.

In the 2021 March quarter, Australia's LNG export earnings increased to AUD$8.3 billion, up 12% quarter-on-quarter. Despite this strong gain, export earnings remained 35% lower year-on-year, as relatively low oil-linked contract prices affected export earnings.

It is forecast that Australia's LNG export earnings will rebound strongly in 2021–22 as prices recover.

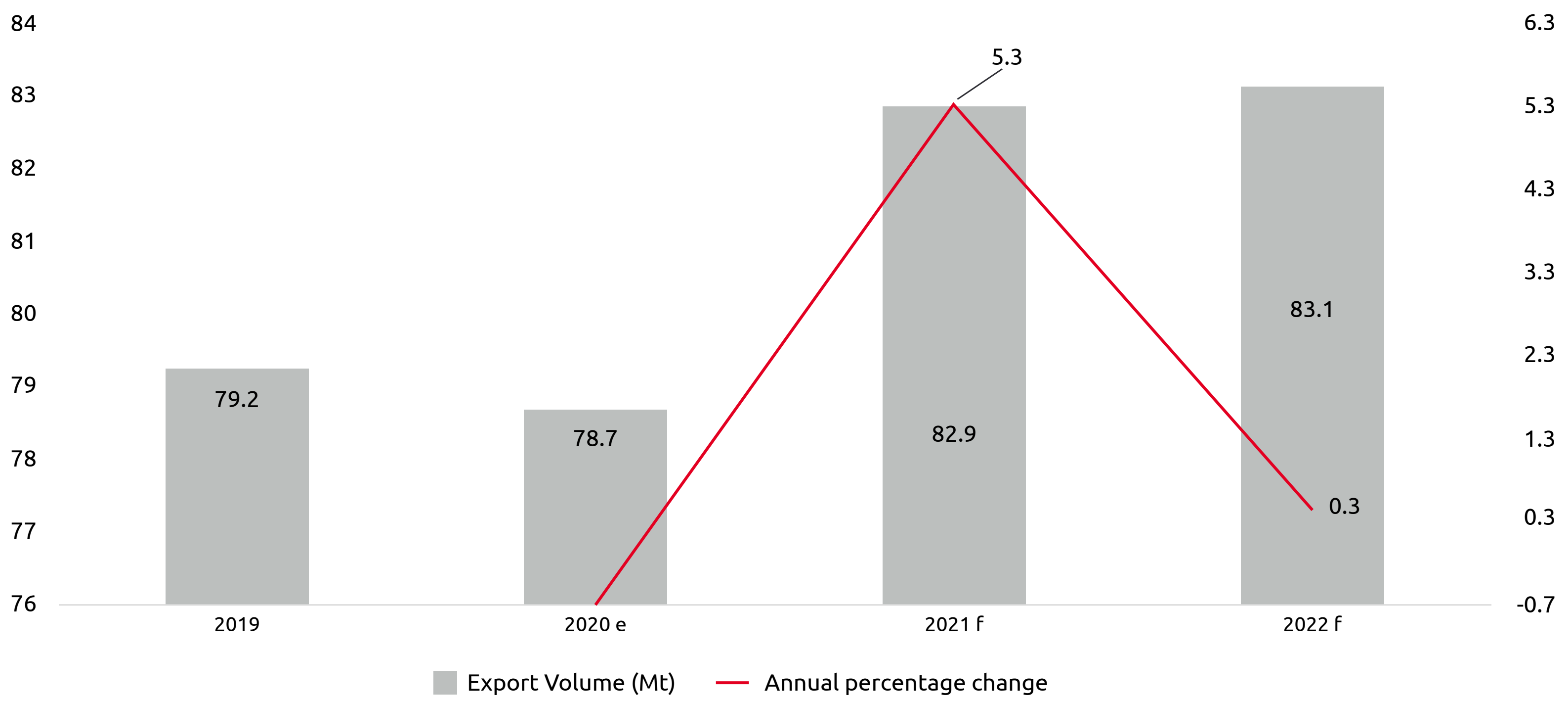
Australian export volumes are forecast to increase by 5.3% to 83 million tonnes in 2021–22, as technical issues are resolved at the Prelude and Gorgon LNG plants.

Export volumes are forecast as relatively flat in 2022–23.

LNG exports earnings are forecast to increase from an estimated AUD$32 billion in 2020–21, to AUD$49 billion in 2021–22, as oil-linked contract prices rise sharply.

FIGURE 12

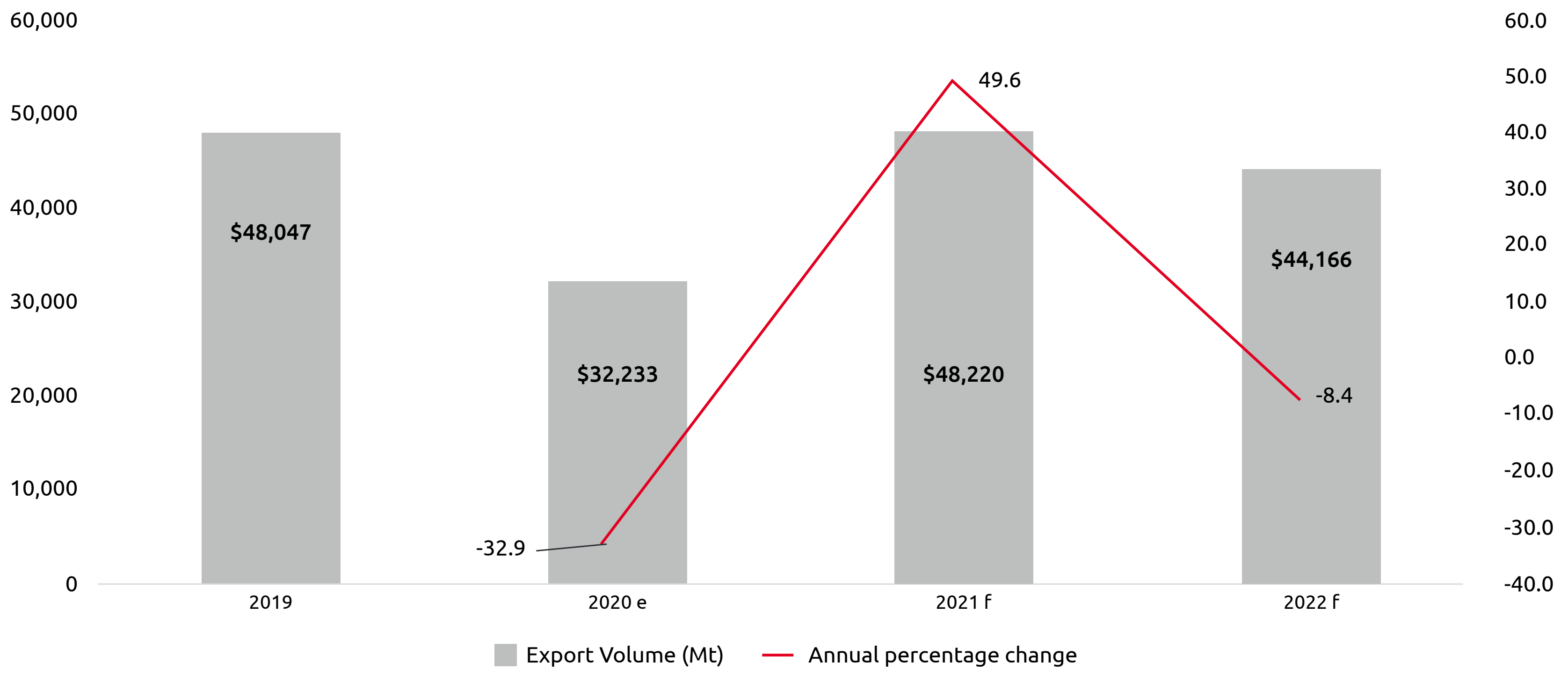
LNG Exports Volume in Mt (2019 – 2022)



Australia Government – Department of Industry< Science energy & Resources - Resources and Energy Quarterly – June 2021
1 million tonnes of LNG is equivalent to approximately 1.36 billion cubic meters of gas.
Source: https://publications.industry.gov.au/publications/resourcesandenergyquarterlyjune2021/index.html

FIGURE 13

LNG exports in A$m (2019 – 2022)



Australia Government – Department of Industry< Science energy & Resources - Resources and Energy Quarterly – June 2021
1 million tonnes of LNG is equivalent to approximately 1.36 billion cubic meters of gas.
Source: https://publications.industry.gov.au/publications/resourcesandenergyquarterlyjune2021/index.html

Australia aims to be the world's cheapest producer of clean hydrogen

Hydrogen is a key priority for Australia under the Government's Technology Investment Roadmap. The Australian Government plans to support its clean hydrogen aspirations through a certification scheme. Japanese investment is also a factor in ramping up focus on, and development of, Australia's hydrogen energy infrastructure.

Hydrogen production and Government initiatives

- According to Advisian's report for the Clean Energy Finance Corporation, Australia's current hydrogen production is around 650 ktpa. Virtually all of it is made using Natural Gas Steam Methane Reforming (NG SMR) and it is immediately consumed by the associated ammonia synthesis (~65%) and crude oil refining (~35%) process.
- Australian Gas Infrastructure Group's Hydrogen Park South Australia (HyP SA) project is currently producing 480 kg of renewable hydrogen per day using a 1.25 MW electrolyser. It is the largest in Australia.
- The hydrogen industry received significant new government and private investment in 2020. That included AUD$70 million from ARENA's Renewable Hydrogen Deployment Funding Round, and AUD$22 million committed to the sector by the Western Australian Government.

Australia is aiming to produce cheap, clean hydrogen with the help of a Guarantee of Origin (GO) certification scheme

- In June 2021, the Morrison Government released for consultation, a discussion paper on the design of an Australian hydrogen GO certification scheme. The scheme will enable a transparent, consistent and accurate approach to track the key attributes associated with hydrogen production, and in particular, its carbon footprint. It is a priority under Australia's National Hydrogen Strategy and will transform the industry.

International partnerships and programs

- The Government has partnered with Germany, Singapore and Japan to accelerate the development of low emissions technologies, including hydrogen, to drive investment and job creation in Australia.

Major investments aligned with Australia's and Japan's commitments to green hydrogen

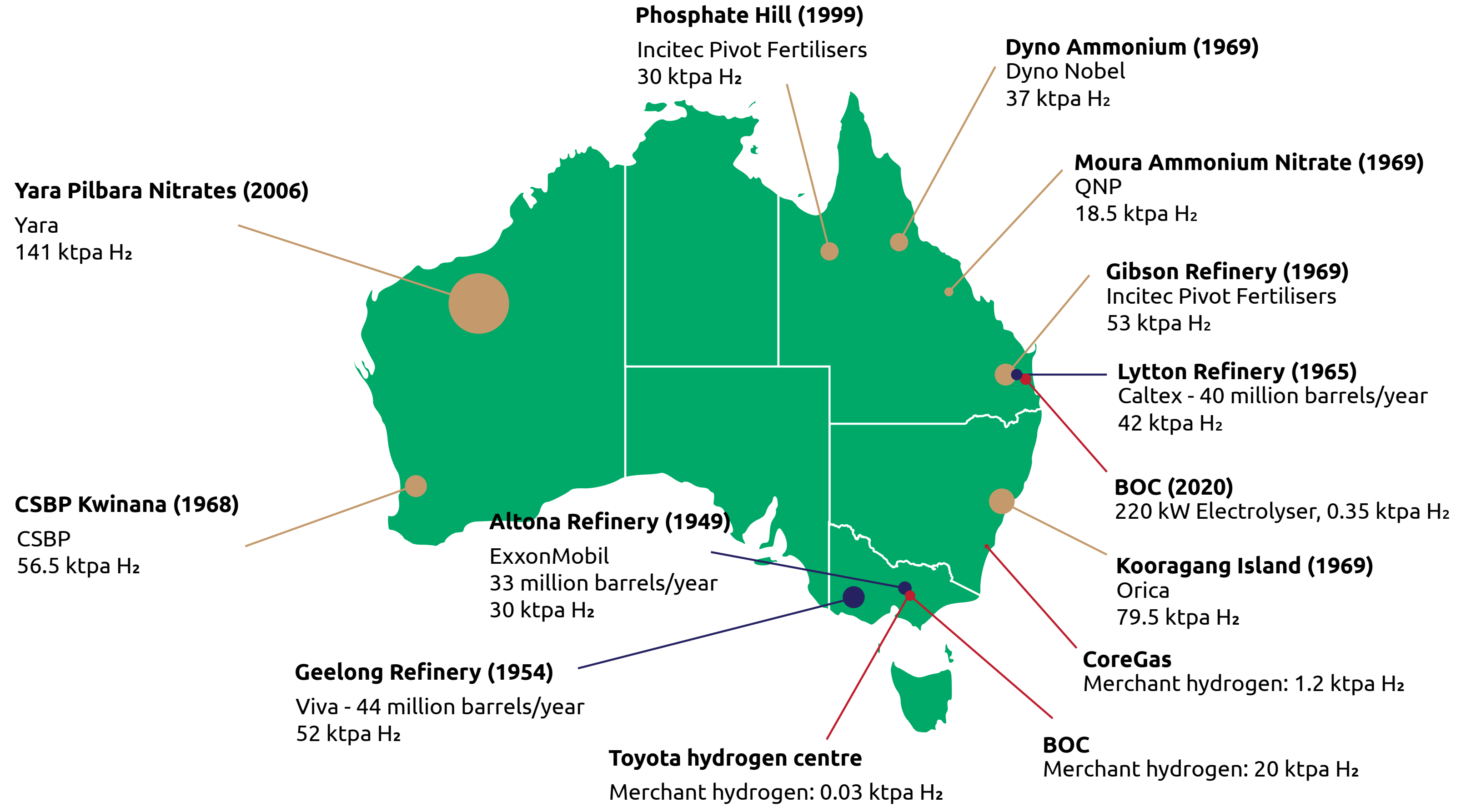
- In November 2020, Mitsubishi Heavy Industries, Ltd (MHI) announced a capital investment in Hydrogen Utility (H2U). It is the leading Australian developer of green hydrogen and green ammonia projects using power derived from renewable energy sources. In June 2021, MHI signed a new partnership with H2U that seeks to harness the world's best solar and wind resources to produce, and eventually, export unprecedented volumes of clean, zero-emission fuel.
- Kawasaki Heavy Industries has teamed up with Australia's Origin Energy on a 300 MW electrolyser in Townsville, far north Queensland.
- Also in Queensland, Japan's largest hydrogen supplier Iwatani Corporation has formed a consortium with Queensland Government-owned Stanwell Corporation and now APA Group through additional ARENA and Japanese Ministry of Economy, Trade and Industry (METI) funding. The consortium will establish Queensland's largest green hydrogen project and progress a new renewable hydrogen export facility in Gladstone. The project is expected to scale up to over 3,000 MW of electrolysis capacity by the early 2030s.
- In South Australia, Mitsubishi Heavy Industries (MHI) announced it would invest in the developer of the AUD$250 million Eyre Peninsula Gateway Project, set to be Australia's largest green electrolyser project.

"While gas will continue to play a critical part in our energy mix, APA also understands that there are opportunities in supporting the development of technologies that can support Australia's transition to a low carbon economy,"

-Hannah McCaughey,
EGM Technology & Transformation,
APA Group

FIGURE 14

Existing hydrogen production/use centers



Key Points: Energy reliability improved in 2020, but unreliable fossil fuel generators, and the lack of a unified, central plan for generation and grid transition continues to present significant challenges

To make way for Australia's renewable energy future, fundamental changes are required in the way the grid is planned, designed, built and operated.

- As the grid becomes more distributed and flexible, synchronous machines will become increasingly difficult to accommodate. Some progress has been made by individual utility organisations and through initiatives such as the ISP. However, investment must remain a priority.
- The rising growth of rooftop solar resulted in record low demand for grid power in several states in 2020. While this is a positive development for emissions reduction and electricity prices, it also makes it increasingly difficult to maintain the reliability of the electricity system. As a result, state and territory governments began exploring new ways of soaking up excess supply in 2020.

Planning and synchronisation of grid transformation and the power generation mix is a key strategic priority for government and market participants.

- The electricity grid requires controls to keep frequency and voltage within safe limits. Historically, that was managed by coal, gas and hydro power stations. Now batteries and renewable energy could by used to keep the grid secure. However, increasingly distributed energy resources make control of the grid a far more complex activity.
- The NEM will need to continue to adapt to mitigate risks of reliability, security and affordability, and particularly those caused by sudden, unexpected exits of thermal (coal) generators.

New renewable generation has eased supply shortfalls and contributed to reduced prices

- Energy demand is expected to continue to increase in Australia to 2025. Continued acceleration of renewable energy investments and adoption will continue downward pressure on energy prices.
- Disruptive drivers impacting energy including electrification, net-zero strategies of key industry participants, and electric vehicles are just beginning to contribute to changes in energy demand and demand profile. Overall, these are expected to continue upward pressure on energy demand.

Gas will continue to play its important transitional role within the domestic and export markets as new technology including Green Hydrogen develops

- The Australian Government has established a Gas-Fired Recovery Plan to ensure stability of LNG supply and pricing. Gas remains an important transition fuel over the coming years.
- Green Hydrogen will play and increasingly important role not just in the generation mix, but also in energy exports, and Australian innovation.

"Regulators have a critical role to play in supporting this transformation. AEMO and COAG must further push for a federal, bi-partisan agreement of a unified plan for energy transition and related policies based on the ISP to avoid further fragmentation and 'island solutions' of individual states and territories."

-Emilie Ditton,
EUC Consulting Lead, Capgemini Invent

- In July 2021, Energy Security Board (ESB) Independent Chair, Dr. Kerry Schott AO provided energy market redesign advice. He explained that timely and interrelated reforms and actions to successfully integrate the transition to renewable generation are already underway. The entry of new generation must coordinate with the exit of ageing coal-fueled generation. Maximizing opportunities and managing the risks associated with this transition will seamlessly deliver affordable, smart, and clean energy for consumers.

- Advice is being prepared to support the critical decisions that are needed for an affordable, reliable and secure electricity system that can ultimately operate at net zero emissions. It covers four market design reform pathways that set out what needs to be achieved in the short term to address more urgent issues, as well as the medium and longer-term directions for evolution of the national electricity market.

- ***Preparing for ageing coal-fueled generation retirement*** by giving incentives for the right mix of resources, weather dependent renewables, and firm and flexible generation. This will restore confidence that energy is available when needed, reducing both the risks of extreme price volatility and the need for expensive government interventions.

- ***Backing up power system security*** by integrating services including inertia, voltage and frequency control into the market, and optimizing their procurement and dispatch, saving money while keeping the lights on.

- ***Unlocking benefits of recent changes including solar PV, batteries, and smart appliances for all energy consumers*** by putting the necessary arrangements in place to make better use of existing rooftop solar and customer batteries. To also open further opportunities for these and other smart appliances so all customers can avoid unnecessary investments.

- ***Opening the grid to cheaper large-scale renewables*** by reducing the costs associated with providing new, geographically dispersed generation to customers.

05 Infrastructure and Adequacy of Supply

05

05 Infrastructure and Adequacy of Supply

Trends in Electrical and Gas Networks

Colette Lewiner
Philippe Vié

Trends in Electrical and Gas Networks

Electricity grids

Investment needs

Networks in developed countries are old — ranging from 30 and 40 years in Europe and 40 and 50 years in the United States and Canada. These networks must be upgraded.

Energy Transition leads to a higher share of electricity in energy use as compared to fossil fuels, such as oil and gas. This means more electricity transiting in local or public grids, which calls for more network reinforcements.

It is also necessary to strengthen the grid robustness in relation to extreme climatic events which could become more frequent due to climate change. This was illustrated in February 2021 during an exceptional cold spell in Texas during which frozen wind turbines could not produce electricity despite very high consumption. Insufficient interconnections with neighbouring states meant that Texas residents had to endure power cuts for several days.

Investments in networks are also linked to the need for interconnection. Very high voltage DC cables under development in Europe are improving security of electricity supply and enabling better utilization of renewable electricity.

China is upgrading its Ultra High Voltage (UHV) electricity grid. In 2020, state-owned power transmission utilities identified many projects for development, which shall employ High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC) technologies. The total size of investments in these UHV projects is estimated to be $26.8 billion.

In addition, China is building and improving grids in along the route of the Belt and Road Initiative. Many of these countries are “low-income” countries; access to electricity will be a considerable improvement in their standard of living.

Investments are also necessary in both distribution networks and transmission networks to connect renewables.

Operators are also investing in networks to increase knowledge about electricity flows, improve their efficiency and better manage their stability—a concept commonly referred to as “smart grids” or “smarter grid”. Operators add connected objects to a certain number of devices—for example, transformers or smart meters (which have been deployed in almost all European countries and largely in the United States). Automation in control rooms and outage detection are also possible with enhanced software.

At the same time, “softer” investments are needed in information systems to improve the processing of large amounts of data and enable analysis using artificial intelligence (AI).

FIGURE 1

AGING GRIDS, TECHNOLOGY ADVANCEMENTS AND ENERGY TRANSITION

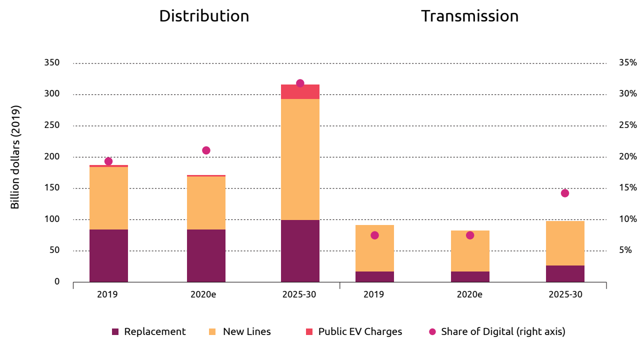
To encourage network operators to develop this type of investment, a revision of the methods for calculating network tariffs is necessary to include these "soft" investments in the "Regulated Asset Base." These soft investments could also reduce line construction, which is always a difficult issue due to local opposition.

The EU commission estimates that between now and 2030, investments in electricity grids will have to double, as compared to the last decade, reaching more than €50 billion per year.

In the US, the Department of Energy announced in June 2021, the availability of up to $8.25 billion in loans for efforts to expand and improve the nation's transmission grid.

FIGURE 2

Annual investment in electricity networks 2019-2030 in the Stated Policies Scenario



Sources: World Energy Outlook, IEA, 2019; World Energy Outlook, IEA, 2020;

The International Energy Agency states that Investment in power grids will grow up to $400 billion each year by 2025[1]:

IEA states also that 30% of this investment will be related to Smart Grid for distribution networks.

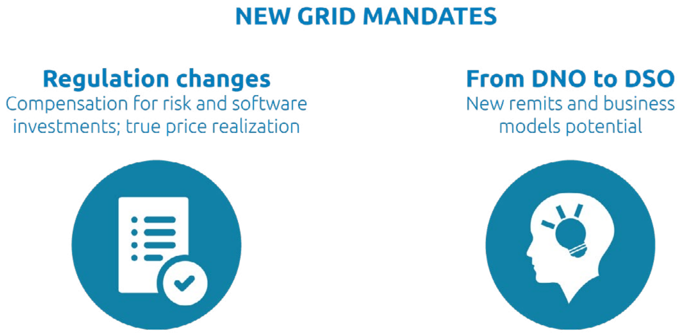
All these investment figures are consistent with the overall Transmission and Distribution announced investments and are contributing to the investment parity in renewables and grid development. Based on this model, every $1 investment in renewables leads to $1 investment in grids.

Investments are also driven by major changes brought by the addition of distributed and intermittent energy sources as well as grid digitization.

Renewables impact grid balancing and therefore security of supply as wind and solar electricity are intermittent and as electricity storage is limited today. When the renewables generation share in the electricity mix becomes significant, it may threaten the stability of the network. This was illustrated by the August 2020 blackout in California as well as in Europe, during the spring 2020 lock-down when the share of renewables in UK surpassed 50% and the dispatcher had to cut schedulable power to avoid blackouts. Multiple resources could be leveraged to manage the required flexibility ensuring the real time load-demand balance.

- **Electricity storage** is mainly provided by pumped hydro at present. However the well-suited sites are now almost all exploited in Europe.
  i. Stationary electric batteries can store a few hours of production. Their cost has dropped dramatically and their performance has increased due to advancements related to electric vehicles (EVs). These batteries are used either in hybrid farms in association with solar or wind generation or on the grid to provide flexibility

FIGURE 3



and ancillary services. Their business model is not yet satisfactory, and it is necessary to stack many usages to make them profitable.

ii. In the medium term, the electrolysis of water to produce hydrogen during periods of electricity surplus and the production of electricity using fuel cells, should make it possible to store large quantities of electricity.

- As the 2020 blackout in California demonstrated, in the absence of massive storage capacity, **it is necessary to maintain schedulable generation** on the power grid.

- Beyond the issues of supply-demand balancing, **the grid design** is impacted by the arrival of solar and wind farms, requiring important development and moving from a one-way to a two-way flow, with Distributed Resources.

On the one hand, these renewables farms must be connected to the grid. This connection can take several years due to local opposition, further delaying the arrival of this carbon-free energy on the grid.
On the other hand, the massive arrival of renewables associated with the closure of large-capacity power plants such as nuclear reactors or coal-fired power stations, is leading to an overhaul of the network. This is the case in Germany where network managers, who must wheel North Sea wind electricity to consumption centres in the southern part of the country, are building very HVDC underground lines. It is technically complex and costly.

- Network balancing must also consider the **new habits of consumers** who are becoming "prosumers." This is characterized by the development of self-consumption or communities almost self-sufficient in electricity. In the latter case, the network has an "insurance" role and the remuneration for its use should take this into account.

- **Demand response.** On one hand, the aim is to give the right economic signals to customers to push them to use electricity when supply of renewable electricity exceeds demand and when prices are low. On the other hand, the objective is to encourage customers to postpone or cancel their demand during peak times. These demand response policies have been implemented for years on both sides of the Atlantic with limited success. Because of increasing renewables connected to the grids, Europe, which seeks to amplify demand response attitudes, adopted a directive on dynamic tariffs in June 2019. It applies from 2021 and onwards. All suppliers with more than 200,000 customers are required to offer this type of tariff which reflects spot market prices, which itself is a good indicator of periods of excess or lack of production. These dynamic tariffs are better suited to businesses than individuals as the latter may have difficulty understanding highly variable electricity bills from month to month.

- Finally, curtailment, which consists of cutting production

  of excess renewables, is possible in some countries. For example, in 2018, the wind power curtailment rate in China reached 7% on a national average. This loss of electricity is a waste of the investments made in wind farms both for the government, which has subsidized them and the end consumers who helped fund them through income taxes and/or electricity prices increase.

Cybersecurity. The growth of the Internet of Things (IoT) and related on network equipment has led to a proliferation of sensitive data that is managed in a decentralized manner. This increases the risk of cyberattacks. Cybersecurity is a crucial component of any grid development (hardware or software) and must be integrated by design.

In April 2021, the US Department of Energy launched an initiative (the 100-day plan) to improve the cybersecurity of Industrial Control Systems for electric utilities and secure the energy supply. This plan was in response to the "Colonial Pipeline" cyberattack and other attacks on sensitive infrastructure. The US President declared a state of emergency and also warned his Russian counterpart that attacks on facilities in 16 sensitive sectors, including energy, were “off limits.”

Gas networks

Investment needs. The challenges for gas networks are different from those for electricity networks. Unlike electricity:

» Gas is easily stored; gas networks therefore do not have the same balancing problems as electricity networks.

» While electricity generation is local, gas must be transported from the gas fields to the point of consumption. This transport takes place either in liquid form (LNG is transported by ship) or in gaseous form by gas pipelines.

LNG represents a growing but limited share of global gas exchanges market representing around 12%.

The transport pipelines are often very long. For example, “Power of Siberia” runs 4000 kilometers between Russia and China, costing about €50 billion.

Other pipelines may be controversial for geopolitical reasons. For example, NordStream 2, which is 1200 km long, would supply Russian gas to Germany without going through Ukraine. A political agreement has been reached between Germany and the US in July 2021 about Nordstream 2. The pipeline construction will come to an end and the pipeline will become operational.

Gas networks management

a. **The correlation between electricity and gas networks management.** With growing high intermittency of renewable power generation, there is an increased need for flexibility in the electricity system. In addition to other technologies such as battery storage, natural gas fired power plants can provide such flexibility2. This will require an increasingly flexible management of the gas networks and better cooperation between the managers of these two types of networks. In the middle term future, Power to Gas and Gas to Power could also provide solutions for storing electricity.

b. **Greening of networks.** In some European countries, energy transition plans provide for reductions in gas consumption in the medium term. Gas networks could eventually become stranded assets. Several operators are therefore seeking to “green” their network either by increasing the share of bio methane or by planning to mix hydrogen with natural gas (methane). The permitted hydrogen mixing rate varies depending on the country. For example, it is 6% in France and 10% in Germany. There are plans to reuse old pipelines to transport hydrogen, provided they are hydrogen tight and sufficiently clean. Nevertheless, additional dedicated pipelines will probably need to be built. In Europe, 11 gas Transport System Operators (TSOs) are planning to have 22900 kilometers of pipeline for hydrogen (or converted gas pipelines or new ones).

c. **Hydrogen Generation impact on electricity grids** will depend on electricity feed system and will follow one of two main options:

i. *Small electrolysers collocated with renewables. In this case there is a need to store hydrogen and then transport it by pipelines. Investment in dedicated pipelines will be necessary.*

ii. *Locate electrolyser’s near usages (steel plants or refineries) and use green electricity to feed them, notably with excess renewable generation. In this scenario, new electricity grid investments will be needed.*

Conclusion:

Networks are impacted by the transformation of the economy towards sustainability.

Electricity is the preferred vector for the energy transition and its consumption growth over the coming years is expected to surpass that of energy.

Significant investments in power lines are needed to improve the robustness of networks and ensure the transit of increasing amounts of electricity. In addition to line construction, system operators must increase soft (digital) investments. Indeed, thanks to artificial intelligence, it will be possible to improve the grid balance and sometimes even avoid planning new lines with long construction times.

In Europe, gas networks are not likely to develop. To match its "Green deal" objectives, the European Commission proposed to end its funding for natural gas (and oil) pipelines and instead funnel cash into electricity and low-carbon energy networks to meet climate goals.

Indeed, strengthening and increasing the performance of electricity grids is crucial for the success of energy transition. Electricity grids are the backbone of energy transition.

06 Retail Markets

06

06 Retail Markets

06 Retail Markets

Europe Retail

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Introduction: Europe

One of the biggest challenges in the European retail energy market is ever-decreasing commodity prices and margins:

- The issue of decreasing margins will not change in the future due to the growing number of competitors, which puts enormous pressure on the energy industry and its players.
- Also, markets which are not deregulated today are opening up increasingly and open the doors for (more) competition. Thus, cost competitiveness becomes an ever-growing topic in those increasingly competitive markets.
- Rising pressure is also seen in the development of current electricity and gas prices.

Data from the current residential energy market supports these trends and offers proof of a highly volatile development across all EU27 countries (see p.4; figure 1.1, 1.2).

Residential electricity prices across the EU27 show a high volatility – the prices vary around a value of +/- 155 €/MWh.

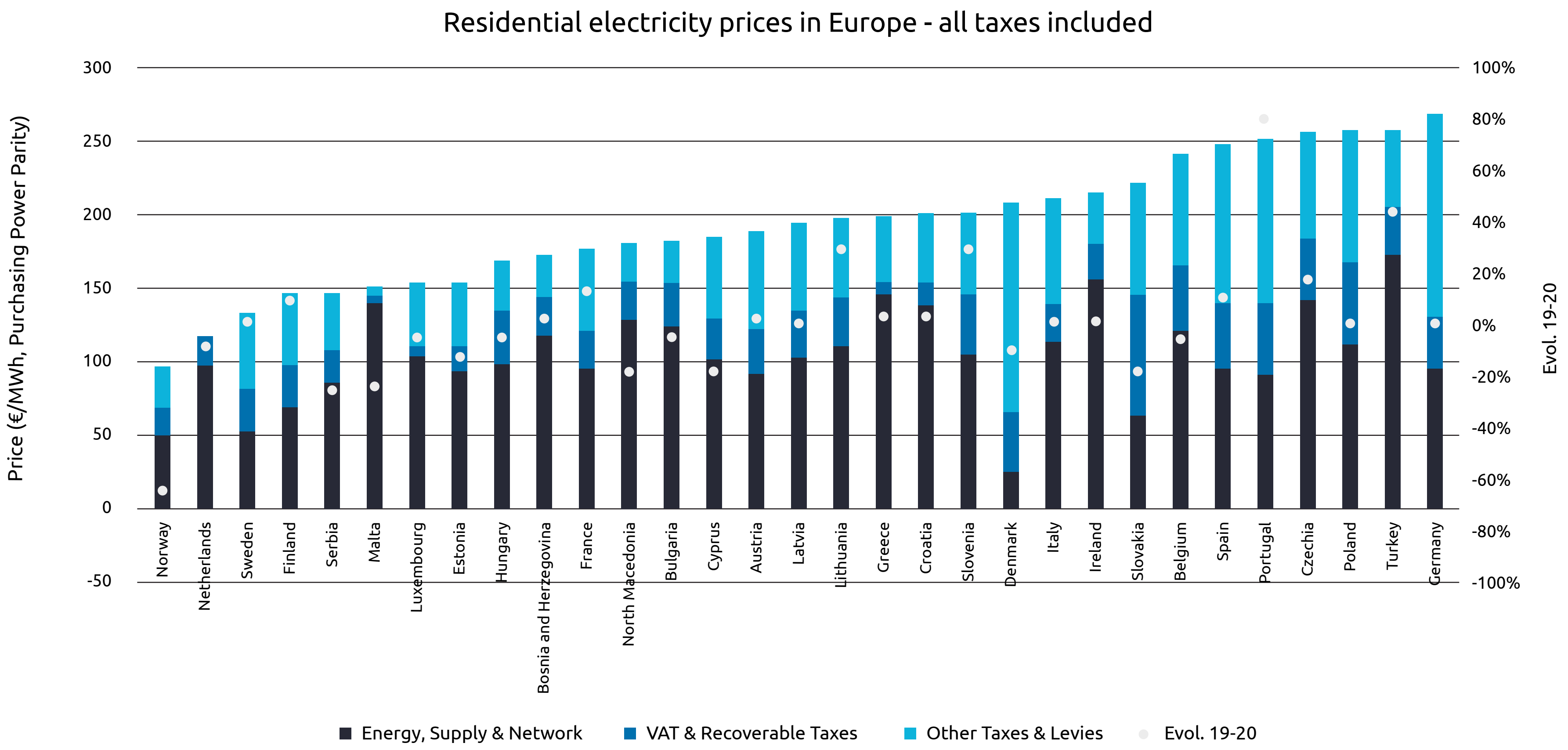
Same applies for the residential gas prices – the prices vary around a value of +/- 62 €/MWh

Annual price increase for residential energy prices in most EU countries in 2020

- Residential electricity prices across the EU27 show high volatility, where prices vary around a value of +/- €155/MWh. Same applies for the residential gas prices; prices vary around a value of +/- €62/MWh.
- In 12 out of 27 countries, residential electricity prices rose between 2019 and 2020. For seven of these countries the increase was more than 10% including France (11%), Czech Republic (14%), Slovenia (28%) and Portugal (83%). There has been an increase in residential gas prices in four of the 28 countries with the average increase reaching just over 7% between 2019 and 2020.
- There is also great disparity across EU countries with regard to residential electricity prices. Prices in Germany (€271/MWh), Turkey (€260/MWh), and Poland (€257/MWh) are more than double the residential electricity prices in Netherlands (€116/MWh), Sweden (€134/MWh), Finland (€141/MWh), and Serbia (€141/MWh).
- There is also great disparity across EU countries as it relates to residential gas prices. Rates in Spain (€96/MWh), Portugal (€93/MWh), Italy (€90/MWh), and Netherlands (€86/MWh) are more than double the residential gas prices in Latvia (€38/MWh), Lithuania (€44/MWh), and Belgium (€44/MWh).

FIGURE 1

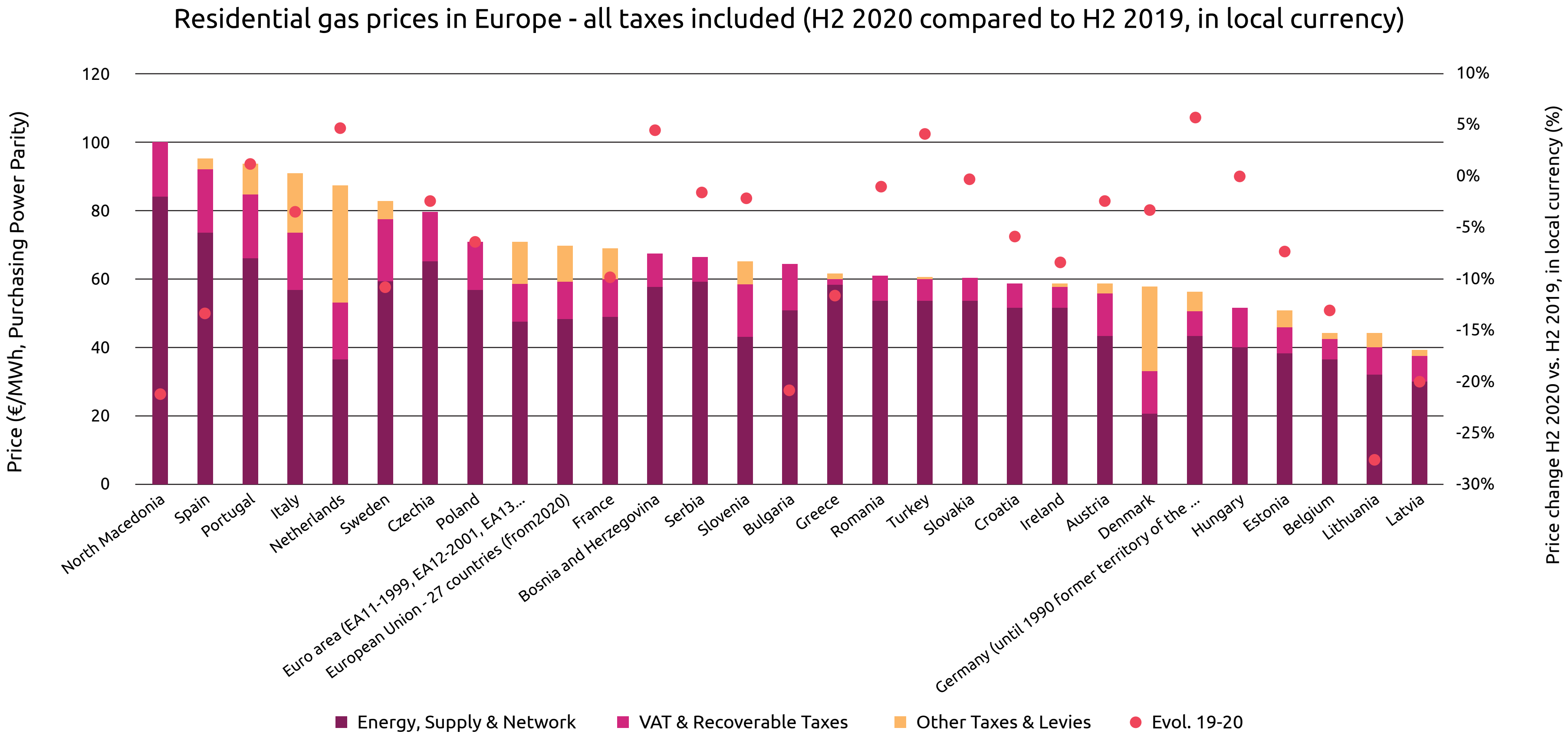
Residential electricity prices in Europe - all taxes included (H2 2020 compared to H2 2019, in local currency)



Sources: Eurostat 2021

FIGURE 2

Residential gas prices in Europe - all taxes included (H2 2020 compared to H2 2019, in local currency)



Sources: Eurostat 2021

Overall comparison of residential energy costs in the EU

- The average consumer in major European cities is paying an annual energy bill of **€1444**, or **7%** of their disposable income. The **downward pressure on prices** due to competition, has meant that Europe can invest in its clean energy future.

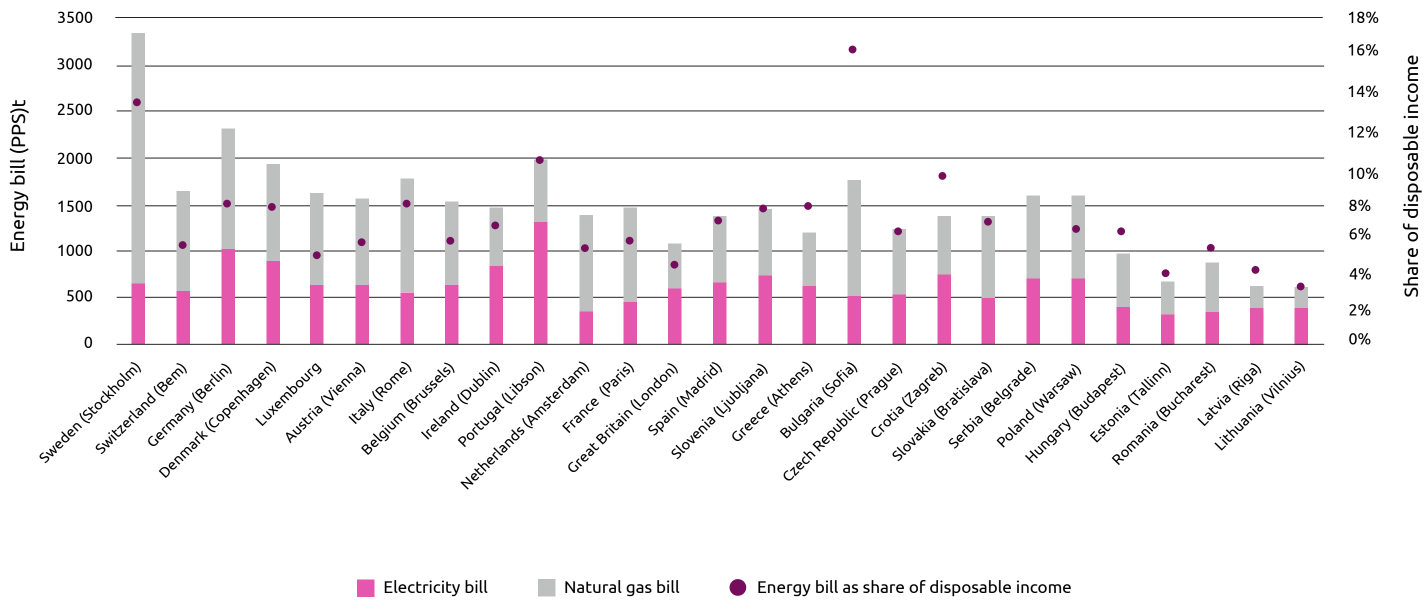
- As a percentage of household income, residential energy costs (across both electricity and gas) **vary throughout the region**. This is based on average typical consumption across major cities [in PPS (purchasing power standard)]. In countries where competition is higher, consumers are **paying a smaller share** of their disposable income. This is seen in the **U.K. (4%) and the Netherlands (5%)**. In countries where competition is lower, consumers are **paying more** as a percentage of their disposable income, as is the case in **Portugal (10%), Greece (8%), and Spain (7%)**. The highest as a percentage of disposable income is paid in **Bulgaria at 16%**. These levels could be seen as unsustainable.

- There are four countries were the annual bill for the **average domestic consumer (PPS) is more than €2000**: Sweden (€3332); Germany (€2314); Portugal (€1980); and Denmark (€1927).

- High competition has put **downward pressure on prices**, enabling European countries to **invest in their clean energy future** (with government levies imposed on energy costs in order to fund this investment). Europe is exploiting the **benefit of high competition**, as these countries are now able to **invest in the transformation** of the sector to create a cleaner energy future.

FIGURE 3

Typical European household energy bill and its share of disposable income (2020)



Sources: VaasaETT

Deep Dive: European energy market

- How electricity and gas prices in the B2C market have developed, as well as which challenges and solutions are relevant will be addressed in this retail markets section.
- Some players in the European retail market are facing the challenges described in the following sub-sections.
- One important factor for market success is addressing the right customers with new and innovative products. This requires digital empowerment to energy retailers as the business evolves from simply selling commodities to offering comprehensive solutions to customers. Digital empowerment is also driving a shift in cost-to-acquire (CTA) and cost to serve (CTS) as seen in Germany (see sub section 1).
- Several countries in the EU, such as Italy, are going through a liberalization process of their energy markets. Even though the energy market in Italy has officially been liberalized in 2007, it is still ongoing in different customer groups. With the end of the protected market for small enterprises and micro-companies, a first critical milestone has been reached. The price protection for domestic users has been set for the January 1, 2023 (see sub section 2).
- Utility retailers are experiencing increasing pressure to transform. Across Europe, these companies have taken up the challenge. In the wake of this change, utility retailers are changing their core technology platforms, including their billing and customer relationship management systems (CRM).
- For example, in the UK, Centrica has been migrating its retail business through their new company, British Gas Evolve, onto a cloud platform (see sub section 3).
- To support the U.K.'s Net Zero target, the energy sector will need to undergo significant structural changes, as will the businesses that operate within it. In order to enable this transition, energy suppliers will need to consider how they respond to technological advancement and the changing consumer landscape (see sub section 4).
- Focusing on the B2B market: The margin level in the commodity distribution of electricity and gas is even lower and more contested compared to the B2C market. In addition, the risks in the portfolio are significantly higher than in the mass market. Companies need to work on the top line, the CTA and the CTS at the same time in order to keep their B2B business (see sub section 5).

FIGURE 4

Overview of retail markets sub sections

1. B2C – Customer centricity & digital enablement in the European Market
2. B2C – Ongoing liberalization process + sustainability and its added value
3. B2C – Transforming Retailers from their core: Customer Relationship Mgmt.
4. B2C – UK's future net zero energy retail market
5. B2B – Platform business replaces commodity-based business

1 – Make it personal

Addressing the right customer with the right product

- Companies that are leaders in customer engagement (like Amazon, Uber, and Airbnb) are setting the bar for digital customer experiences. End users are shaped by customer interactions from other branches like retail, travel, and media, and they demand the same high User Experience (UX) in all their digital engagement. They want personal services, convenience, and unlimited access, anytime and anywhere. Incumbent utilities have to meet these increasing customer expectations in order to assert themselves in the highly competitive energy market. Otherwise, energy providers will be pushed to the infrastructure level by digital players.

- Utilities need to shift their business models due to the following reasons: energy markets in Europe are not liberalizing; there is increased competition from both within the sector and from new players; and the falling margins in commodity and technology prices has led to cost pressure.

- One way to do so is to implement a multi-modular product ecosystem by extending the portfolio with both energy-related and non-energy products or services. Utilities can start to sell smart home appliances (for security monitoring, lighting and temperature control, and connected white goods), thereby entering the telecommunications market, which would require investments in the infrastructures for fiberglass and internet, as well as fixed or mobile network offers.

- Hence, with this strategy utilities capitalize profits by adding products and services to existing contracts and creating a genuine added value for their customers. In the long-term, the so-called "lock-in effect" would take effect: customer relationships would remain steady and the churn rate would be reduced through raised customer loyalty. This change from an energy supplier to a long-term provider of energy services and solutions would result in real differentiation from competitors.

How to address the issue

1.1 Addressing the right customer with the right products

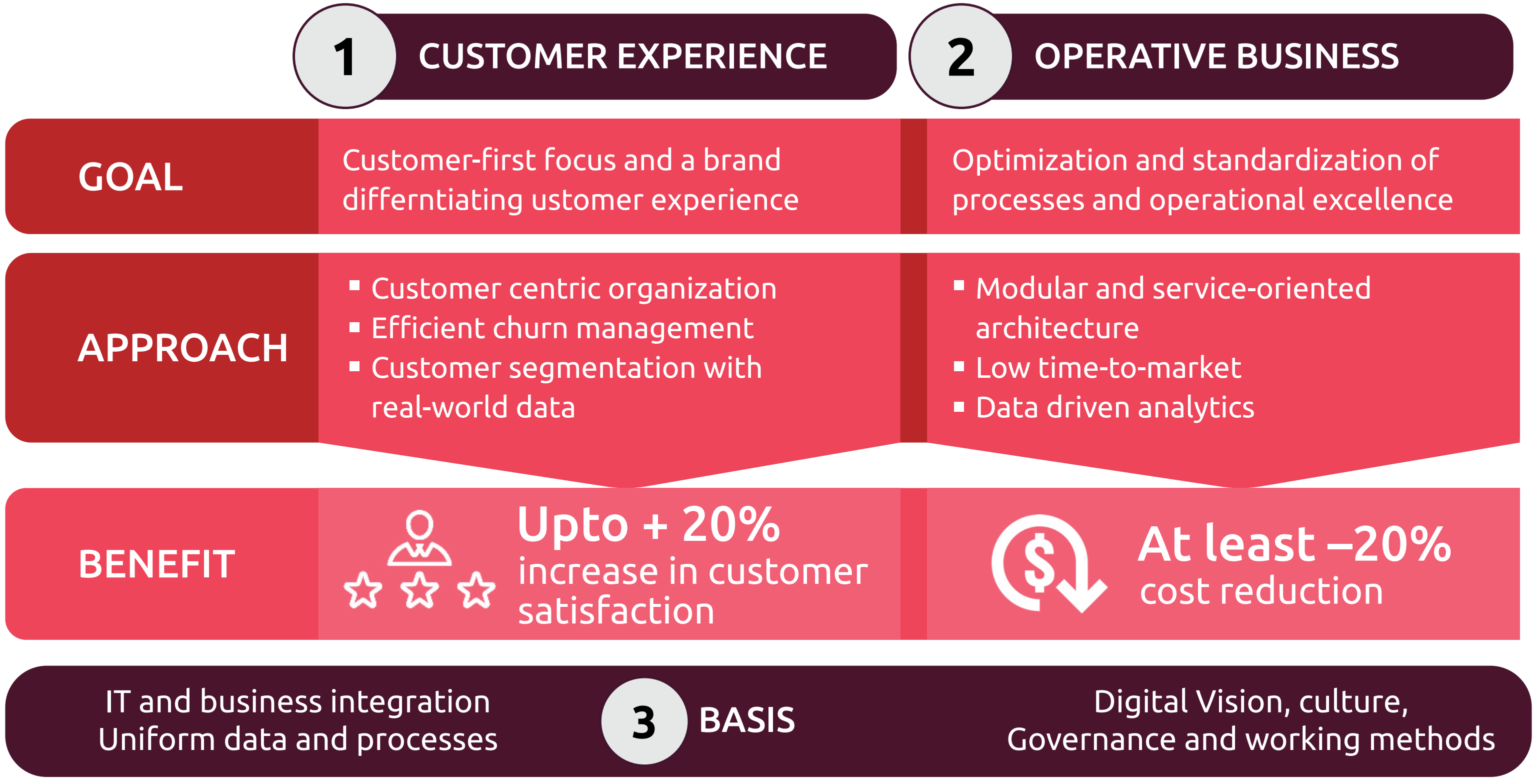
In order to make products and services more attractive to customers, personalization is crucial – not just general customer segmentation into broad groups, but a more delicate differentiation based on deep insights about the wants, needs, and behaviors of individual customers. Micro-segmentation targets each specific customer and enables utilities to offer tailor-made products and services to "a segment of one."

1.2 Digital empowerment

For digital fulfillment of a multi-modular product ecosystem and amazing end-to-end customer experience at low cost to serve, a performant IT-system is needed. After the announcement of the discontinuance of maintenance for SAP Industry Solution Utilities (SAP IS-U), this need is stronger than ever, because that system is responsible for the functionalities of sales, which is a growing segment for energy suppliers. The future coverage of all functional requirements of sales is therefore essential for further growth. As an interim solution, current sales requirements were often added to existing platforms through system customization. Together with complex IT landscapes that have grown over the years, the upcoming transformations represent a major challenge for the energy industry.

FIGURE 5

Framework for cost saving via UX and operational excellence



Source: Capgemini analysis

1.1 – Addressing the right customer with the right products

How customer experience can drive brand differentiation

- Gaining a deeper understanding of **customer behavior** can help a company know when, and where, to start a conversation with them. The outcome – and the ultimate aim of this customer-first focus – is a **brand differentiating customer experience**. Achieving this goal is contingent on the ability to use data to drive a conversation with the customer.

- A real-time database of customers' preferences and purchase behavior can offer a dynamic cross-channel capability.

- Ultimately, this can create a truly **customer-centric organization**. By eliminating silos and improving customer support efficiency, this approach lifts some of the last barriers to becoming a customer-centric company.

- As more and more companies recognize the importance of being more customer-centric, the focus has shifted to understanding which technologies can support this transformation of the customer journey. Systems like Customer Relationship Management **(CRM)** tools are now standard, but in order to gain meaningful insights from this data, a robust integration of the systems into a larger architecture is required - including systems **for data acquisition, analysis, interpretation, and visualization**.

- It's important to understand that building a meaningful customer journey requires more than just a group of marketers sitting together to design, execute, and analyze a fixed journey for the customer to follow.

- Real personalization should revolve around the changing needs of the customer at any given time. Therefore, the correct "orchestration" of the journey requires that companies use all their expertise to link internal and external data sources and to coordinate the goals of all departments. Does the sales team want to maximize the number of calls recorded in their CRM tool? Does this compete with the marketing team's goal of increasing the volume of emails opened? Maybe they should talk to each other before the customer signs off entirely.

- It's clear that a well orchestrated customer journey provides a better end-to-end experience for customers, which in turn leads to improved brand loyalty and more sustainable business growth.

- Customer segmentation with real-world data (RWD) allows brands to deliver the right message, at the right time, with the right media. We have to segment our customers precisely, with the help of RWD, and personalize the interaction with tailored marketing pitches. While most people would agree that customer segmentation is necessary to hit the right note, the next generation of personalization and orchestration aims to view each customer as an individual in order to further personalize the experience.

Brand differentiation that is build on a variety of non-commodity products isn't yet standard

*Besides e-mobility and solar solutions, only **3 of the 5** big suppliers offers additional services and products.*

1.2 - Digital empowerment

A shift in digital solutions will allow for new business models

- Incumbent utilities have to establish new capabilities according to customer needs, and simultaneously address cost pressure by driving operational excellence through modern technologies and simplified, standardized, end-to-end business processes.

- In order to accomplish this, utilities must build up required competencies in two central areas of the organization: IT and culture. While culture and organization enable digitalization on a human and organizational level (change management), IT obtains a totally new meaning in the age of digitalization. It becomes a key enabler for innovative business models by optimizing business processes and reimagining the customer journey. In the future, a key focus of IT must be to demonstrate the potential of new technology.

- This includes not only assisting the business in digital transformation but also ensuring operative excellence. To this end, the trend in which internally-developed core business applications are replaced by comprehensive software solutions is noteworthy. Classic examples in this context include the booming business with ETRM-software in energy trading as well as CRM solutions in (energy) sales. Historically grown IT applications, which are still mostly based on spreadsheet software, are no longer able to handle these new, digitally-driven business requirements.

- New IT-systems for energy retailers must enable an automated multi-modular product ecosystem that is able to perform intelligent processing for both energy-related and non-energy products or services.

- In depicting these new product landscapes, new IT systems must cover four basic requirements:

  - **Scalability:** IT systems must be able to easily adjust capacity according to fluctuating demand/number of users, which will reduce costs and enable growth.

  - **Flexibility:** They should improve response to market developments through easier integration of new functionality.

  - **Agility:** They should offer increased speed-to-market so that new innovations can be developed and implemented more quickly.

  - **Stability:** They should protect business processes through trouble-free operation of the traditional IT infrastructure.

1 – The influence of digital transformation on CTA and CTR

A glimpse at Germany

- As already described in the articles above, digital transformation ambitions enable the optimization of business models and processes such as customer engagement and customer journeys.

- An impressive example of the increasing importance of customer-related data, its evaluation through innovative IT systems, and the derivation of implications and strategies for the company can already be seen today in the development of CTA and CTR within the last decade.

- **CTA:** Through digitally-controlled new customer journeys, retailers are planning a permanent reduction of the CTA in the entire channel mix from €140-160 to around €40-60.

- **CTR:** CTR is of increasing relevance since a shift from new customer acquisition to retention measures can be observed. CTR costs currently range from €20-50 and are thus significantly cheaper than the channel mix for CTA. Whereas in the 2010s, the retention budget often only accounted for a share of 5-15% of the total CTA+CTR budget, for the past two to three years, this has shifted significantly in the direction of 50:50, in some cases even predominantly stronger towards CTR budget (depending on the strategy).

- Looking at churn data for electricity and gas across Europe (see following page), it becomes clear that especially in hot and warm active markets, it is important to focus on customer retention. Costs will become very high if all leaving customers must be replaced by new customers with expensive acquisition costs.

Reasons for the increasing importance of CTR are:

1. Customers kept active are increasingly loyal to the retailer. The effects and developments shown in the articles above are expressions of this phenomenon.

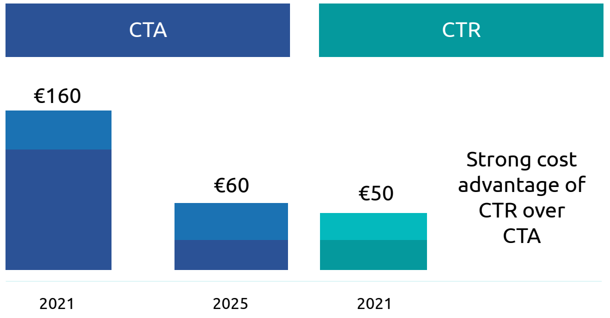
2. Improved value of customers (at a basic level): With existing customers, certain behaviors are already known (payment history, actual consumption, service intensity, etc.), whereas this context is not available for newly-acquired customers. Retention therefore enables a much more value-oriented approach, as efforts can be focused on more valuable customers.

3. Improved value of customers (at the expansion stage): With an increasing share of ecosystem product worlds, retailers can increase the service-side interlock with their customers through retention measures, which results in up-/cross-selling potential. For example, a customer might initially only purchase electricity, then subsequently buy electricity and internet in a bundle. If necessary, the customer can be offered perks on top.

- Thus, by focusing on the retention of existing customers in addition to gaining new customers, retailers can reduce costs and deliver more value to customers.

Cost ambitions for CTA and CTR in Germany

FIGURE 6



Shift towards higher customer retention efforts due to price advantage compared to new customer acquisition

FIGURE 7

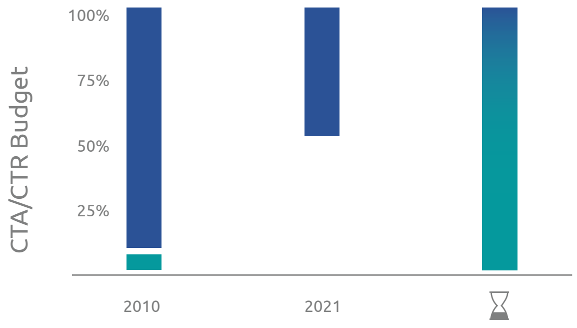


FIGURE 8

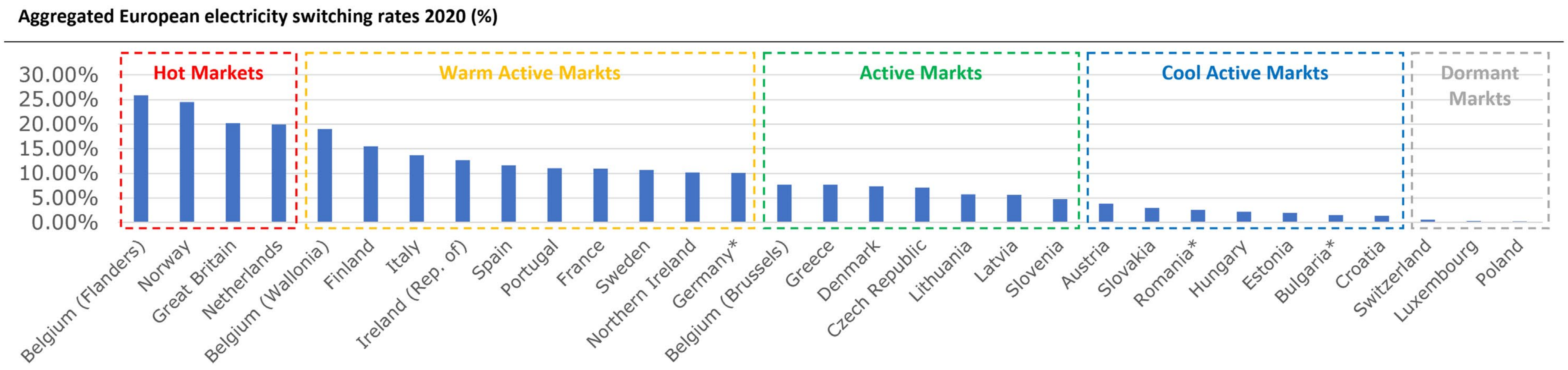
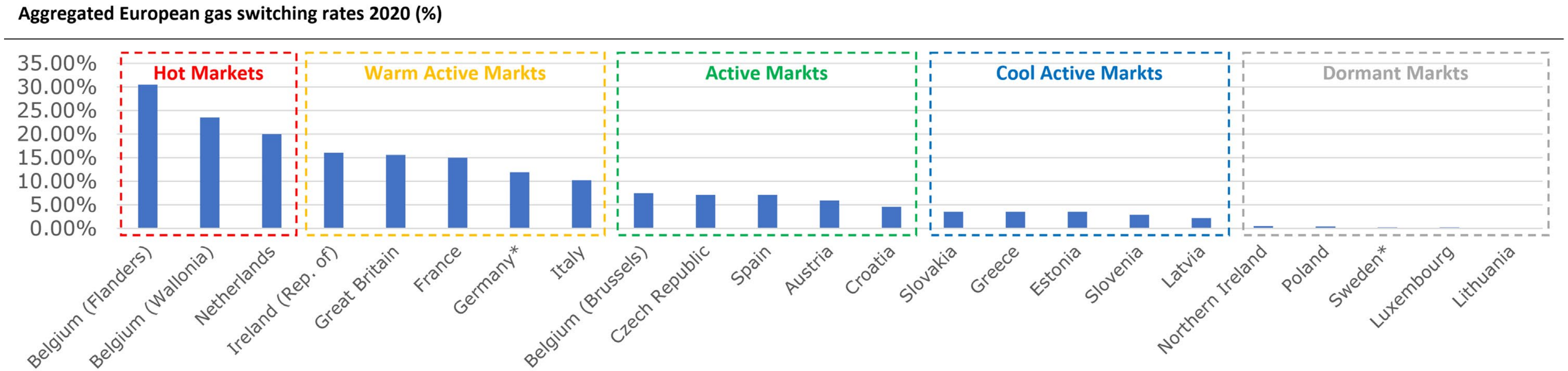


FIGURE 9



2 – At a glance: The Italian energy market

The liberalization process is ongoing

How is proceeding the liberalization of the energy market in Italy? What are new trends besides commodity? How are energy retailers are expecting to grow their revenue stream?

The context

The Italian energy market was liberalized in 2007. Since that point, many retailers were born and developed their business. Besides the larger global operators within the EU sector like Enel, ENI, and other firm players, like Edison and A2A, new players emerged, such as Sorgenia, Repower, and Green Network. Global operators, like E.On and Engie, also entered the Italian market[1].

The current customer base on deregulated market has reached more than 21 million withdrawal points[2], and shows that the ford has been almost passed. Nevertheless, more than 15.9 million withdrawal points[3] are still serving clients in the protected market.

The first critical milestone occurred on January 1, 2021. This date marks the end of the protected market for small enterprises and micro-companies with contractually committed power not greater than 15kW.

Clients that had not yet selected a provider in the free market were moved to the "gradual standard offer service" and will be assigned to the operator who won the auction for the territory, with specific economic conditions. The process envisages a gradual removal of price protection.

The price protection for domestic users has been set at January1, 2023.

The social and political pressure (the time is now)

The global community is under pressure to take immediate action to address climate change, following the shout "right here, right now", with the ambition to stem human activities that are causing irreversible damages to the environment.

Social pressure is relevant and echoes the new EU strategy to launch the new green deal and commit significant investments to achieve Sustainability Development Goals (SDGs).

Besides the targets set by the EU, global operators are seriously interpreting the risks of climate change. This will become a critical variable in the operative risk analysis, affecting not only long term, but also mid- and short-term operations and business resiliency.

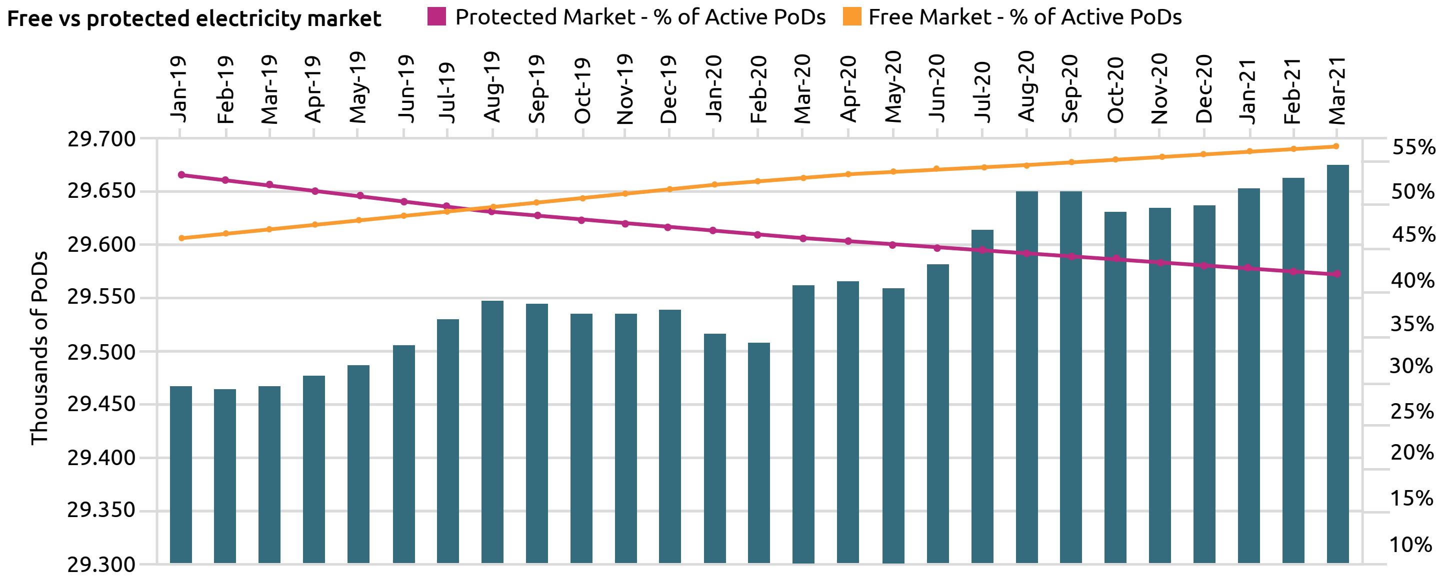
In 2021, the Italian government, led by prime minister Mario Draghi, established the new Ministry for the Ecological Transition to focus on sustainability efforts and: accelerate the path to decarbonization; combat global warming; and foster sustainable development, energy efficiency, and the circular economy.

With this background, some market dynamics are occurring in Italy, in the wave of what happened in other lively European markets (e.g. in Spain with Iberdrola), where the customer interest to renewable energy is becoming a relevant factor.

1 https://www.arera.it/allegati/relaz_ann/21/RA21_volume_1.pdf tav. 2.44
2 https://www.arera.it/allegati/relaz_ann/21/RA21_volume_1.pdf tav. 2.46
3 https://www.arera.it/allegati/relaz_ann/21/RA21_volume_1.pdf tav. 2.33

FIGURE 10

Domestic Clients – Italian electricity market



Source: Arera
World Energy Markets Observatory 2021

In Italy as in Europe

The ultimate passage to the deregulated market in Italy and the "ecological transition" are threatening the share of top retailers.

The European retail companies are changing their business models through creative value-add services and new competitive offers, available in the new open and evolving market.

Italian retailers are moving along this path, breaking consolidated positions and dealing with competitive pressure.

Despite the repeated postponement of the end date for the protected market for domestic clients, since one year the number of Points of Delivery on the free market has surpassed the number or PoDs in the protected market, with an increment of +14% as of March 2021.

The top 3 retailers need to speed up the process to attract and retain most profitable domestic clients.

New marketing strategy, and value added offer is pivotal.

Sustainability and value added services

The new target customer is a middle-income household interested in renewable energy sources.

Sustainability also means efficiency, which opens the door to a broader portfolio of products and services "beyond commodity," such as the supply of air conditioners and heat pumps, as well as installation, maintenance, or insurance.

One step above this target customer is the prosumer community. This may take the form of rooftop PV panels or a cluster of clients embracing the end-to-end offer, which includes home charging points (wall boxes) and electric vehicles.

This market evolution is prompting operators to change their relationship with customers. Competitiveness is no longer based solely on the best possible discount on energy prices (the PE component of energy bill: "Prezzo Energia" / "Price of Energy") or the yearly margins of sales (the PCV "Prezzo di Commercializzazione e Vendita" / "Price of Commercialization and Sale"). The client acquires an intrinsic value through the assets that fall outside the broader commodity portfolio (e-mobility, e-home, energy efficiency, financial services). This, in turn, shifts many retailers into a subscription model.

Following the model of Telco

We shouldn't be surprised if new metrics for the profit evaluation will be borrowed from the telecommunications and entertainment market. These may include: ARPU (average rate per unit) and ARR (annual recurring revenue), as well as CLTV (customer lifetime value).

FIGURE 11

Energy contracts + additional service in 2020

Source: Arera
World Energy Markets Observatory 2021

FIGURE 12

Energy contracts + additional service in 2020

CONTRACTS	2016	2017	2018	2019	2020
Fix price	84,6	83,9	85,9	84,7	84
Variable price	15,4	16,1	14,1	15,3	16
Additional services of fixed price contracts					
No additional serice	n.d.	n.d.	12,20%	12,20%	20,40%
Guarantee of energy from renewable sources	49,60%	45,70%	39,10%	44,40%	39,40%
Guarantee of energy produced in Italy	n.d.	n.d.	n.d.	n.d.	2,30%
Point collection program (own or other)	42,20%	45,00%	36,00%	38,30%	31,10%
Accessory energy services	3,90%	5,70%	7,40%	2,60%	3,30%
Bonus and Gadget	n.d.	1,40%	0,20%	0,40%	0,40%
Offer & programs for other goods or services	2,60%	0,50%	0,30%	0,70%	0,90%
Other products or services bundled with electricity	n.d.	n.d.	n.d.	n.d.	0,02%
Other	1,80%	1,70%	4,70%	1,50%	2,10%
Total	100%	100%	100%	100%	100%
Additional services of variable price contracts					
No additional serice	n.d.	n.d.	53,00%	51,60%	53,20%
Guarantee of energy from renewable sources	60,90%	48,90%	27,50%	28,40%	25,70%
Guarantee of energy produced in Italy	n.d.	n.d.	n.d.	n.d.	0,00%
Point collection program (own or other)	5,80%	6,90%	2,50%	3,40%	2,80%
Accessory energy services	22,00%	16,10%	8,50%	10,70%	12,20%
Bonus and Gadget	n.d.	23,10%	3,10%	1,30%	1,50%
Offer & programs for other goods or services	4,10%	3,60%	1,40%	2,50%	1,80%
Other products or services bundled with electricity	n.d.	n.d.	n.d.	n.d.	1,30%
Other	7,20%	1,40%	4,10%	2,10%	1,50%
Total	100%	100%	100%	100%	100%

Source: Arera
World Energy Markets Observatory 2021

An incentive-based approach

An incentive-based strategy is still in place. The cost of access to energy efficiency is still high. For example, e-mobility is not yet affordable to the majority of the consumer customer base.

At the same time, energy transition at the production level is characterized by several incentive tools adopted over the years in order to foster the shift to renewable energy sources (RES).

The energy communities

The shift to renewable sources requires a decentralized transmission and distribution system. However, distributed energy resources including local peripheral production from renewable sources, can address the collective auto-consumption for an aggregation of producers and consumers. This supports the formation of energy communities, launched in conjunction with the EU directive 2018/2001 and 2019/944, which were then regulated in Italy through the ARERA deliberation 318/2020/R/eel.

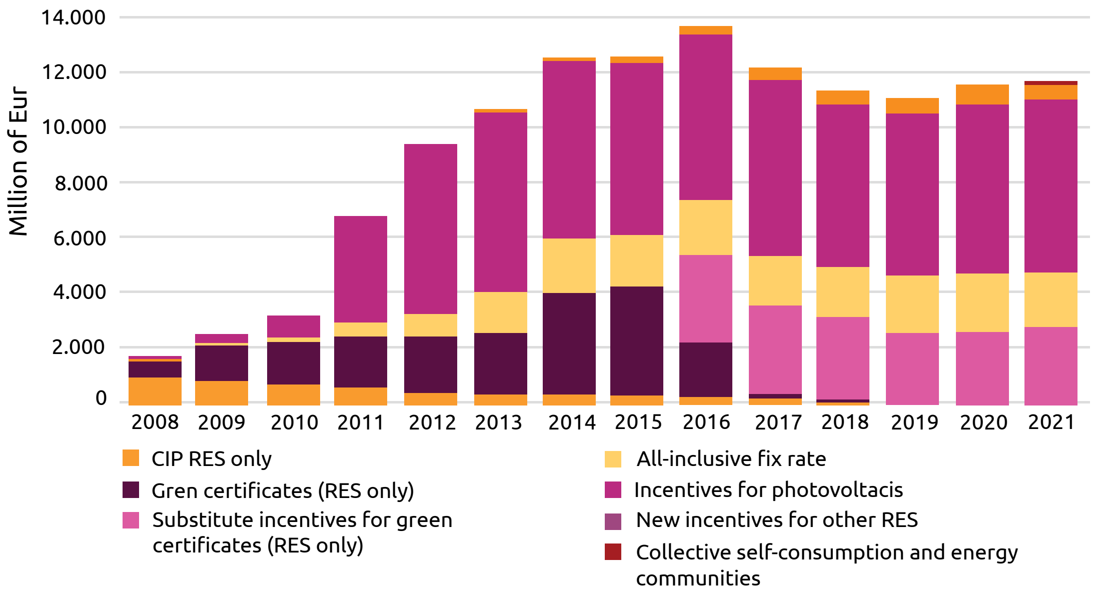
It should be noted that these energy communities represent a great opportunity for Italy, representing many important economic and environmental benefits. For example, turnover generated by the supply of the necessary technological components or the recovery of the building sector with integrated energy efficiency projects would deliver positive fiscal and environmental benefits.

Incentive policies

Current incentives are still largely allocated to photovoltaic and green certificates. Nevertheless, new incentives tools have been introduced, like "feed-in tariffs" and "feed-in premium," assuring favorable remuneration to energy produced from renewable sources and placed in the network or allocated to on-site exchange.

FIGURE 13

Cost of incentivization tools for energy produced through renewable sources



Source: Arera
World Energy Markets Observatory 2021

3 - U.K. retailers are transforming their core technology platforms through customer relationship management (CRM) platforms

With the emergence of disruptive technologies and the recent challenges of the COVID-19 pandemic, large technology companies are lurking around the energy market. As a result, utility retailers are experiencing increasing pressure to transform. Throughout Europe, these retailers have embraced the challenge by changing their core technology platforms, including their billing and customer relationship management systems (CRMs).

Part 1: Moving from generalist CRM to energy specific solutions

A. The struggle with legacy systems

A vast majority of energy retailers in Europe use versatile but generic CRM solutions to power their businesses. The fast-paced customer-centric evolution is pushing these generic systems to their limits. Over time, these systems become harder and harder to maintain, with every change adding complexity and cost. This often means that it takes too long to build new features to meet the relentless evolution of customers' expectations.

B. Challengers are commercializing their tailor-made technology

In contrast, challenger organizations have invested in tailor-made, built-for-energy systems to power their businesses. These new built-for-energy platforms connect and automate the key steps of the energy retail business, from energy supply to billing. They are designed to be a comprehensive management system, giving customers a seamless experience and enabling the company's operations team to run common processes and solve problems efficiently.

These platforms are often hosted off-premises. This optimizes cloud mobility to guarantees greater flexibility for service agents to work remotely, thus enabling scalability. For example, Octopus Energy has chosen to run its Kraken platform entirely on Amazon Web Services1, the largest worldwide cloud services provider.

In the U.K., Octopus, Ovo and Bulb have been very competitive in the market due to their flexible, light, and cost-effective platforms. They are now going one step further; not only are they relying on their technology to thrive, but they are also licensing their technologies to other utility companies.

Here are a few examples of the most popular solutions in the European market:

- **Kraken (U.K.-parent company: Octopus):** Kraken is an energy tech platform based on advanced data and machine learning capabilities, designed around the customer's needs. Using a scalable, cloud-based architecture that supports continuous deployment, this platform focuses on customer centricity through an intuitive user interface and straightforward interactions.
- **Kaluza (U.K.-parent company: Ovo Energy):** Kaluza enables energy retailers to operate with agility at scale and deliver market-leading products at speed, while reducing cost-to-serve. They are specialized in demand response, managing the charging of smart home devices to create a flexible, zero carbon grid.
- **Powercloud (Germany):** Powercloud provides a platform for the processing and billing of electricity, gas, heat, water, and sewage products and services. It currently serves approximately eight million end-customers, with 17 million end-customers in the process of migration.
- **ENSEK (U.K.):** Founded by industry experts, ENSEK provides organisations in the energy market with cutting-edge cloud technology and outsourcing and advisory services to improve their business performance and competitiveness.
- **Efluid (France-parent company:** UEM Energy): Developed over the last ten years by a small French energy retailer, Efluid provides expert software package solutions, covering all requirements of electricity, gas and water stakeholders.

C. The switch has already started

These built-for-energy platforms have quickly found a sizeable market with traditional retailers willing to accelerate their transformation. For example, in the U.K., Centrica has been migrating its retail business from their new company, British Gas Evolve, to the ENSEK cloud platform. EON is relying on Kraken to run activities in the U.K. with more than six million customers already2 on this platform; they are also partnering with Powercloud in Germany.

In parallel, the retailers owning these platforms are using them as a key asset and competitive advantage to pursue opportunities in new markets. Octopus Energy is expanding its activities in Japan3 and Spain4 (thanks to strategic partnerships and acquisitions). The implementation of Kraken is a cornerstone in their global strategic growth plan.

Part 2: What are the drivers to explain this trend?

It cannot be a coincidence that these major players are all partnering with new technology platform providers. The following four main drivers explain this:

- **Enabling a customer-centric business**

When asked about the main barriers to being more customer-centric, many companies will point out one key system: CRM. A built-for-purpose billing and customer management system is essential in breaking down silos and helping customers in a timely and cost-efficient manner. This is probably the biggest strength of these new platform providers in that they have been designed specifically to answer these needs. For example, they offer a single view of the customer regardless of their product portfolio, proposing next best actions or cross-selling opportunities to call-center agents. They also offer a myriad of analytics and reporting tools that enable operators to leverage data to offer better and more proactive support.

- **Reducing IT and customer-related costs**

Relying on an external platform is also a great way to cut costs as there is no need to have an ever-growing team of CRM developers or project managers in-house. These platforms are also built to provide more efficient customer support, leading to better customer satisfaction and enhanced cost savings. They are supported by a plug-and-play API compatible with the operator's website or app, enabling a quick roll-out of efficient and customer-friendly self-serve journeys.

- **Increasing IT flexibility**

By relying on a focused solution and partnering with an external platform provider, utility retailers can then focus on their customers' needs, delegating most of the technical overhead to the platform provider.

- **Building a future-proof structure**

EV tariffs, connected homes, and home batteries, are just a few of the game-changing innovations for the energy retail market. Energy retailers need a robust platform to manage their customers and maintain a 360-degree view of their needs. By relying on leading industry technology, utility retailers can then focus on growing in these markets, trusting that the IT support will already be there.

Part 3. What does it mean for the market in the future?

The first impact of this transition will be affect the customer. By using leaner billing and customer management systems, energy retailers will be able to make significant efficiency gains, and offer not only a better customer experience, but also lower prices.

This transformation can also be used to accelerate the customer and digital transformation within the industry. For example, Origin Energy, one of the largest Australian retailers, has recently acquired 20% of Octopus Energy5, and signed up for the Kraken platform. Historically known for its large reliance on fossil fuel, this company has taken the opportunity to partner with a leader in green energy to support their transition into a more environmentally friendly energy source. This acquisition also grants them the right to use Kraken for their different operations and to be fully involved in its development. Not only can this transition benefit the bottom line of the energy retailers, but also help us move to a greener future.

4 - Smart suppliers for smart consumers: Exploring value propositions in the U.K.'s future net zero energy retail market

In order to reach the U.K.'s net zero target, the energy sector, and the businesses that operate within it, will need to undergo significant structural changes. To enable this transition, energy suppliers will need to consider how they respond to technological advancements and the changing consumer landscape. Market share and value proposition will influence the urgency of responses between companies. However, if energy suppliers want to maintain a competitive advantage, we believe that they cannot afford to wait when considering their future value propositions.

What is changing for consumers?

A. The struggle with legacy systems

The "three D's" of energy transition – decentralisation, decarbonisation and digitalization – are well-known drivers in the future energy landscape. Different transition scenarios will determine how these drivers play out. Nevertheless, we believe the future energy landscape will consist of:

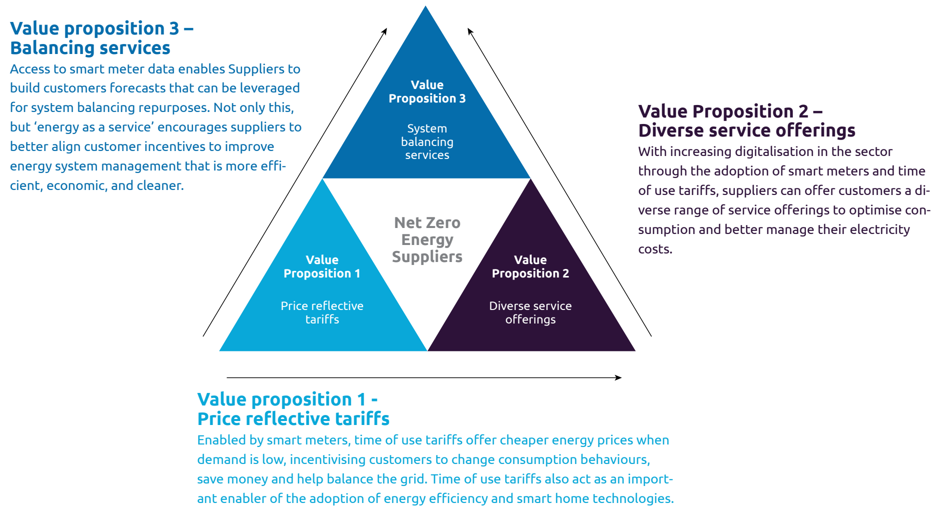
- A system dominated by renewable and low-carbon generation, enabling the electrification of heating and transportation.
- More decentralized technologies with significant distributed and local generation, supported by battery storage and demand side energy efficiency solutions.
- Advanced, open access data and analytics, shaping the way market participants interact and enabling better-informed business decisions.
- Consumers being able to produce, store and sell energy, in response to market signals based on cost and carbon intensity. This will be achieved through intermediaries such as peer-to-peer low voltage trading platforms, smart home energy services, and participation in the balancing service markets.

How can suppliers provide value to consumers?

Energy suppliers are the sole provider of electricity for our homes, businesses, and transport. Therefore, their role is essential in meeting net zero targets. However, due to the scale of change, the current energy supplier business model will need to respond accordingly. We have identified three value propositions for energy suppliers, which will enable an efficient transition to a net zero energy market.

FIGURE 14

Value market propositions for net zero energy suppliers



Source: Capgemini analysis

Value proposition 1: Price reflective tariffs

Enabled by smart meters, suppliers can offer time of use tariffs that are reflective of the real price of energy. Such tariffs will incentivise customers to change their consumption behaviour to use electricity when demand is low and less carbon intensive. This will result in a reduction in peak demand, helping to balance the system.

The roll out of smart meters allows energy suppliers to remotely access information on their customers' energy consumption throughout the day. Access to accurate consumption data enables energy suppliers to offer time of use tariffs.

Time of use tariffs reflect the time-varying nature of energy costs. Rather than charging customers a fixed price regardless of their consumption patterns, prices will vary by time of day, which are in line with wholesale and system price fluctuations. These price signals give customers an incentive to shift their demand for energy to periods when it is cheaper and less carbon intensive. Such demand reductions can, in turn, provide savings on customer energy bills.

There are also several wider, long-term market benefits associated with the adoption of time of use tariffs. First, they are considered an important enabler in the adoption of energy efficiency and smart home technologies. Second, they are expected to deliver an overall reduction in network augmentation.

Value proposition 2: Diverse service offerings

With increasing digitalization through the adoption of smart meters and time of use tariffs, energy suppliers can offer customers a diverse range of service offerings, optimizing consumption and better managing their electricity costs. Other innovations, like EVs, solar panels, and smart thermostats, can also result in different service offerings.

The availability of smart home devices has enabled the continuous monitoring and control of electricity consumption. As home energy interoperability is maturing, devices and services are able to communicate in an intelligent way. This unlocks opportunities for energy suppliers to provide more and diverse service offerings to energy customers, especially in relation to energy efficiency.

Historically, incentives to reduce energy consumption have been misaligned between energy suppliers and their customers. Energy suppliers were financially motivated to increase electricity demand, and therefore had little reason to encourage energy efficiency, regardless of the benefits for customers and the environment.

The 'energy as a service' value proposition could, in exchange for a recurring a subscription-based fee, provide customers with packaged energy services, such as heat pumps, solar panels, and electric vehicle charging. The customer can also enjoy the benefits of a product without purchasing it outright or directly managing its use. Service-based business models can provide energy suppliers with steady revenue streams, while benefiting customers through increased product value and accessibility.

An 'energy as a service' approach also shifts from selling asset-focused, centralized power generation to passive consumers, to the offering of the end-to-end management of a customer's energy assets and services. Such approaches could save consumers money while providing societal benefits by better matching electricity demand with supply, integrating renewables, and reducing emissions.

Value proposition 3: System balancing services

Access to smart meter data enables energy suppliers to build customer forecasts that can be leveraged for system balancing purposes. Furthermore, 'energy as a service' offerings encourage energy suppliers to better align customer incentives, making the energy system management more efficient, economical, and less carbon intensive.

Decarbonisation of the electricity sector will likely create new challenges for the U.K.'s Electricity System Operator to meet demand. The rise of intermittent renewable generation, like wind and solar, requires extensive forecasting, an increased need for flexible demand, and a greater use of grid service (to manage system constraints).

Real consumption costs and drive load shifting behaviours not only enable greater energy efficiency, but also allow energy suppliers to better understand customer demand.

Through increased 'energy as a service' offerings, there are opportunities for energy suppliers to capitalize on decentralised generation and flexible demand providers to their customers. As a result, this provides balancing services which better support the sustainable management of the electricity system.

Conclusion

The adoption of these three value propositions by energy suppliers could result in a reframing of the energy sectors as we know today. It would mark a move away from demand driven generation to a system that encourages consumption when energy is available at its cleanest and most affordable. The U.K. is leading the way with its net zero ambition. Energy customers are becoming increasingly engaged in the transition through the role out of smart meters and smart home technology. However, the pace and scale of the transition will rest on how energy suppliers choose to response to customers in a net zero retail market.

5 - B2B commodity shifts towards platform business

B2B platform business replaces commodity-based business

- Most B2B retailers continue to focus on selling electricity and gas, as this has been proven practice for decades. However, as the market is becoming increasingly complex and competitive, retailers are trying to increase hit rates by selling additional services and solutions.
- One key challenge for retailers is finding a way to maintain their business despite decreasing commodity margins and a lack of scalability of solution sales.

Decreasing commodity margins

- Due to intense competition and high price sensitivity of customers, margin levels in sales of electricity and gas is extremely low throughout many B2B markets. In addition, risks in the portfolio are significantly higher than in the mass market.
- Additionally, selling commodities economically via traditional personal channels in the smaller B2B segments is nearly impossible due to high sales costs and low margins. The higher the competition, the lower the hit rate and the higher the specific CTA. This leads to the fact that the contracted gross margin often does not cover the CTA.
- As a result, many retailers either withdraw completely from B2B markets or only serve carefully selected sub-segments in which they specialize. However, this makes it hard to reach a critical minimum customer base.

Lack of scalability of solutions

- The solutions business itself suffers from two main difficulties: 1. The need for a high degree of product customization to meet individual customer needs; and 2. Low capabilities for solution sales.
- Each customer has individual requirements, which often cannot be met by offering standard products. This demands high customization efforts and individual sales approaches within the offer process, driving instances of one-off product sales.
- As these approaches usually cannot be scaled up across multiple customers due to a high degree of product customization, an enormous risk is entailed within the product development stage, long before any profit has been made.
- In addition, scalability of process and IT costs is often limited due to high customization, which affects after-sales processing of products (resulting in CTS). Therefore, high costs also result from low fixed cost degression.
- As a result, companies need to work on the top line, the CTA and the CTS at the same time in order to keep their B2B business.

Possible approaches

Retailers have two options: 1. Withdraw from the B2B business, or 2. Shift to a platform solution model.

- **Withdrawal from the B2B business** is a trend which is most likely to continue in the near future. Several players have already withdrawn from the B2B business or will do so within the next 1-2 years due to insufficient profitability. One example of this trend is required investments into IT systems. Due to aforementioned reasons, return on invest is not guaranteed. Hence, retailers shy away from investments and phase out.

- The retailer's alternative is to **expand the product offering through integrated solutions**, which aim at meeting as many customer needs as possible beyond the provision of electricity and gas. Through a service platform, the goal is to offer entire process groups as a service, which cannot be performed effectively by the customer. As customers continue to draw services from this platform, a lock-in effect occurs. If the customer cancels the electricity/gas contract, all other services are also cancelled and the customer has to reorganize significantly. The lock-in effect poses an enormous advantage for the retailer in terms of customer loyalty. The service platform, in turn, must be easy to activate from the company's product portfolio.

    - Examples in the Real Estate industry include processes like submetering, vacancy management, tenant communication, etc. Real Estate companies typically handle these tasks directly, though they do not create any value or profit.

    - Another example from outside the industry is a German manufacturer of construction items and tools. The company is part of the integrated supply chain and production process chain in many industries. Customers have the advantage of being concerned with less affairs to deal with since the provider takes over processes that the customer cannot or does not want to manage directly.

    - Lastly, platform solutions also allow for sustainable transformation ambitions which are highly relevant to many customer groups. Energy suppliers can achieve customer proximity in such a manner, that all Net Zero emitting processes of the customer can be monitored and optimized. In the context of Europe's Net Zero Ambition Capgemini analyzed the 55 Technologies which can help Europe achieve their Net Zero Ambitions.

In conclusion, a multi-service solution platform can have various advantages for both the customer and retailer. The following components are required for a successful service platforms:

- Highly digitalized process excellence in scaled worlds;

- High degree of process automation (RPA/AI) and significant expansion of digital customer interaction across all sales touchpoints and throughout delivery;

- A turnkey modular platform service portfolio (for which leading retailers are currently developing suitable strategies).

The Following advantages result from platform solutions

- Retailers can move away from product-based, single sales thus avoiding a high CTA.

- Retailers can build close customer relationships. Peripheral services, which are available to the customer on a scaled platform basis, allow the provider to become closely involved in customer processes. The customer is thus permanently tied to high-margin core products (which can include electricity or gas). Customer losses can thus be reduced.

- Retailers can gradually create additional business in the peripheral services.

Moving away from commodity-only business is progressing steadily. The question will be a matter of how retailers will position themselves in this situation: Either they withdraw from the commodity business or they start building platform businesses with integrated process services for focus customer segments, which are subsequently scaled up.

In conclusion, this means that instead of broad market penetration, the retailer prefers to focus on deep customer penetration through a platform business model.

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North America Retail

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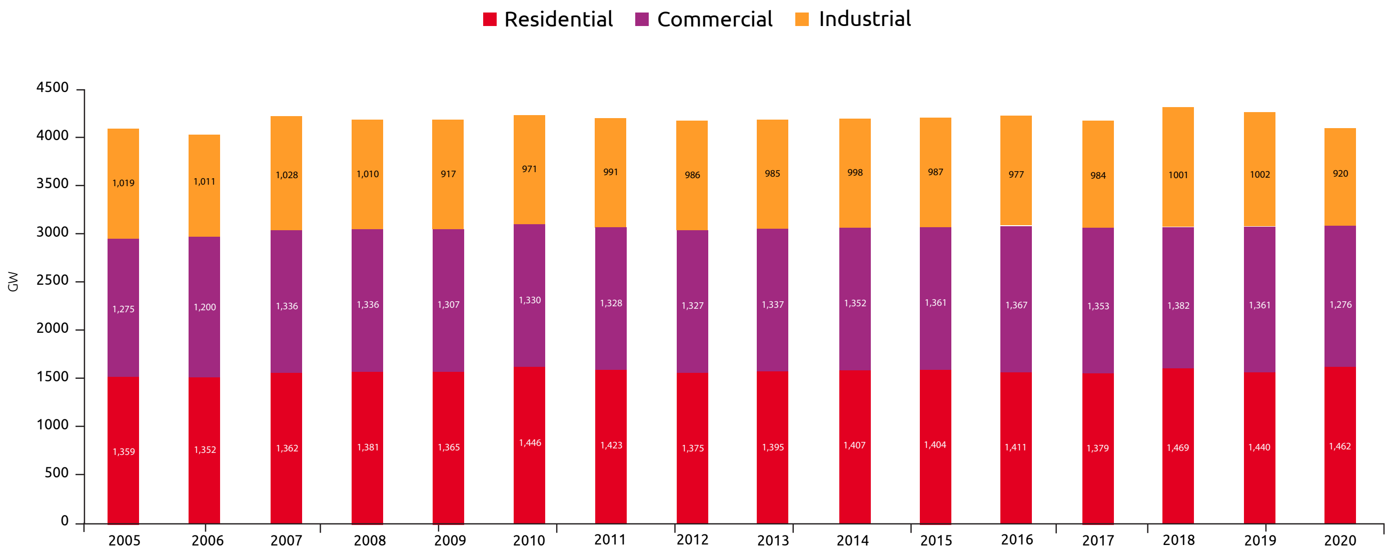
U.S. electricity sales: There was a decline of retail electricity sales in 2020 due to the effects of COVID-19

Annual electricity sales overall have shown only modest changes from 2005 to 2020 as improved energy efficiency has largely offset the effects of population and GDP growth.

- Total electricity sales in 2020 fell around 3.9% below 2019 sales. With this decline, sales fell back to approximately the same level as in 2005.
- The largest drops in electricity retail sales in 2020 were in the March to May period, during widespread lockdowns at the beginning of the pandemic, and again in the September to November period of 2020.
- Compared to 2019, commercial electricity sales fell 6.3%, and industrial sales fell 8.3%.
- Conversely, with office buildings closed and millions of Americans directed to work from home, residential electricity sales rose 1.5% in 2020, with demand peaking in the spring and summer.

FIGURE 1

U.S. retail electricity sales by sector, 2005-2020



Source: US EIA 2021
Link: https://www.eia.gov/electricity/data/browser/#/topic/5?agg=0,1&geo=g&endsec=vg&linechart=ELEC.SALES.US-ALL.A~ELEC.SALES.US-RES.A~ELEC.SALES.US-COM.A~ELEC.SALES.US-IND.A&columnchart=ELEC.SALES.US-ALL.A~ELEC.SALES.US-RES.A~ELEC.SALES.US-COM.A~ELEC.SALES.US-IND.A&map=ELEC.SALES.US-ALL.A&freq=A&start=2005&end=2020&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0
Link: http://www.bcse.org/factbook/#

Electricity Sales is expected to rebound in the coming years.

The EIA forecast expected residential electricity sales to grow by 2.4% in 2021 and by 1.6% in 2022. Commercial sector retail electricity sales were expected to grow by 0.9% in 2021 and by 1.8% in 2022. Amid increased industrial production, industrial electricity sales were expected to rise by 1.2% in 2021 and by 1.1% in 2022.

U.S. electricity prices: The U.S. annual average retail price of electricity was 10.66¢ per kWh, an increase of 1.1% over the 2019 price

In 2020, the U.S. annual average retail price of electricity was about 10.66¢ per kWh.

The annual average prices by major types of utility customers in 2020 were:

- Residential: 13.20¢ per kWh
- Commercial: 10.65¢ per kWh
- Industrial: 6.66¢ per kWh
- Transportation: 9.20¢ per kWh

Overall, nationwide average electricity prices edged up slightly from the 2019 rate, coming in at 10.66¢ per kWH. The increase can be attributed to rising cost of power production and power grid maintenance. However, this increase was not felt everywhere, as 23 states and the District of Columbia actually benefitted from a decrease in their average electricity prices during 2020. Only 26 states experienced rate increases in 2020.

FIGURE 2

U.S. Average Electricity Price, 2005-2020 (2020 cents per KWh)

Source: US EIA 2021
Link: https://www.eia.gov/electricity/data/browser/#/topic/7?agg=0,1&geo=g&endsec=vg&linechart=ELEC.PRICE.US-ALL.A~ELEC.PRICE.US-RES.A~ELEC.PRICE.US-COM.A~ELEC.PRICE.US-IND.A&columnchart=ELEC.PRICE.US-ALL.A~ELEC.PRICE.US-RES.A~ELEC.PRICE.US-COM.A~ELEC.PRICE.US-IND.A&map=ELEC.PRICE.US-ALL.A&freq=A&start=2005&end=2018&ctype=linechart&ltype=pin&rtype=s&maptype=0&rse=0&pin=

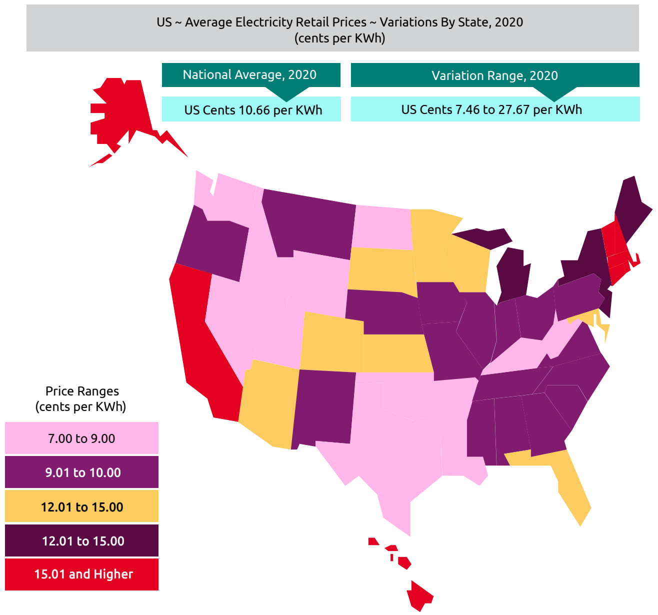
U.S. electricity prices: In 2020, lower electricity rates were seen across four of the highest-priced jurisdictions (Alaska, Hawaii, Massachusetts, and New Hampshire), but the other highest priced states (Connecticut, Rhode Island, California, and Vermont) continued to watch their high electricity prices grow

In 2020, the annual average electricity price for all types of electric utility customers ranged from 27.67¢ per kWh in Hawaii to 7.46¢ per kWh in Oklahoma.

- Prices in Hawaii are high relative to other states mainly because **the majority of its electricity is generated with petroleum fuels that have to be imported into the state.**
- The eight states with electricity prices above 15¢ per kWh remained the same in 2020. Due to their geographic and electrical isolation, Alaska and Hawaii are perennial members of this club. **These states are unable to access the diversity of resources linked across the broad, interstate grid networks of the lower-48 states.**
- California, which experienced the highest year-over-year jump in its average electricity rate, ranked as the third highest electricity rate in the lower 48, at 18.15¢ per kWh.
- New York, New Jersey, and Maine remained in the second-highest pricing tier, ranging from 14.90¢ per kWh in the Empire State to the 13.59¢ per kWh charged to Mainers.

FIGURE 3

U.S. average electricity price variations by state, 2020



Source: Global Energy Institute, 2020
Link: https://www.globalenergyinstitute.org/average-electricity-retail-prices-map#

In 2020, Oklahoma became the holder of the lowest average electricity price in the nation, swapping spots with Louisiana, the lowest average electricity price holder in 2019.

- The lowest average electricity rate in Oklahoma is **due to the benefits of a diverse electricity generation portfolio.**
- Natural gas powered the majority of Oklahoma's electric generation, smoothing out the variable nature of Oklahoma's robust wind resources.

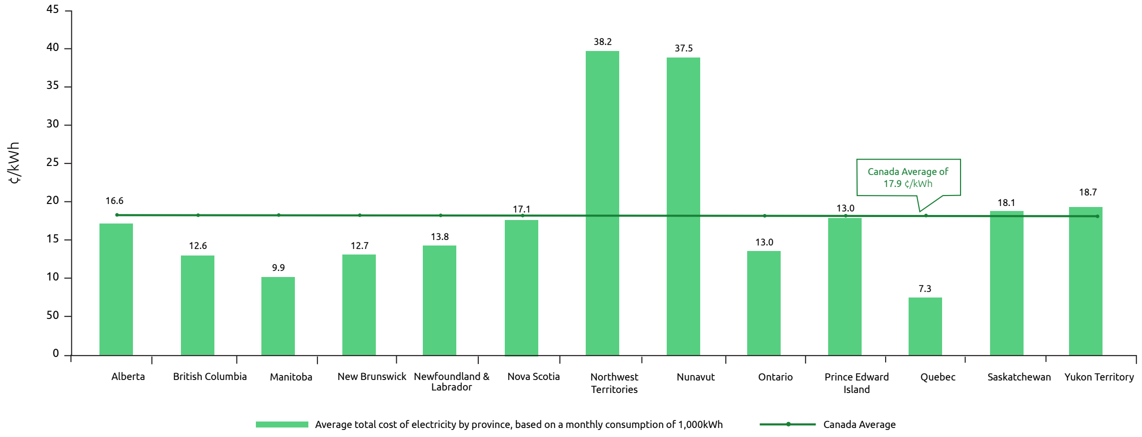
Canadian electricity prices: In 2020, a low electricity rate was seen in Québec while a high electricity rate was seen in the Northwest Territories and Nunavut

The average residential cost of electricity in Canada is 17.9 ¢/kWh, which includes both fixed and variable costs and is based on an average monthly consumption of 1,000 kWh.

- If territories are excluded, the average electricity cost decreases to 13.8 ¢/kWh.
- Québec has the cheapest electricity prices in all of Canada (7.3 ¢/kWh).
  - The widespread use of hydroelectric dams in Québec contributes to the province having the cheapest electricity prices in all of Canada.

FIGURE 4

Canadian average total cost of electricity by province, based on monthly consumption of 1,000kWh, 2020



Source: Energy Hub.org, February 2021
Link: https://www.energyhub.org/electricity-prices/

- Electricity prices in the Northwest Territories and Nunavut are significantly higher than the rest of Canada. The Northwest Territories has the most expensive electricity prices (38.2 ¢/kWh).
    - In much of northern Canada population density is low and communities are remote, which limits the viability of lower-cost energy infrastructure like natural gas pipelines and hydroelectric facilities.
    - Geography poses a challenge for the broader use of renewables and as a result, northern Canada relies heavily on relatively expensive and carbon-intensive energy sources.
    - The Northwest Territories generate most of its power and heat from diesel and fuel oil.
    - Power generation facilities in Nunavut are almost all diesel-fired and most homes are heated by fuel oil.

U.S. corporate procurement of clean energy: Corporate power purchase agreements declined in 2020 as companies tightened their budgets in response to COVID-19

Corporate power purchase agreements (PPAs) for clean energy totaled 12 GW in 2020. This is down from 14 GW in 2019 and the first drop in annual corporate PPA volumes since 2016.

- COVID-19 was the biggest factor in the drop. Few deals were announced in the first half of 2020, as companies tightened budgets and shifted priorities internally in response to the pandemic.
- There was a revival in the number of deals announced in the second half of 2020, which signaled that companies will be better prepared to carry on sustainability initiatives during future disruptions.
- Solar has become the dominant clean energy technology sought by corporations. This reflects growing expertise in power markets among buyers, who are trying to capture peak power pricing, in which solar tends to fare better than wind.
- Additionally, many wind projects in popular markets like ERCOT and SPP have seen their revenues erode as more zero marginal cost clean energy is built, which depresses prices. This has prompted companies to seek solar contracts in these markets instead.

Amazon was by far the largest corporate buyer of clean energy in 2020 at 3.8GW

- The company announced 21 individual clean energy PPAs in the U.S., with most projects located in Virginia and Ohio. Verizon (1GW) and General Motors (797MW) were the next largest buyers.
- A slew of first-time buyers also entered the market in 2020, including Applied Materials, Henkel, and Nucor.

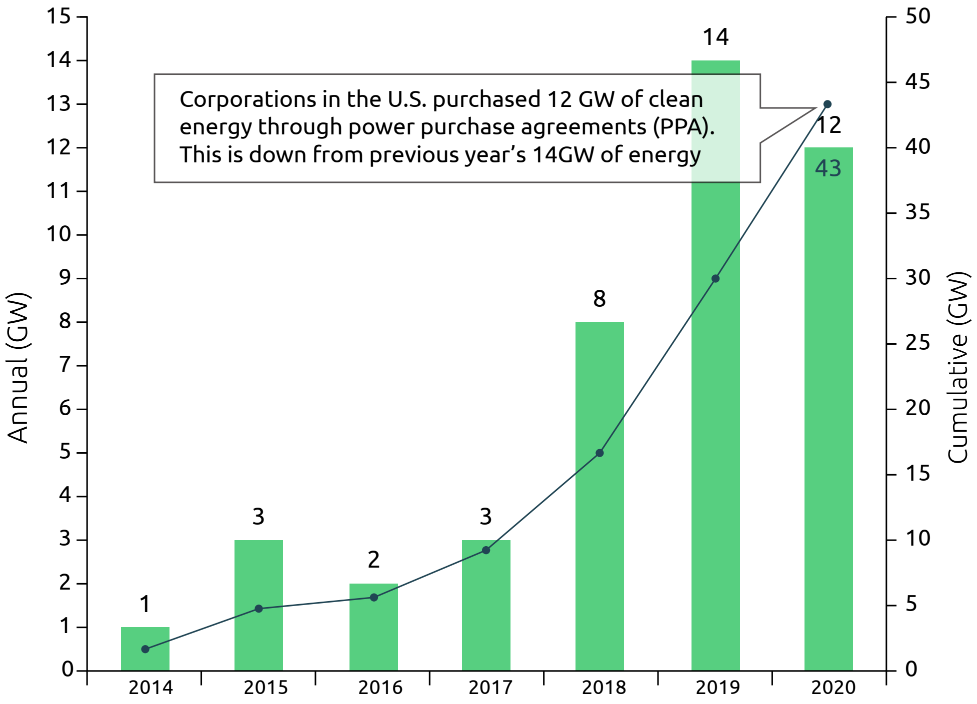
Total addressable market for corporate renewable PPA in U.S. is materially smaller than total C&I electricity demand. It is clear that there is still significant room for corporate renewables PPA penetration to increase due to the following factors:

- a vast and largely untapped U.S. C&I power demand pool
- an increased focus on the sustainability profiles of US corporations
- rapid growth in technology-sector power demand
- continued cost declines for wind and solar

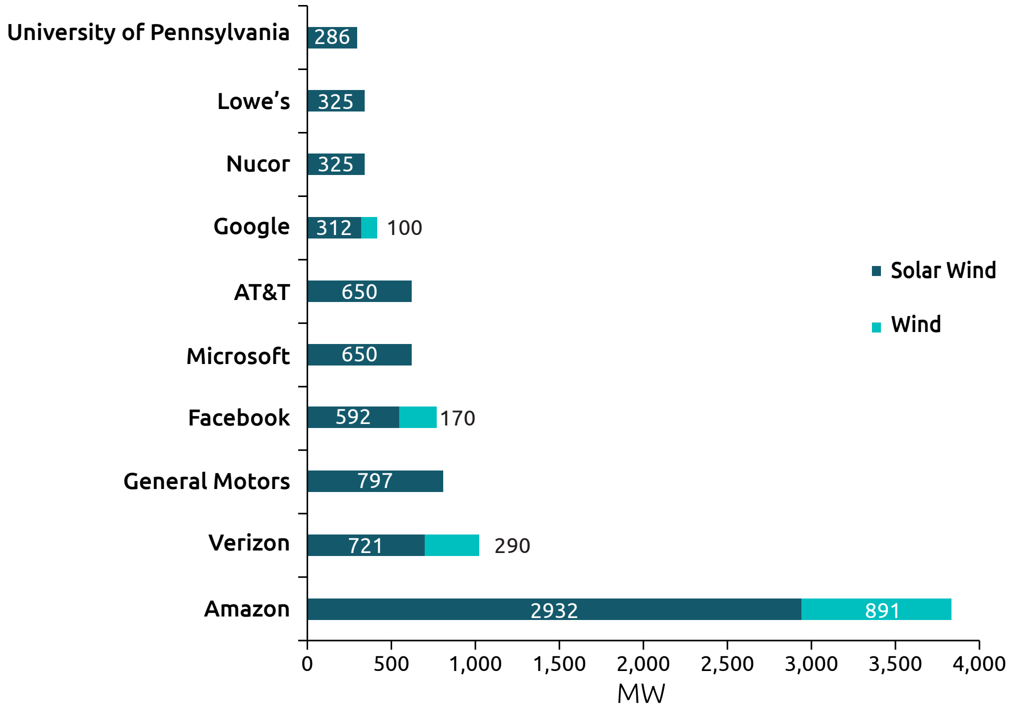
FIGURE 5

Corporate Procurement of Clean Energy, 2020 (GW)

Renewable Capacity contracted by Corporations, 2014-2020



Top 10 Corporate Off-takers, 2020



Source: BNEF ~ Sustainable Energy in America Factbook, 2021 ;
Link: http://www.bcse.org/factbook/#

U.S. sources of electric generation: There is a growth in the number of utilities offering green tariff programs in U.S.

U.S. companies announced 2.4GW of green tariffs in 2019 and just 1.5GW in 2020.

- The U.S. green tariff model, in which a regulated utility purchases clean energy on behalf of a corporate customer, has failed to grow after a record 2.6GW of clean energy was purchased through this mechanism in 2018. Companies announced 2.4GW of green tariffs in 2019 and just 1.5GW in 2020.
- Despite the slowdown, the number of utilities offering these programs continues to grow.
  - Some 20 regulated utilities in 20 states offered green tariff programs for corporate customers through 2020.
- Green tariffs are still popular with large, experienced buyers with operations in regulated markets.
  - Google, Facebook, and Toyota are some of the major companies to announce green tariff deals in 2020.
- Green tariffs are desirable for more risk-averse companies as well. By serving as the offtaker and firming up intermittent renewable power with its existing energy portfolio, a utility offering a green tariff program can absolve their customers of things like weather, and operational risk. Throughout the country, the design of green tariffs vary.

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South East Asia

Consumption and Retail Prices / Residential Market / B2B Market

Nupur Sinha
Ankita Das

Electricity generation in most Southeast Asian countries has been reduced due to the impact of COVID-19

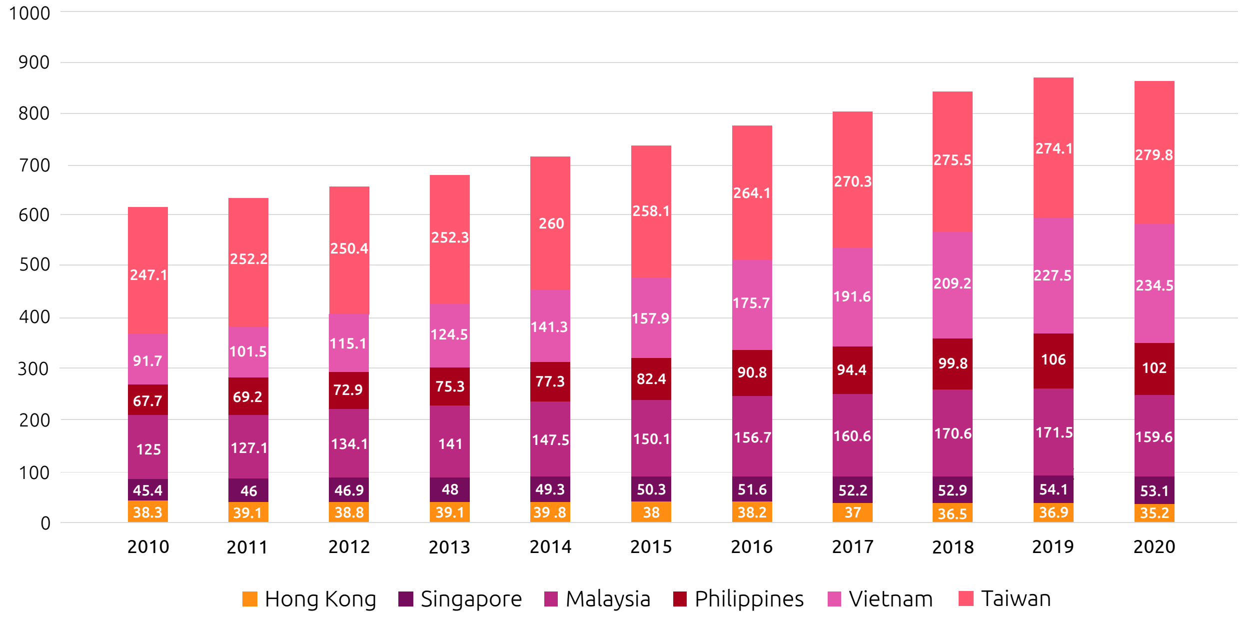
Southeast Asia is one of the fastest-growing regions in the world in terms of electricity demand. This is driven by the growing ownership of household appliances and air conditioners, as well as increasing consumption of goods and services.

- The economic impact of the COVID-19 pandemic in Southeast Asia has resulted in reduced electricity demand in Hong Kong, Singapore, Malaysia, and the Philippines.
- Vietnam and Taiwan increased their electricity generation in 2020.
- Southeast Asian countries have put forward ambitious regional development projects to support economic growth and the integration of higher shares of renewable energy in their electricity generation mix.

- **Vietnam's electricity generation increased by 3.1% in 2020 compared to 2019.**
  - That increase is low compared to the 8.7% increase in electricity generation from 2018 to 2019. The low percentage increase can be attributed to the impact of COVID-19.
- **Electricity generation in Taiwan increased by 2.1% in 2020 compared to 2019.**
  - Taiwan was the only region in Southeast Asia that experienced a decrease in electricity generation in 2019 compared to 2018.

FIGURE 1

SEA~ Electricity generation by country (terawatt hours), 2010-2020



Source: BP Statistical Review of World Energy, 2021
Link: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf

Most of the Southeast Asian countries are focusing on creating a more competitive electricity market

Electricity market deregulation initiatives are underway in Vietnam, Singapore, and the Philippines which focus majorly on opening up the market for competition ns green energy.

- **Vietnam:** All segments of the electricity sector (generation, transmission and distribution) continue to be dominated by the state utility Vietnam Electricity (EVN) and its subsidiaries. However, power purchase agreement (PPA) are playing an increasingly important role in introducing private sector participants into the power sector and creating a more competitive electricity market.

- In 2017, Vietnam announced the development of a new pilot program that would allow commercial and industrial organizations to access renewable energy in the form of a direct power purchase agreement (PPA). In 2020, Prime Minister Nguyen Xuan Phuc reportedly asked for draft rules for implementation of this long-awaited PPA program.

    - The pilot program is a first-of-its-kind in Vietnam, which would expand the options for companies who are looking to procure renewable power to reach their goals in the country. Until now, purchasing energy attribute certificates (EACs), installing onsite solar and direct project investment were the only avenues to green power procurement in Vietnam. The new PPA model would, in theory, be a win-win for companies and the country.

    - For companies, it will increase competition in the wholesale energy market and be a direct avenue to satisfying renewable procurement targets in a historically restricted market.

    - Although energy market deregulation in Vietnam was already underway, this corporate pressure is directly shaping the programs.

- **Singapore:** Since 2001, Energy Market Authority (EMA) has progressively opened the retail electricity market to competition to allow business consumers more options to manage their energy cost. Instead of buying from SP Group at the regulated tariff, consumers can choose to buy from a retailer at a price plan that best meet their needs.. Since 1 November 2018, the Open Electricity Market was extended to all consumers across Singapore by zones. Close to half of all residential consumers have switched to buying electricity from a retailer since the electricity market in Singapore was fully liberalized two years ago, the Energy Market Authority said on May 2021.

- **Philippines:** The Philippine power sector underwent significant privatization following the passage of the Electric Power Industry Reform Act of 2001 ("EPIRA"), which now provides the principal regulatory framework for the Philippine electricity industry. It provides a good example of a developing economy whose power sector has transitioned (in the relatively recent past) from a largely state-operated model to a market-oriented model.

- **Taiwan:** Taiwan has a long history of state-owned power supply – Taipower was established in May 1946. The electricity sector has been regulated by Taipower for several decades, and the company's position as a monopoly maintains relatively low prices. In 2017, Taiwan's Electricity Act mainly focused on opening up the market for green energy. It was amended to allow the sale of renewable energy power direct to end users. Prior to the liberalisation of the energy market, only Taiwan Power Company (TPC) was permitted to be an electricity retailer. The CPPA market has seen significant growth since 2017, as underlined by the recent signing of the world's largest (920 MW) CPPA between Ørsted and Taiwan Semiconductor Manufacturing Company (TSMC) in July 2020.

- **Hong Kong:** Hong Kong has resisted the global trend toward electricity market restructuring and deregulation, and maintains two vertically integrated utility monopolies. However, the regulated market achieves impressive performances with relatively low tariffs, rare electricity disruptions, and quick service restoration following outages.

- **Malaysia:** The energy market in Malaysia and its participants are subject to a great deal of legislation governing the supply of electricity generally and the mining of energy resources. There are multiple regulatory authorities in Malaysia overseeing the various segments of the energy sector.

06 Retail Markets

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Australia Retail

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Energy demand in Australia declined overall in 2020 due to Covid-19

Energy demand in Australia declined in 2020. There was a drop in commercial load as businesses closed during lockdowns. This was partly offset by a rise in household consumption. Falling international fuel prices contributed to lower energy prices in local markets.

Maximum energy demand declined in response to Covid-19

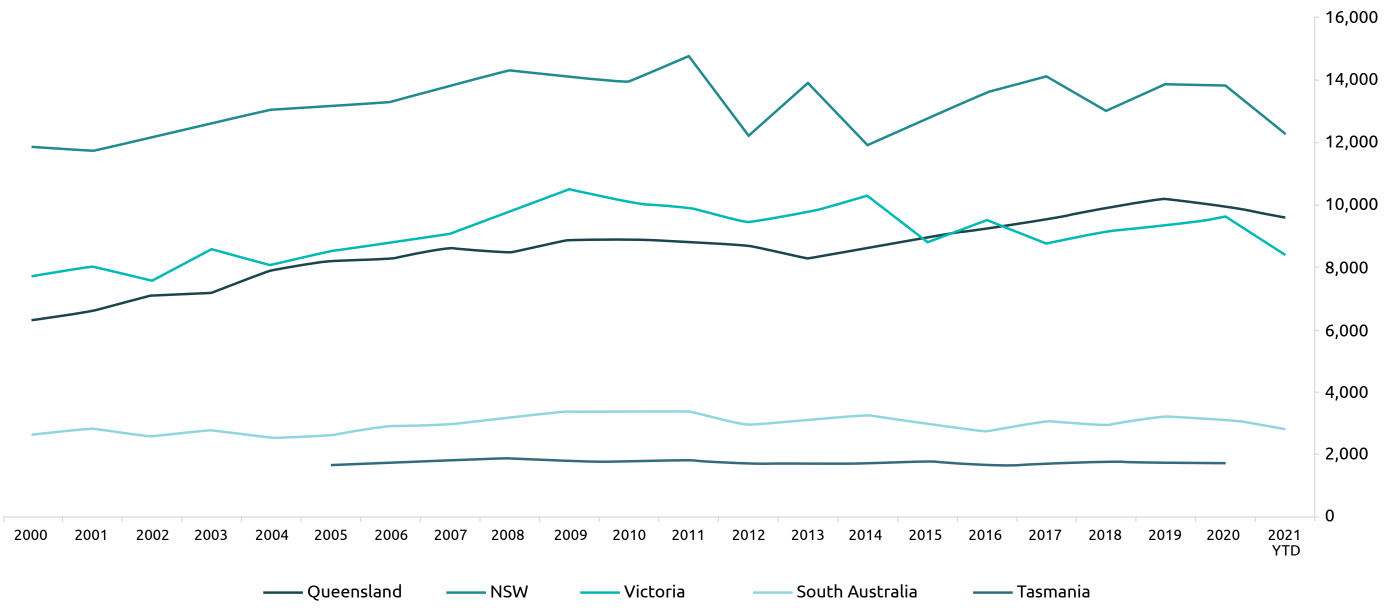
- Covid-19 caused a decline in overall electricity demand. Cultural and recreational services were restricted across all states during lockdown periods, which led to decreased commercial and industrial demand.
- Residential demand for electricity increased and offset the decrease in commercial demand.
- Many Australians adapted to remote working and some moved away from CBDs altogether. As a result, energy demand has shifted from the CBD to outer suburbs and regional cities, resulting in a more decentralized demand profile.
- Before 2025, higher residential sector demand partially offset lower electricity demand from the commercial and industrial sectors.

Managing minimum demand was the major challenge in 2020

- A key challenge for the Australian Energy Market Operator (AEMO) over 2020 was managing minimum demand.
- South Australia (SA), Victoria (VIC) and Queensland (QLD) all recorded their minimum demand in 2020 was approximately at noon. This was driven by mild temperatures and high rooftop solar generation.
- In VIC, demand fell to its lowest level in history of 2,539 MW on Christmas Day 2020.

FIGURE 1

Maximum grid demand by region



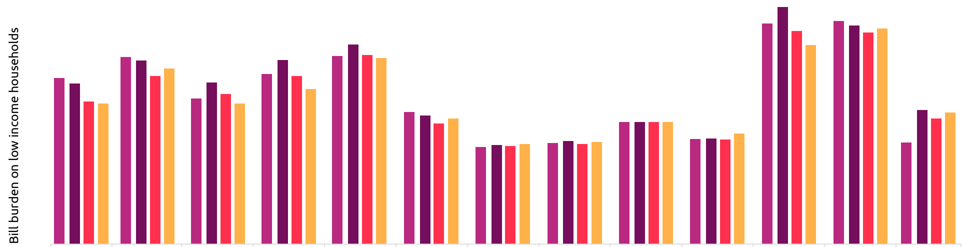
State of the energy market 2021Source: Clean Energy Australia 2021 report Data
Link - https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2021-data

Electricity affordability remains a key concern with an increase in residential demand due to the pandemic

In line with global trends, residential consumption rose significantly during lockdowns. Colder weather in some states was a contributing factor. At the same time, business consumption plummeted.

FIGURE 2

Electricity bill burden on low income households



	Energex (Qld)	Ergon Energy (Qld)	Ausgrid (NWS)	Endeavour Energy (NWS)	Essential Energy (NWS)	AusNet Services (Vic)	CitiPower (Vic)	Jemena (Vic)	Powercor (Vic)	United Energy (Vic)	SA Power Networks (SA)	TasNetworks (Tas)	Evoenergy (ACT)
2017	4.5%	5.1%	4.0%	4.6%	5.1%	3.6%	2.6%	2.7%	3.3%	2.8%	6.0%	6.1%	2.8%
2018	4.4%	5.0%	4.4%	5.0%	5.5%	3.5%	2.7%	2.8%	3.3%	2.9%	6.5%	6.0%	3.7%
2019	3.9%	4.6%	4.1%	4.6%	5.2%	3.3%	2.7%	2.7%	3.3%	2.9%	5.8%	5.8%	3.4%
2020	3.9%	4.8%	3.8%	4.2%	5.1%	3.4%	2.7%	2.8%	3.3%	3.0%	5.5%	5.9%	3.6%

State of the energy market 2021Source: Clean Energy Australia 2021 report Data
Link - https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2021-data

Household electricity affordability remains elevated.

- Power costs remain an issue in Australia, despite affordability had improved for some customers due to lower 2020 wholesale prices.
- In comparison to average income households, energy costs, as a proportion of income, doubled for some low-income households.
- In June 2020, electricity costs rose slightly to 2.7–5.9% of disposable income for low-income, energy bill concession households on the median market offer (compared to 2.7–5.8% in 2019).

Electricity affordability varies by state.

- In 2020, Tasmanian low-income households have the highest electricity costs to income ratio. The colder climate drives higher demand for heating. Low gas penetration is also a contributor.
- SA low-income households also experienced a relatively high average electricity costs to income ratio. In the National Electricity Market (NEM), SA has the second lowest electricity use, and its electricity prices were 16–49% higher than in other NEM regions.
- The Australian Capital Territory (ACT) had the most affordable electricity costs as a percentage of disposable income. They had relatively low electricity prices and higher average incomes.

"The pandemic is exacerbating energy affordability concerns. At a time when many consumers are experiencing reduced incomes, increased electricity consumption could lead to rising household debt and financial strain",

- Rod Sims, ACCC Chair

"We remain concerned about the level of residential debt, as detailed in this report, with a 16% increase in the number of customers in debt as of December 2020 compared to the previous year, and their average debt up by more than A$200",

- Clare Savage, AER Chair

While wholesale prices continue to drop, the average residential energy bill increased due to the increased residential consumption

Residential consumers' electricity consumption increased significantly during the pandemic. Small businesses were severely disrupted, and their consumption decreased.

Wholesale power prices fell

- Wholesale electricity prices fell to a five-year low in 2020. Between June 2018 and February 2021, median market offer prices for residential customers fell by 8–16% in QLD, 10–18% in New South Wales (NSW), 7–10% in VIC, 19% in SA, and 4% in the ACT.
- The states with the most renewable energy enjoyed the most significant wholesale price falls. Tasmania (TAS) recorded a 67% reduction, and SA's wholesale price fell below NSWs' and VIC's for the first time in 7 years.

Power bills increased in residential however fell for small business customers

The economic effects of the pandemic meant that many Australian households faced difficulties paying their electricity bills in 2020. When the crisis was at its worst, more than 1,000 customers per week sought payment assistance from their electricity retailers.

Installation of rooftop photovoltaic (PV) systems, primarily on residential and commercial buildings, and combined heat-and-power systems in industrial and some commercial applications, will account for more than 7% of total electricity generation by 2050, almost doubling the 2020 share of on-site power generators.

On average, residential customers across Australia experienced a 7% increase in their median Q3 quarterly bill. It increased from A$310 in 2019 to A$332 in 2020.

- The exception was in south-east QLD where residents benefitted from their Government's Covid-19 economic relief package. Their median quarterly bill decreased by 12% (A$33), even though consumption increased by 6%.
- In VIC, the median quarterly residential bill increased the most at 13% (A$40), followed by NSW at 11% (A$37).
- In SA, the median quarterly bill increased the least at 2% (A$9).

On average, small business customers across Australia experienced a 16% decrease in their median Q3 quarterly bill. It declined from A$554 to A$467.

- VIC had the biggest decrease at 19% (-A$104), followed by NSW at 15% (-A$90).
- In south-east QLD, the median bill decrease was 14% (A$73), despite the consumption rate had decreased at a smaller rate compared to VIC and NSW.
- In SA, the median bill decreased the least at 8% (-A$34).

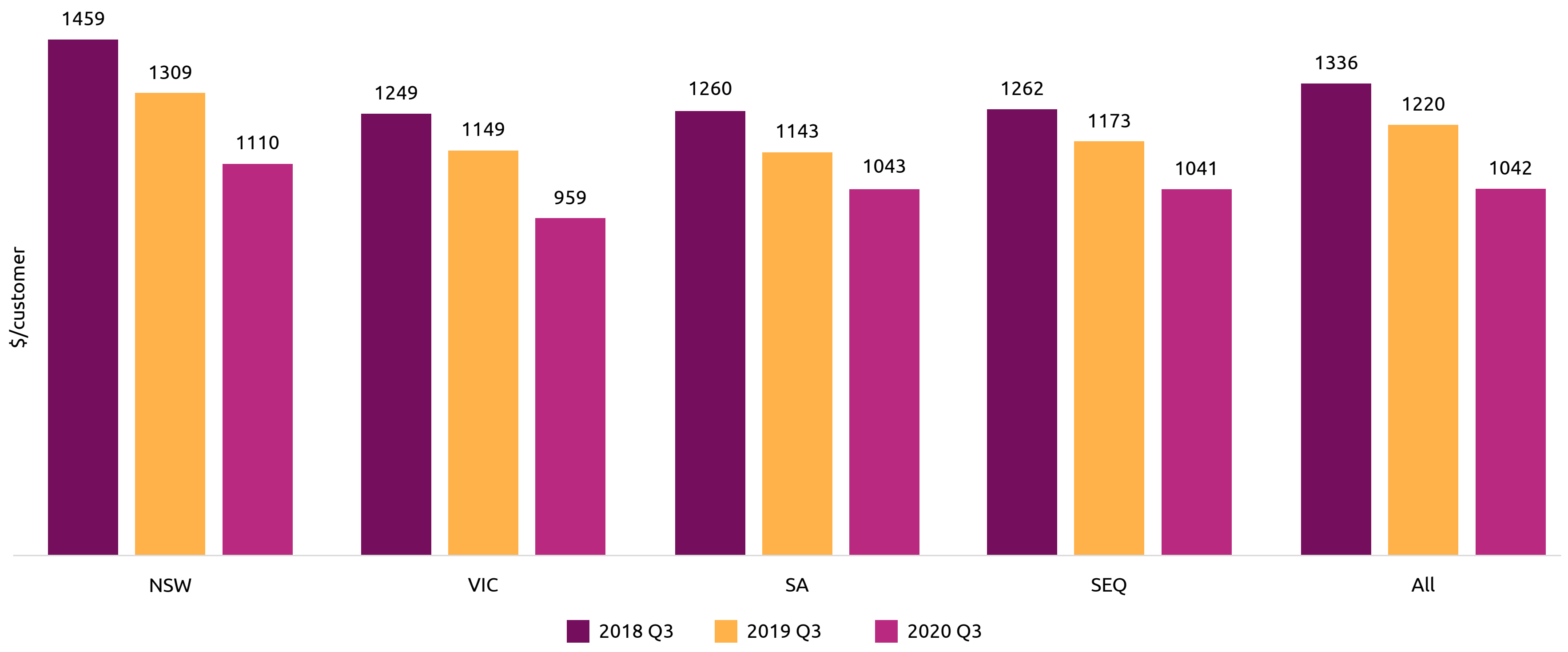
FIGURE 3

Quarterly bills for residential customers

Source: ACCC - Inquiry into the National Electricity Market
Link: https://www.accc.gov.au/system/files/Inquiry%20into%20the%20National%20Electricity%20Market%20-%20May%202021%20report%20v2.pdf

FIGURE 4

Quarterly bills for small business customers



Source: ACCC - Inquiry into the National Electricity Market
Link: https://www.accc.gov.au/system/files/Inquiry%20into%20the%20National%20Electricity%20Market%20-%20May%202021%20report%20v2.pdf

State and Federal Governments, as well as energy providers in Australia, supported consumers by ensuring affordable access to power and offering bill support in response to Covid-19

Federal Government

- In June 2021, the Australian Energy Regulator (AER) introduced the Statement of Expectations to provide extra pandemic protection and support. The AER continues to monitor the rapidly changing situation across all National Energy Customer Framework (NECF) jurisdictions.
    - In July 2021, a new standby statement applied to areas affected by stay-at-home orders in NSW. It provided additional protection for residential and small business customers until two weeks after the stay-at-home orders ended.
- In June 2021, the Federal Government committed to ensuring households and businesses could continue to access energy at an affordable price. The AER released compliance and enforcement priorities for 2021-22, including:
    - Effective identification of consumers in financial difficulty and payment plans offers that consider their capacity to pay;
    - Consumer access to Ombudsman schemes;
    - Registered generators' compliance with AEMO dispatch instructions and compliance with their latest offers;
    - Ensure service providers meet information disclosure obligations and other Part 23 National Gas Rules obligations;
    - Ensure timely and accurate gas auction reporting by registered participants.
- In May 2021, the Federal Government invested more than A$1.8 billion in the 2021-22 Budget to boost jobs, reduce emissions, and support affordable, reliable energy. Minister for Energy and Emissions Reduction, Angus Taylor said, "the Budget is supporting the Government's responsible and pragmatic approach to energy policy and emissions reduction, setting Australia up for a prosperous future as the economy continues rebuilding from the Covid-19 pandemic."
- In April 2021, the Federal and SA governments signed a A$1.08 billion State Energy and Emissions Reduction Deal. It will deliver secure, reliable and affordable energy to SA and help Australia continue to meet and exceed its emissions reduction targets.
    - Prime Minister Scott Morrison said, "This agreement will support investment and more jobs in South Australia and will be a key driver of our economic recovery from Covid-19."
    - Minister for Energy and Mining, Dan van Holst Pellekaan said, *"The inclusion of gas supply targets and regulatory reform actions in the agreement builds on the measures the Government has outlined as part of our gas-fired recovery from Covid-19"*.

"People enter into a contract when they sign up with an energy retailer. But businesses also have a deal, a social contract, with the community in which they operate,"

- Clare Savage, AER Chair

State Government and Energy Companies

- In June 2021, the QLD Government announced a A$2 billion investment into renewable energy and hydrogen through the 'Queensland Renewable Energy and Hydrogen Jobs Fund', as part of the Government's Covid-19 Economic Recovery Plan which increases the existing A$500 million Queensland Renewable Energy Fund by A$1.5 billion.

- Several State and Territory governments also introduced Covid-19 support packages for households.
  - In QLD, households received a A$200 utility payment to assist with their electricity and water bills.
  - In the ACT, holders of a utility concession received a A$200 rebate on their electricity bill.
  - The TAS Government capped price increases in energy bills for 12 months.
- In April 2020, energy networks across NSW, VIC and SA (Ausgrid, AusNet Services, CitiPower and Powercor, and SA Power Networks) announced a suite of measures to provide support to customers enduring hardship as a result of the pandemic. Discounted bills were provided from the start of April to the end of June 2020, where consumption was less than 25 per cent of 2019 levels. More than 600,000 customers were affected. Key objectives included:
  - Tariff relief for small and medium-sized business customers impacted by Covid-19;
  - Incentivizing all retailers to offer affected customers payment plans;
  - Ensure viability of small retail businesses;
  - Support retail competition.
- Large energy retailers also extended payment terms and suspended disconnections for customers experiencing hardship.

Although energy consumers experienced a significantly higher number of planned outages in 2020, the performance indices highlight stable and improved network reliability compared to 2019 when bushfires caused significant power disturbances

2020 was a much less eventful year for power suppliers in Australia. Milder weather and the absence of serious bushfires in 2020 meant improvements to the energy supply.

In 2020, the total minutes of supply increased on average, but so did the frequency and duration of planned supply interruptions

- In 2020, the average customer experienced significantly more total minutes off supply compared to 2019. This increase was driven primarily by the impact of the devastating bushfires which burned throughout the spring and summer of 2019–20. The bushfires destroyed thousands of homes and burned over 17 million hectares of land across NSW, VIC, QLD, ACT, Western Australia (WA) and SA.
- On average, in 2020, the distributors performed 17% better than their weighted System Average Interruption Frequency Index (SAIFI) targets and 3% better than their weighted System Average Interruption Duration Index (SAIDI) targets.
- According to the AER, across the NEM, lost supply events due to transmission failures have occurred 25 times or less per year since 2006. Since 2018, the unplanned minutes off supply has been increasing and increased by 27% in 2020 compared to 2019.

Coal fired generation outages

- Major unplanned outages in 2020–21 included Yallourn unit 1 (360 MW), offline for 4 months from July; Stanwell Unit 2 (365 MW), offline for almost 3 months from 20 December 2020; and Liddell Unit 3 (500 MW), offline for most of the 2020–21 summer following a significant transformer incident on 17 December.

“58% of household consumers and 64% of business consumers are worried that there will be frequent electricity outages in 10-20 years’ time”

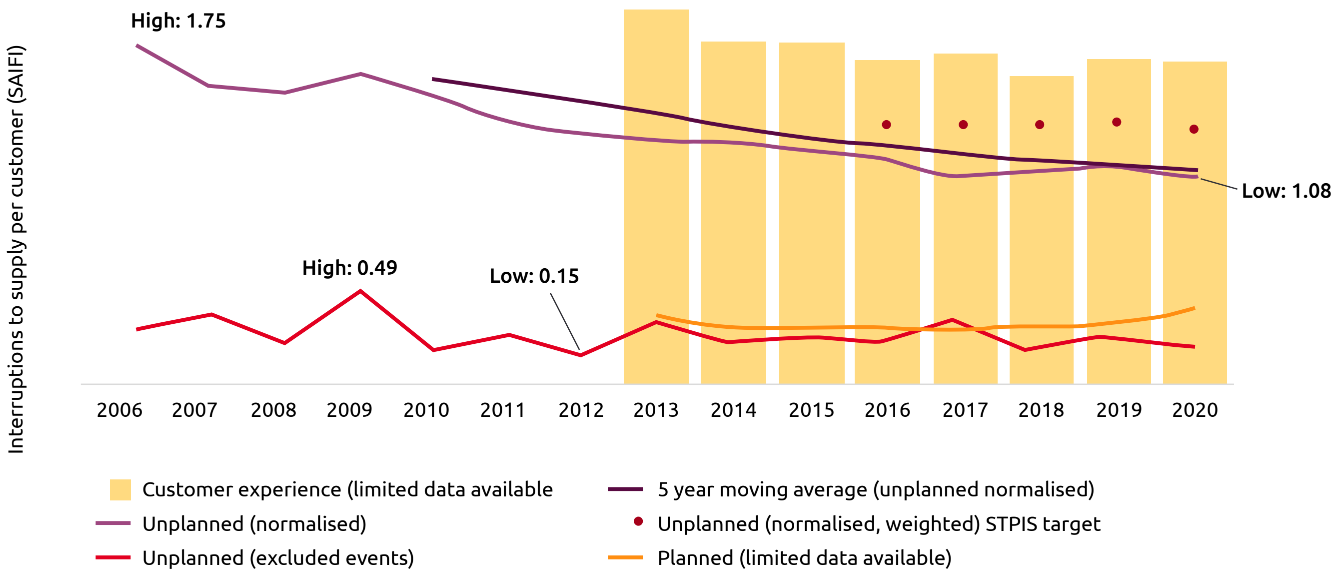
- Energy Consumers Australia 2021

“When there’s an upgrade to the network, cutting back trees or repairing outages, our teams are communicating with customers and our crews are working on the ground,”

- Andrew Dillon,
Chief Executive Officer Energy Networks Australia

FIGURE 5

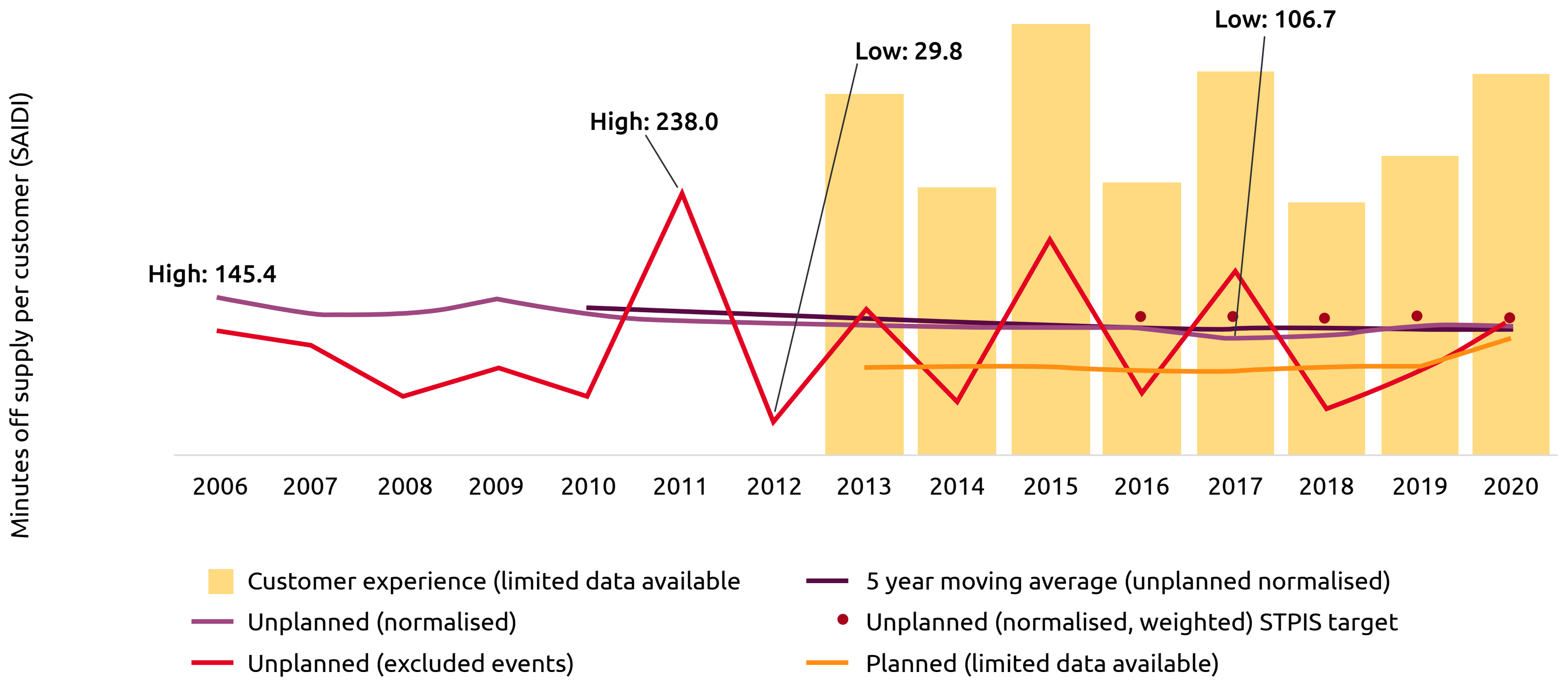
Interruptions to supply (SAIFI) – electricity distribution networks



Source: State of the energy market 2021 data
Link: https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2021-data

FIGURE 6

Minutes off supply (SAIDI) – electricity distribution networks



Source: State of the energy market 2021 data
Link: https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2021-data

Reduction of outages is still one of the most critical issues for electricity consumers

Outage management is a critical connecting point between grid operations and customer experiences with their retail energy providers. Lack of visibility, lack of communication and the inability to respond immediately to power outages continues to be a critical issue for power companies and is one of the key drivers of power customer dissatisfaction. Increased intelligence and automation within the distribution network will improve visibility for power companies, but critically, so is providing an interconnection of systems and data, e.g., creating a connection between Advanced Distribution Management System (ADMS), customer relationship management (CRM), billing and usage to provide the level of visibility expected by power consumers in the event of an outage.

Two examples of recent electricity supply outages handled promptly by the utilities affected

QLD was hit by widespread power outages after fire and explosions at Callide power station in May 2021

- Fire occurred in one of the turbine halls at CS Energy's Callide power station. As a result, the three units that were generating at the time went offline.
- The outage impacted 470,000 customers, of which 380,000 customers were in south-east QLD and 90,000 customers in regional QLD. In total, there was a loss of 3,100 megawatts of generation in QLD
- Response actions:
    - Powerlink, Energex and Ergon Network teams worked to progressively restore power as soon as it was safe to do so.
    - In response to the shortfall in available generation heading into the evening peak demand period, AEMO issued an actual Lack of Reserve 2 (LOR) notice and a forecast LOR3 notice identifying the potential for electricity demand to exceed supply in QLD.
    - QLD customers were also asked to voluntarily reduce their energy usage to assist in managing demand on the network. This notice was later cancelled due to sufficient power supply from generators returning to service around the state.
    - As a result of the action, power was progressively restored throughout the afternoon and the number of impacted customers continued to reduce. All south-east QLD customers affected by the power station issue were resupplied within two hours.

Mass blackout that left 100,000 WA homes in the dark in Jan 2021

- A fire at a privately owned power station sparked an outage which left approximately 100,000 homes and businesses across Perth, Kalgoorlie and Geraldton in the dark for several hours. The event was reportedly triggered by a generator in Kwinana failing to generate.
- Approximately 100,000 customers were affected by the load shedding. Suburbs across inner and greater metropolitan Perth were affected. Effect of that failure on the network led to two further failures at other power stations including Badgingarra Wind Farm and at a power station in Worsely, near Collie in the south-west.
- Response actions:
    - When the incident occurred, Western Power began "load shedding" (rolling blackouts) to prevent damage to the electricity network.
    - Firefighters were called to a power station on Leath Road in Kwinana following reports of a smouldering bearing in a turbine.
    - Almost 30 firefighters attended the power station and extinguished the fire with guidance from power station staff.
- As a result of the action, Western Power could restore power to approximately 80,000 homes within 4 hours.

Energy competition is increasing in Australia, and customer perceptions of energy providers are improving, however Australia's energy retailers experience some of the highest customer churn rates in the world, although recent trends indicate churn rates are declining

In Australia, consumer perceptions of their retail energy providers are historically low compared to satisfaction of retail customers of other industries. Customer satisfaction of their energy retailers are driven by factors including reliability, price, value for money, customer service, technology uptake and ability to switch.

Five states - QLD, NSW, SA, TAS and the ACT – apply a common national framework for regulating retail energy markets. VIC already has regulatory arrangements that are broadly consistent with the national framework.

Australian Energy retailers can be organized in different tiers:

- Tier 1 includes the big three: AGL Energy, Origin Energy and EnergyAustralia, which supply 64% of small electricity customers and 73% of small gas customers.
- In Tier 2, three retailers have significant market share in some regions:
  - Snowy Hydro supplies around 7% of electricity customers and 9% of gas customers. Its market share is highest in VIC, supplying 13% of electricity customers and 14% of gas customers.
  - Alinta Energy supplies 5% of electricity customers and 3% of gas customers. Its market share is highest in QLD, with 9% of electricity customers and 1% of gas customers) and SA (6% of electricity customers and 5% of gas customers).
  - Simply Energy, supplies 4% of electricity customers and 6% of gas customers, including 9–10% of customers in VIC and SA. It is the third largest energy retailer in SA.
- Smaller retailers, gained market share in recent times, increasing from 5% of small electricity customers in 2016 to 8% in 2020.

New participants have emerged in the Australian Electricity Market

- Since 2020, 11 new retailers have been authorized to retail electricity and 2 to retail gas. 5 new companies commenced selling electricity.
- 16 new retailers were authorized to sell electricity and 5 were authorized to sell gas in 2019–20. These are:
  - Electricity Retail: Localvolts, SmartestEnergy Australia, CleanTech Energy, CleanCo Queensland, Active Utilities Retail, Energy On, Energy Services Management, Radian Holdings.
  - Gas Retail: Energy On, Discover Energy, OVO Energy, Humenergy Group and Tas Gas Retail

Customer churn rates in Australia

Some Australian retail power markets witness the highest rate of market churn, i.e. the number of customers who change their energy providers, in the world. With many new providers in the market, margins have already been squeezed to the minimum. Australian utilities must identify new ways to attract new customers at a workable cost, service existing customers more efficiently and reduce customer churn.

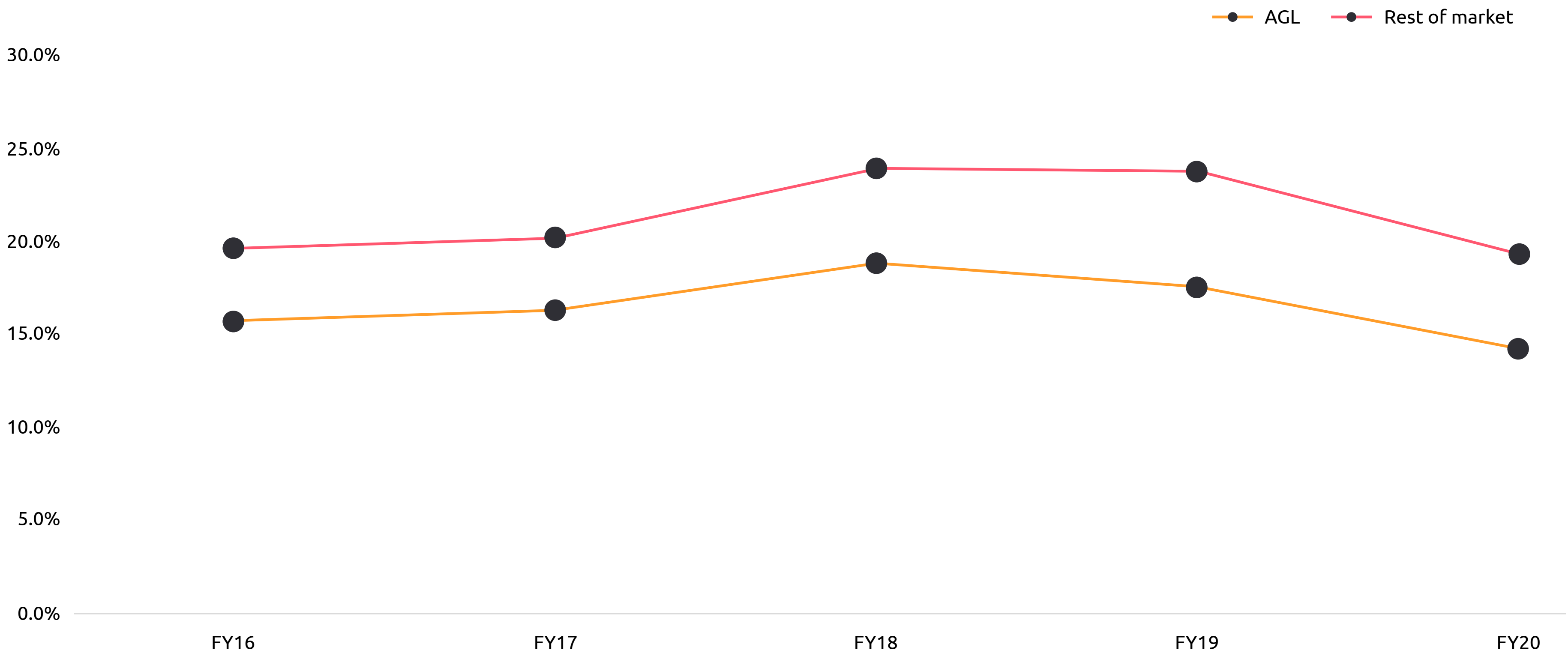
AGL stated a significant drop in churn numbers during FY20 due to Covid-19. AGL's churn rate has dropped to 14.3% in FY20 which is still lower than average churn experienced in the rest of the market.

"The latest assessment of consumer sentiment shows record levels of satisfaction with energy retailers and a "growing belief that consumers are getting better value for money". It represents the culmination of a positive trend since 2017"

- Carl Kitchen, Australian Energy Council

FIGURE 7

AGL Churn Rate compared to rest of the market - FY2016 - FY2020



Source: AGL
Link: https://www.2020datacentre.agl.com.au/customers/customer-churn

Renewable growth will have an enormous disruptive impact on all parts of the Australian energy ecosystem over the coming years

In Australia, consumer perceptions of their retail energy providers are historically low compared to satisfaction of retail customers of other industries. Customer satisfaction of their energy retailers are driven by factors including reliability, price, value for money, customer service, technology uptake and ability to switch.

Impacts of renewable growth on the Australian energy ecosystem

- ***Negative Wholesale Prices:*** With more low-priced renewable generation operating at times of low demand, the incidence of negative prices has increased. In 2020, there was a record number of negative prices NEM-wide, with 3,662 instances of negative spot prices across the five Australian NEM regions. Over 40% of these occurred in the fourth quarter, where prices reached a record low daily average in VIC, SA and TAS. Nearly half of all instances of negative prices in 2020 occurred in SA.

- ***Reduced Customer Cost:*** As an example of reducing customer cost of energy services resulting from renewable growth, according to the Clean EnergyAustralia Report 2021, SA's increased renewable energy generation has translated into significant price reductions, with the state recording the lowest wholesale prices in the NEM for the last four months of 2020. In recent years, the phenomenal growth of rooftop solar resulted in record low demand for grid power in several states in 2020. While this is a positive development for emissions reduction and electricity prices, it also makes it increasingly difficult to maintain the security of the electricity system.

- ***Risks to System Security:*** The transition to a more renewable generation mix poses twin challenges to system security.

  - Firstly, inverter-based resources such as wind, solar PV and batteries have only recently been configured to support frequency control and provide system strength in the same way as coal, gas and hydro plants. But more work is required to procure and integrate these services from inverters. Secondly, those resources require system strength to ride through faults and meet performance standards.

- ***Whole of system plan (WoSP) modelling:*** The WoSP is a 20-year outlook and detailed plan developed by Western Power, the State Government, EPWA and AEMO. It documents how the generation, management and distribution of energy in the south-west interconnected system will change over the next few decades, and what needs to be done to respond, such as the investment or infrastructure required. The WoSP modelled four scenarios for WA's main grid, with renewables expected to account for at least 70% of generation capacity under all four scenarios by 2040.

Wind was the preferred form of large-scale capacity in the WoSP, with the highest demand scenario expected to see more than 3000 MW of new wind capacity added over the next 20 years. In particular, the WoSP modelling identifies an opportunity for energy storage facilities such as batteries to enter the market (across all scenarios), mainly to provide certain energy services such as frequency control.

- ***Financing for Battery Developments:*** Traditional project finance sourced from the commercial bank market has provided a source of financing for a number of battery developments. In this context, committed offtake arrangements with state government (or relevant state government agencies) or other credit-worthy off-takers is a key factor as is certainty of transmission connections to the grid, reliable technology and availability of funding from ARENA and CEFC to bridge any funding gap.

  - For example, Vena Energy's Wandoan South Battery Energy Storage System in QLD reached financial close in December 2020 solely utilizing debt sourced from the commercial bank market of key importance was the fact that the project had secured a 15 years offtake agreement with AGL and adopted a traditional procurement and delivery model with a fully wrapped EPC contract.

- ***The QLD government*** is investing A$145 million to establish three ***Queensland Renewable Energy Zones (QREZ)*** across the state to more renewable projects, attracting new industries, and supporting the achievement of Qld's targets for 50% renewable energy by 2030, and net zero emissions by 2050. It is an auction model run by the state-owned renewable company CleanCo.

- VIC government's developing six renewable energy zones. Part of a A$1.6bn clean energy commitment, which will be used to buttress and make best use of the solar and wind-farms built to meet a state renewable energy target.

- The NSW government laid out plans to deliver Renewable Energy Zones, more energy storage including pumped hydro, and measures to improve certainty for investors. As part of the plan, the government to introduce Electricity Infrastructure Investment Safeguards, a framework for offering long-term agreements to projects dependent on their type which will be awarded through a competitive reverse auction process.

"Network overload from renewables will only get worse unless there is a co-ordinated response from regulators, state governments, the federal government, network owners and household energy suppliers"

- Renewable Integration Study, 2020

Affordability is the key reason customers change Energy providers in Australia. For relevancy in an increasingly competitively energy market, Australian retailers need to drive simplicity and ease of management through engaging service delivery and customer interactions.

Australian Competition & Consumer Commission (ACCC) conducted research on consumer preferences and expectations through the Energy Consumer Sentiment Survey (ECSS) in August 2020. The research revealed that the Australian energy consumers are least satisfied in the area of value for money and hence they expect the retail energy market to prioritize the affordability of the consumers the most. The report highlighted that consumers preferences have shifted and now geared towards contributing to the clean and inclusive development of the energy system in general.

These survey insights apply not only the customer preferences towards their retail providers, but also towards their transmission and distribution providers. For all participants across the energy value chain in Australia, understanding customer preferences and being armed with the right level of insight to enable the appropriate response is the most critical focus that utilities organisation need to have strategically.

FIGURE 8

Consumer vision and expectation for the future retail energy market

Affordable	Simple	Easy to manage	Clean	Inclusive
Consumers doesn't like rising energy prices and feel they are being over-charged by energy companies. Lower prices are always a key desire and fundamental to a better energy future.	Energy bills and plans consistently confused and overwhelmed consumers who struggled to understand the breakdown of costs and found comparing providers near impossible. A better future mean simplified with more comprehensible information.	Apps, real-time information and smart homes were examples of technology to assist energy management, which would improve the lives of individuals into the future. This did not mean technology that to control of everything, but gave consumers options and automated energy, saving behaviors.	An over-whelming number of consumers believe that renewables were the future and wanted Australia to be a country that move towards a small carbon footprint. The ideal future involved adoption of more sustainable energy sources and an eventual shift to renewables.	Most consumers felt they did not know much about the energy sector and felt powerless. Further, some consumers wanted to have a say regarding the future of energy but felt they didn't have an information based to do so. Empowering consumers through information and a platform to have a say if desired, were seen to contribute to a better future.

Source: ACCC
Link: https://ecss.energyconsumersaustralia.com.au/sentiment-survey-june-2021/

Reflecting competition and the rate of customer churn, Australian retailers are responding by focusing digitisation efforts on the transformation of customer experience and customer journeys

Some examples of customer experience related initiatives of Australian largest retail utilities: AGL, Origin Energy and EnergyAustralia:

AGL transformed its digital customer experience with Khoros

- AGL was conducting in-house social media support on Twitter and Facebook until the expansion of thair social media team and audience necessitated collaboration with Khoros to build an intelligent, contextual FAQ integration on their website leveraging the Khoros REST API which allowed customers to easily find answers to commonly asked questions promptly.
- AGL customers now have access to content and support in a way that helps them build trust with the brand and feel empowered as consumers.
- AGL is also leveraging Khoros Marketing and Care to respond to customers on social platforms in real-time.

Origin Energy powered self-service expansion with Amazon connect

- Under Retail 2020 transformation, Origin Energy deployed Amazon Connect, a cloud-based contact center platform that provides smart interactive voice response (IVR) capabilities for the company.
- Previously, customers had to call up, go through messaging with an agent and talk about the plan that they're going on. But now the Amazon Connect solution is allowing its 4 million-strong customer base to get the benefit of self-service options.
- Amazon Connect is helping to reduce call transfers, speed up resolution times, free up agents to handle higher-value call types, and introduce a greater degree of self-service to many types of interactions.

EnergyAustralia empowered customers to choose multiple services in a single platform

- EnergyAustralia in partnership with Acurus, a Melbourne based ICT multi-product enablement company, has launched an innovative product, Stack On, that allows eligible customers to save time and money by bundling a range of utility, data and insurance services and manage them all in one place.
- The goal of the product is to make customers confident by providing consumers the opportunity to choose services provided by some of Australia's biggest brands - EnergyAustralia, Optus and Open Insurance on a single platform.
- The solution is currently offering limited access as it is going through initial trials through EnergyAustralia's own innovation trailing platform. The platform uses customer insights to mature the solution before making it widely available.

Learnings from other industries for utilities companies

Digital customers have new expectations:

- Traditional utility business models do not prioritize high levels of customer interaction. Slower adoption of digital tools for self-service and attention to customer experience has undermined the trust needed to build strong customer empathy and satisfaction.
- Through digital technologies and tools, utilities can now design new experiences as they roll out new products and services to build goodwill, similarly to the experience of AGL, Origin Energy, and EnergyAustralia.

Learnings from Telecom sector:

- One industry that generates considerable data about their customers' experiences is telecommunications. Faced with an aggressive marketplace, telecoms operators have had to adapt and innovate to defend their market position and secure new revenue streams.
- For utilities, one of the game changers in accessing customer insight, and knowledge about how their customers operate is smart meters. Deployment of smart meters will have a critical role in driving utilities to create the capability to create customer insights at scale and building services that align with their customers' preferences.

Utility and High-tech:

- There has been a transition from standalone, licensed software to digitally connected software-as-a-service (SaaS) across the IT industry. The utilities industry is also going through a similar transition from one-way power delivery to digitally connected two-way asynchronous interactions.
- Utility companies will have to rethink their business models in the context of this transition to subscription-based services, to create new recurring revenue opportunities. Since Utilities have the advantage of being subscription-like, they can learn how to drive and grow value to earn monthly fees and renewals.

Australian utilities are focusing on innovation to better capture the market, cut costs and drive efficiency

Regardless of where utility companies sit in the energy value chain, the customer is the focus of digital reinvention

- The Australian energy sector is on the cusp of change, and for all utilities, at the core of that change must be the customer. This is regardless of what part of the utility value chain an organisation is operating in - a retailer, a transmission and distribution company or an operator of renewables.
- For all utilities, and amongst infrastructure operators particularly, cost cutting, and efficiency is a high priority, but efficiency-based change should be considered within the context of the ability of the business to deliver the services customers require and seek on the most efficient and effective basis. Operations-based innovation and transformation must be centred on how the physical assets managed by utilities enable innovation, new services and new capabilities aligned with the requirements that customers have. Investing in the intelligence of the grid and integrating physical operations with customer processes is an enormously important source of value creation for utilities and the customers they serve. For many utilities in Australia, these ideas mean a fundamental reassessment of business modesl, operating models and what the digital priorities are going forward.
- Most of the energy companies in Australia aren't doing justice to their potential when it comes to enabling their transformations with digital capabilities. There is a requirement to redefine business models digitally to drive the genuine productivity gains that can help create customer, community and shareholder value.

There are some great examples of Australian retailers who have brought innovation to the sector.

- Origin Energy and AGL have partnered with UK-based disrupters Octopus Energy and OVO Energy to bring better customer experiences and capture market share. Both OVO's and Octopus' solutions use a hybrid approach to scale, enable direct business-to-consumer models in some markets and business-to-business models in others, to provide an end-to-end superior customer and employee experience.
    - Origin Energy adopted the leading operating model and technology platform offered by Octopus to deliver significant benefits for their customers, employees and shareholders.

- AGL partnered with OVO Energy in a joint venture that allowed AGL to license their intelligent energy platform to offer customers real-time information and provide control over their energy use, using smart meters, home solar and batteries, and electric vehicle to grid (V2G) charging technologies.

- Simply Energy partnered with Rheem Australia and SA Power Networks to launch an Active Hot Water Control project aimed at increasing the uptake of renewable energy and improving Southern Australia energy system.
  - The project hopes to bring new and flexible options for grid management by testing ways to use home heating systems for energy storage and to help maximize the use of renewable energy and improve the stability of the local electricity network. The project was launched under Rheem Australia's renewables brand named "Solahart".
  - The project has the potential to deliver both cost savings and a route to further grid stability in SA where rooftop solar power has reached record levels and was awarded funding from the Australian Renewable Energy Agency (ARENA) as well as the SA government.

- EnergyAustralia, in partnership with a Brisbane-based startup Redback Technologies, launched the Redback Smart Hybrid System that combines a solar inverter, battery enclosure, and cloud-based energy management software into a unit that can be mounted inside or outside the home. The solution offers an "all-in-one" solar, battery, and software solution aimed at providing consumers with greater visibility over their energy consumption.

- Powershop partnered with UPowr to offer customers an easy, stress-free and innovative way to get solar. UPowr is a digital solution that uses advanced 3D modelling considering roof orientation, tilt and shading to design quotes and systems specifically for a particular roof. UPowr is able to provide estimates on how much the system will generate and what the customer is likely to save based on past energy usage.

Connecting with start-ups to nurture utilities innovation.

Free Electrons is a global accelerator program seeking the next generation of ideas in energy innovation and aims to connect the people with these ideas to major utilities currently serving more than 70 million customers in 40 countries. Leading Australian utilities AusNet Services and Origin Energy are the founding members of the consortium and share a commitment to innovate and work collaboratively with energy entrepreneurs to transform the energy market by leveraging cutting edge solutions.

Surging renewables uptake and the increasing importance of energy, how it is sourced and what the relationship is between customers and energy suppliers, will drive innovation in the Australian energy sector

Penetration of smart meters in Australia is continuing, but outside of VIC, the penetration of smart meters is still low

- VIC was the first state to progress metering reforms. Its electricity distribution businesses rolled out smart meters from 2009 to 2014. As per AER's state of the energy market 2021 report, around 98% of small consumers in Victoria have a smart meters.
- In February 2021, NSW had the highest penetration of smart or interval meters, at around 25% of residential and small business customers. Smart-Meter installation levels in other states ranged from 15% of customers in QLD to 23% of customers in the ACT.

The relationship between energy and consumers is changing

- Sustainability, climate change and net-zero targets have shifted the importance of energy as a product for consumers. It is no longer simply a necessary service: Where the energy comes from, how it is generated, how it is consumed is now increasingly important.
- Associated with the above, take up on renewables is creating new roles for customers in the market. Renewables at scale not only distributes energy resources but also disrupts the basis of service delivery and changes the nature of relationships between energy providers, infrastructure managers and customers.
- As an example of the nature of changing relationships and in order to reach out more directly to its end customers, T&D operator Ausgrid has trialed what it says is the first of many community batteries in the Sydney suburb of Beacon Hill. Through the battery trial, Ausgrid is seeking to engage its customers who have solar panels already installed or who are planning an installation. Through the battery, Ausgrid will provide storage on a shared basis so that individual customers don't have to make individual storage investments. Ausgrid intent to implement more batteries of this type in areas of high solar uptake across its network.

Multiple utility firms are innovating new services to customers

This environment for innovation drives the need for new business models to access new revenue streams. Below are selected recent examples:

- ***AGL has launched smart home kits:*** In September 2020, AGL announced a new range of smart home kits to assist customers to reduce their energy bills through automated energy efficiency improvements. The kits, which contain different smart home devices, consist of voice-activated lights, energy monitoring plugs, smart controllers for split air conditioning systems and smart speakers.
- ***Mojo Power Retail Marketplace "Elemental" provided by WePower:*** The new Mojo Marketplace serve Mojo Power's small business and corporate customers and is the first full-featured version of WePower's "Elemental" to be deployed in the Australian market.
    - WePower's Elemental Marketplace has been designed to enable electricity retailers to offer renewables-linked retail electricity contracts to business and corporate customers.
    - Mojo's customers can purchase locally-sourced renewable energy as a standard retail electricity contract – a novelty in the Australian retail electricity market.
- ***Social Energy launched in Australia with an aim to reduce electricity bills to as little as A$0 for customers who buy a solar and battery system:***

- Smart energy retailer Social Energy entered in Australia market to offer customers its service that reduce electricity bills to zero, with a completely green energy package and exclusive Duracell home solar battery system.
- The green energy retailer uses its artificial intelligence platform and virtual power plant technology to optimize solar-connected battery storage.
- Social Energy is working with Duracell, a consumer battery company, to provide access to consumers with its' lithium-ion Duracell Energy Bank 2, scalable to different sizes to meet indoor and outdoor needs of every home.
- Innovative energy retail start-up Amber Electric provides its customers direct access to wholesale electricity prices: Customers pay a fixed monthly subscription ($15 a month plus tax and insurance) plus a variable usage charge. Customers can adjust their consumption in response to wholesale electricity price spikes and the share of renewables supplying the grid. Total cost to the customer is limited by Amber, for example to the Victorian Default Offer (VDO) in VIC.

How is the Australian Energy Market Expected to Change?

In comparison with some other energy markets around the world, particularly Europe, the Australian energy sector has been slow to innovate, transform and change. This is the case even in Australian states where competitive retail markets are operating. As the Australian market faces this period of considerable change, there will be an increasing requirement for providers to understand and respond to the impact these changes have on their operations.

Changes the Australian power market will experience:

In its State of Energy report 2021, AER set out several key areas where change is expected in the market:

- Wholesale prices are forecast to fall which will drive electricity retail prices lower.
- The market share held by Tier 1 retailers including AGL, EnergyAustralia and Origin and primary regional retailers including Ergon, Aurora and ActewAG continued to decline this quarter. More customers are moving to Tier 2 retailers.
- The pandemic continued to have an impact on energy debt amongst energy consumers.
  - The number of residential gas and electricity customers in debt in Q3 2020-21 was 178,167 compared to 161,117 for Q3 2019-20.
  - Average residential debt for gas and electricity at the end of Q3 2020-21 was A$1,021, which increased from A$826 in Q3 2019-20.
- In coming years, customers are anticipated to increasingly store surplus energy from solar PV systems in batteries and draw on it when needed. In this way, customers will reduce peak demand for electricity from the grid. This will allow distributed energy resource (DER) owners to better control their electricity use and power bills, while taking initiative on environmental concerns. If DER is properly integrated with the power system, they could also help manage demand peaks and security issues in the grid.
- Batteries will play an increasing role for energy consumers in managing their power requirement, and consumers could be paid by energy suppliers to reduce their energy use or inject stored electricity when the grid is under stress. Technological advances that make battery storage more economical will accelerate this shift.
- The pace of electric vehicle (EV) uptake is anticipated to have a significant impact on electricity demand and supply. Charging EV batteries to likely generate significant demand for electricity from the grid and it may also provide electricity back to the grid at times of high demand.

Implications for retailers:

- Consumers expect flexible service offerings that can combine their own demand and generation patterns with local community offerings while at the same timeprovide the same level of safety and reliability of supply of the traditional offerings. According to Energy Consumers Australia, most Australians still buy electricity on a monthly or quarterly based billing cycle which is only distantly connected to everyday decisions. Consumers are interested in new and different approaches to how they access electricity which also includes consumers who are in vulnerable circumstances and struggling to pay their bills.
- In the future, the electricity system is planned to be 100% renewable and storage based, which will prompt consumers to be more flexible in their use of electricity.
- While it is evident from the examples referenced, there is progress in the Tier 1 and Tier 2 retail space around new business models. Retailers need to continue to develop and implement new digital based business models to support the strength and resilience of the overall system while making it easier for consumers to benefit from the choices. If prominent retailers fail to transition their service capability in line with consumers requirements, the opportunity for smaller players and new entrants like Amber Electric and Powershop, who are more future focussed, will continue to grow.

Implications for distribution network service providers:

- Distribution businesses need to work with AEMO and market participants to develop an integrated model for the energy system of the future and the future role of distributors i.e., the role of distribution system operators.
- There is an opportunity to do more to continue the journey of driving customer centric business models and culture.
- Grid modernization for flexible renewables integration and grid stabilisation needs to continue to be a focus.
- Continuing to embrace digital to reduce the cost of grid operations is a must.

"A small but growing fleet of electric vehicles on our roads also continues to prompt policy debate about network charging"

– AER State Of the Energy Market 2021

"Customers needs to be the single biggest driver for regulated monopolies, which have historically had a different lens. To be a sustainable business, we need to be customer focused."

- Jason Clark, Executive General Manager, PLUS ES

Key Takeaways: Australian energy retailers operate largely traditional business models. Accelerating renewables growth, changing customer expectations and new technologies puts increasing pressure on their business models and service offerings

Overall energy demand decreased in 2020, but energy affordability remains a challenge especially for low-income households

- Falling international fuel prices and low-cost renewable generation flowed through to households resulting in lower cost energy.
- Power is still a significant household expense item, particularly for low-income households which still pay more than double energy cost as a proportion of income.

While wholesale prices continue to drop, the average household bill rose due to increased residential consumption

- Between 2017-2020, median market prices dropped between 4-19%, depending on state.

- However, despite the fall in market prices, in 2020, residential customers experienced a 7% increase in their median quarterly bill from A$310 to 332. This was a consequence of the Covid-19 pandemic causing an increase in power utilization for residential customers at home. However, in contrast, business customers who were disrupted by the pandemic, particularly in the small business segment, heavily impacted power utilization.

- The AER introduced a Statement of Expectations to provide extra protection and support to customers and the market through the Covid-19 pandemic.

Although customers experienced significantly more time off supply primarily due to bushfire and weather events, the performance indices highlight stable/improved reliability performance of the grid operators."

- The average customer experienced a significant increase in total minutes off supply in 2020.

- Distribution companies beat their interruption frequency targets (SAIFI) by 17% and performed 3% better against their interruption duration targets (SAIDI).

Australia's energy retailers continue to experience one of the highest customer churn rates in the world, though Covid-19 has significantly reduced churn.

- Australia's average churn rate in 2020 was 23.9%. While this is still a record high on a global level, it is a significant drop from 19.4% in 2019, driven by Covid-19.

- In a very crowded market, retail companies are racing to differentiate themselves, not just in price, but customer service, transparency and reliability to increase "stickiness".

Renewable growth will have enormous disruptive impact on all parts of the Australian energy ecosystem over the coming years

- 2020 saw a record number of negative wholesale electricity prices in the NEM.

- Renewables are driving significant cost reductions for end consumers as well.

- Inverter-based generators such as wind, solar and PV are still causing stress on the traditional grid, although new technology solutions to support frequency control and system strength are emerging.

- While state and federal government continue to support and subsidise renewable investments, initiatives are emerging that are solely funded by market financing.

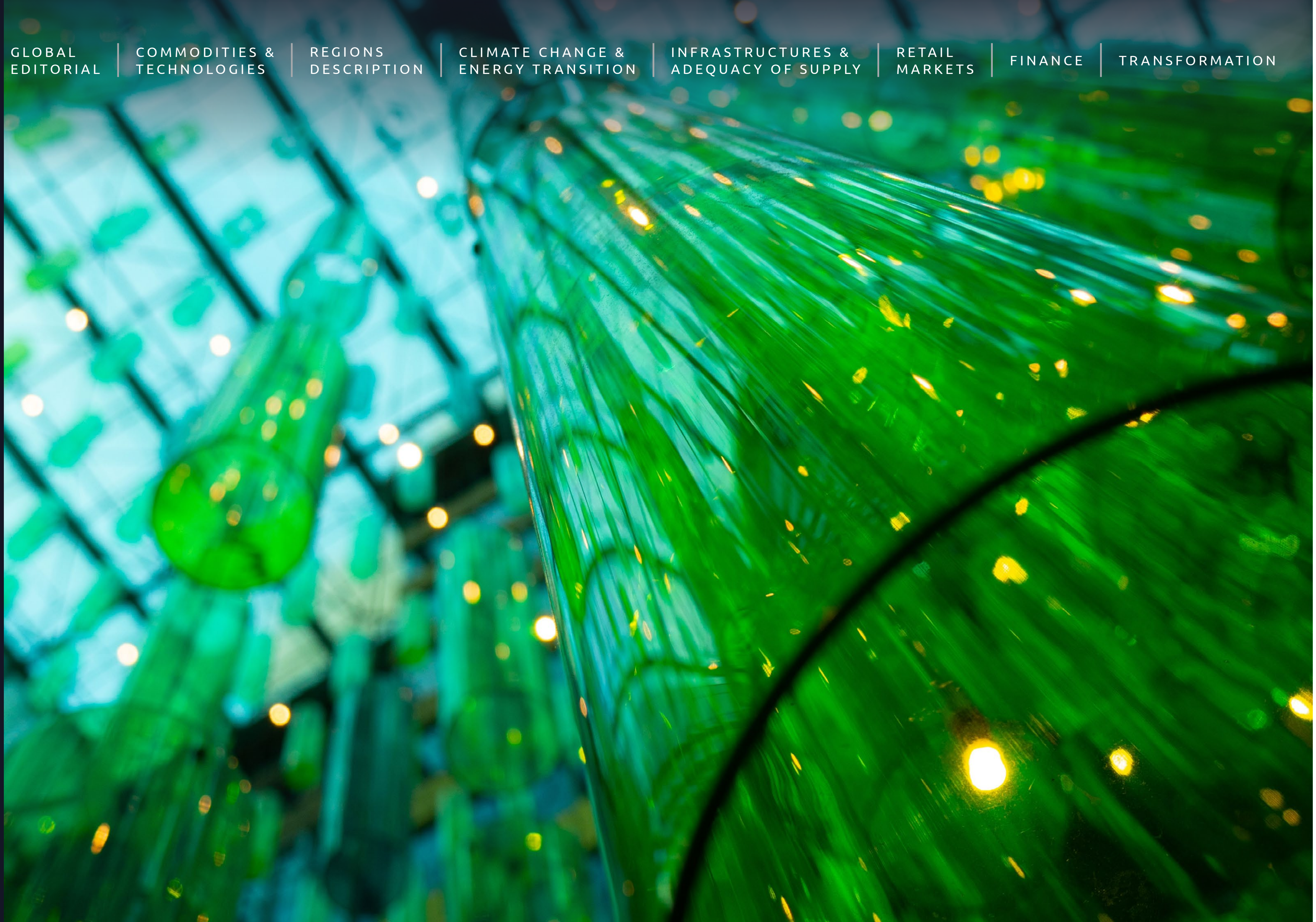
- Renewable energy combined with investments in the grid to create more autonomous and intelligent grid response, will create the environment for customer solution innovation at an individual, household, community and regional level.

Operating in high churn markets has led Australian retail utilities to prioritise digital investments around customer experience and journey transformation

- Energy customers have developed new expectations from their experiences in other industries. Changing attitudes to renewable energy, the customer's relationship with their energy provider and preferences relating to the sources of energy for example will continue to drive changes in customer preferences that retail utilities will need to respond to.

- Power utilities have an opportunity to learn from the experience of other industries such as telecommunications and banking, who have similarly managed negative customer perception in highly competitive retail marketplaces.

07 Finance



07 Finance

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07 Finance

Europe Finance

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Dashboard of the Main Energy & Utility Companies in Europe

Seven indicators are going to be analyzed to give an accurate view of the operational and financial performance of the companies within this panel, including:

- Revenues
- Net debt and earnings before interest, taxes, and amortization (EBITDA)
- EBITDA margin
- Stock performance
- Dividend yield
- Credit rating
- CO2 intensity

Based on the above indicators, utilities are divided into three groups: **Leading** (those well ahead of average on a given indicator), **Average**, and **Lagging** (those below the average on a given indicator).

At a glance: 16 European utilities Our sample includes the 16 major European utilities, based in 10 different countries. This sample presents a good view of the European energy sector's evolution covering coal, gas, nuclear, and renewables production. This table should be read in conjunction with the analysis and comparisons that follow.

A dynamic comparison is done for each utilities (group of utilities) in order to determine whether its performance has been ahead of the previous year or not. This analysis also takes into consideration how well the utilities of the studied panel overcame challenges related to the COVID-19 crisis.

FIGURE 1

Dashboard of the main energy & utility companies in Europe

Company	Country flag	MARKET CAPTALIZATION (€BN) AS OF 3rd SEPT 2021	NUMBER OF CUSTOMERS (MILLIONS)	RENEWABLE ENERGY SHARE AS % OF TURNOVER (0-20% | 21-50% | 51-100%)	GEOGRAPHIC MIX AS % OF TURNOVER (Europe, North America, Others, South America)
Enel	Italy	79	68.5		
Iberdrola	Denmark	68	34		
Ørsted	Spain	56			
Engie	France	29			
EDF	France	35	37.9		
E.ON	Germany	29	53		
RWE	Germany	23			
EDP	Portugal	19	9.36		
Fortum[1,2]	Finland	23	2.4		
Naturgy	Spain	21			
SSE	UK	20	3.6		
EnBW	Germany	21	5.5		
Uniper[3]	Germany	12			
CEZ	Czech Republic	15	>7		
Centrica	UK	4			
Vattenfall[4]	Sweden	-	14.2		

1 Geographic mix including Russia
2 Renewable energy share as % of capital expenditure
3 Geographic mix including Turkey
4 Non-listed company

Sources: Annual reports, Bloomberg, various sources

2019 and 2020 revenues in € billion and CAGR 2015-2020

Due to the negative impacts of the COVID-19 crisis on the economy, utilities decreased their revenue by an average of 9.7% in 2020.

- In 2020, utilities faced a fall both in demand and in commodity prices. These two issues, combined with mild weather and the growing penetration of renewables, resulted in a significant drop of spot prices in wholesale markets.
- Yet, utilities managed to soften the negative effects of the pandemic on their revenue thanks to resilient hedging strategies on futures markets.
- The global evolution for our sample* shows an average decrease of 9.7% in revenue compared with 2019.

A leading group overperformed thanks to changes in portfolio (M&A).

- **Fortum** showed the highest revenue increase in 2020 (+800% compared with 2019), mainly explained by its increased ownership in Uniper from 49.99% to 76%. Notably, its Generation segment faced lower achieved power price and lower nuclear volumes, partly offset by exceptionally higher hydro volumes in the Nordic regions.
- **E.ON** grew their revenue by 49%, with sales of €60.9 billion in 2020. The increase was largely explained by the integration of Innogy Group for the entire year.
- **RWE** managed to increase their revenue by 4%, from €13.125 billion in 2019 to €13.668 billion in 2020. On one hand, this was due to the successful acquisition of E.ON's renewables business and favorable weather conditions, enabling high wind farm utilization with payments exceeding market levels. On the other, the company achieved higher market prices for the electricity generation of its conventional power plants than in 2019.

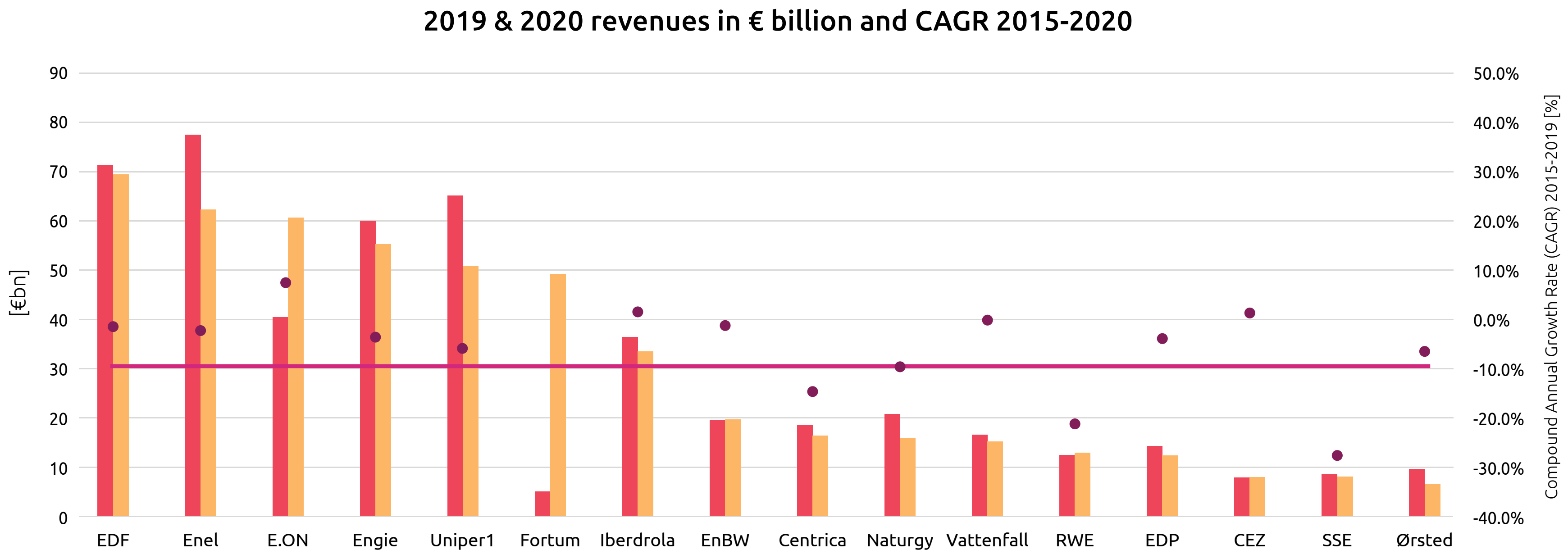
Most utilities in our sample faced a decrease in their revenue due to the simultaneous drop in energy demand and prices caused by the COVID-19 crisis.

- **Ørsted** lost 29% of revenue due to significantly lower power and gas prices, lower volumes sold, a drop in thermal heat and power generation, and the limited construction work on wind farms for its partners during the pandemic.
- **Naturgy** lost 26% of revenue due to lower energy demand and lower energy prices compared with the previous year. In addition, its revenue was eroded in Latin America since the COVID-19 crisis had a negative FX impact on Latin American currencies.
- **ENEL** faced a 19% drop in revenue due to three main factors:
  - First, the pandemic led to lower power sales in Italy and Spain.
  - Second, the depreciation of currencies in Latin America combined with lower volumes and electricity sale prices resulted in a decrease in revenue in this region.
  - Finally, gas sales to end users in Italy and Spain were significantly lower.
- It is also notable that the general slowdown in collections of accounts receivable eroded the revenues of utilities, resulting from the regulation adopted in certain countries.

** E.ON, Uniper and Fortum have not been considered for average revenues evolution because of important perimeter changes.*

FIGURE 2

2019 & 2020 revenues in € billion and CAGR 2015-2020



1 2016-2020 CAGR
Disclaimer: E.ON, Uniper and Fortum have not been considered for average revenues evolution because of important perimeter changes.

2019 Revenue | 2020 Revenue | Panel's Revenues 2019-20 evolution average | 2015-2020 CAGR

Sources: Thomson Reuters EIKON data

FIGURE 3

2019 & 2020 EBITDA margins

	Ørsted	Vattenfall	Iberdrola	CEZ	Enel	Naturgy	SSE	EDP	EDF	RWE	Engie	EnBW	E.ON	Centrica	Fortum	Uniper
2019 – 2020 evolution	+15%	+21%	+9%	0%	+16%	+11%	+71%	0%	+1%	+5%	+1%	+40%	+15%	-12%	-83%	+58%
2016 – 2020 CAGR	+1%	+2%	+1%	-1%	+5%	+2%	+33%	-2%	-1%	+5%	+2%	+34%	+33%	+5%	-34%	+16%

Sources: Thomson Reuters EIKON data

2020 EBITDA margin

European utilities have shown exceptionally high EBITDA margins considering the pandemic, mainly due to efficient cost-cutting measures and high performance from renewables and networks businesses.

Despite a drop in revenues due to the COVID-19 pandemic, European utilities have shown exceptionally high performances with a weighted EBITDA margin peaking at 21.7% in 2020. This was achieved thanks to efficient cost-cutting measures and good performances from renewable energy sources as this segment has lower risk than conventional generation, given the fixed tariffs and the priority given on the grid. The studied sample of utilities companies in Europe can be divided into three main groups based on their EBITDA margin:

1. ***Those in the lead with the highest EBITDA margins.***

These companies increased their 2020 EBITDA margin thanks to good performance of renewable assets and successful implementation of efficiency measures. It should be noted that:

- Orsted maintained stable operations and increased generation from offshore and onshore wind farms, reaching the highest EBITDA margin of the panel with 31.3%, ahead of its initial forecast.

- Enel is successfully implementing its strategy based on sustainability and electrification along the entire value chain. This led to an increase in the value generated by the group with excellent performance of renewables and efficiencies achieved in conventional generation.

2. ***Those with stable average sector performance.***

These companies presented lower EBITDA margins than the leading group, but still showed a resilient performance compared to 2019 thanks to well-managed operating expenses and the good performance of renewable assets.

- After years of average performance, SSE's EBITDA margin in 2020 increased significantly. This is mainly supported by renewables and networks businesses and successful disposal programs to leverage renewable power generation. SSE aims to accelerate its transition to net zero through financial partnering in renewables.

- After two years of low EBITDA margins in 2017 and 2018, RWE has recovered with an EBITDA margin peaking at 22.8%. This was primarily due to a very good trading performance and favorable weather conditions, enabling high utilization of wind farms.

3. ***Those lagging behind the utilities average.***

These companies achieved the lowest EBITDA margins in 2020. This can be explained by various reasons including adverse effects of the COVID-19 pandemic and warmer temperatures affecting energy consumption.

That said, progress is on track for some utilities like Engie, EnBW, E.ON and Uniper, while Centrica and Fortum are facing challenging situations:

- For the third year in a row, EnBW has improved its EBITDA margin. The main drivers of this success were the grids and renewables businesses with two new high-achieving offshore wind farms: Hohe See and Albatros.

- Fortum's EBITDA margin dropped significantly from 32.4% in 2019 to 5.4% in 2020, mainly due to weak results in the heating and cooling business, negative effect of the Russian Rouble exchange rate, and lower achieved power price in the generation segment.

Despite the good performance of European utilities, the 2020 average net margin decreased compared to 2019 (only six out of the 16 utilities from the sample managed to increase their net margin). Fortum and SSE have the strongest decrease (-24% and -11% respectively), while Centrica and Engie scored the lowest with negative net margins.

Continuing to reconfigure the asset portfolios towards a clean, reliable, and smart model and improving the growth profile are key priorities to remain competitive in the market.

Note : 2019 EBITDA margins were adjusted for SSE and E.ON, from 15% to 13.6% and 10.7% to 11.6% respectively .

Net debt and EBITDA in € million and leverage ratios for 2019 and 2020

Foreseeable slowdown in net debt after several years of growth.

Net debt decreased globally for European utilities whereas EBITDA continued increasing, following last year's path:

- Average net debt decreased by -1% within the 2019–2020 period;
- Average EBITDA increased by 12% within the 2019–2020 period.

These figures have resulted in a stronger average leverage ratio, going from 3.6x (2019) to 3.26x (2020). However, we can still distinguish a few different dynamics within this global one.

Uncertain times lead to a reduction of financial costs across European utilities.

Globally, European utilities are trying to decrease their leverage ratio, going from an average of 3.60x (2019) to 3.26x (2020). This systemic decline in the leverage ratio is one of the results of the crisis experienced by utilities over the past year.

- Indeed, in a world where demand is contracting, fixed costs (including the cost of debt) must be optimized as much as possible in order to limit the impact on the company's cash flow. In a nutshell, reducing the debt is a way for companies to better manage the risk inherited from the current crisis.
- Significative investments/CAPEX have been postponed or frozen because of the crisis, helping utilities to reduce their need for raising new debts within the 2020 period.

Good performance from all German utilities: German recovery continues despite crisis.

German utilities are outperforming their peers within the same time frame despite the impact of COVID-19. They basically reduced their new debt by -4% (four times panel's average) and increased their EBITDA by 36% (three times panel's average). German utilities are getting financial compensations from the government to offset the closure of coal/lignite/nuclear-based powerplants. Moreover, utilities are leveraging renewables and grid activities (ensured revenues) to reduce demand contraction impact on their EBITDA. EnBW strongly increased its EBITDA (+42%) as driven mainly by renewables' good performance in 2020, especially coming from offshore wind farms (Hohe See and Albatros). Company's net debt increased because of organic growth investments aimed at entering new markets (e-mobility) and strengthening EnBW renewables portfolio.

- Fortum net debt increased by 105% from 2019 to 2020. This is mainly related to the majority stake acquisition (76%) in Uniper (March 2020) for €2.6 billion, leading to a consolidation of Uniper's net debt. For the same reason, Fortum's EBITDA rose by ~50%, including the consolidation of Uniper's EBITDA.
- SSE EBITDA increased by 61% from 2019 to 2020. This performance needs to be put into perspective of the 43% EBITDA decrease from 2018 to 2019. 2020 performance (barely reaching 2018 levels) is mainly due to the restauration of GB capacity market payments, reduced EPM-related losses, and a strong performance in renewables.

FIGURE 4

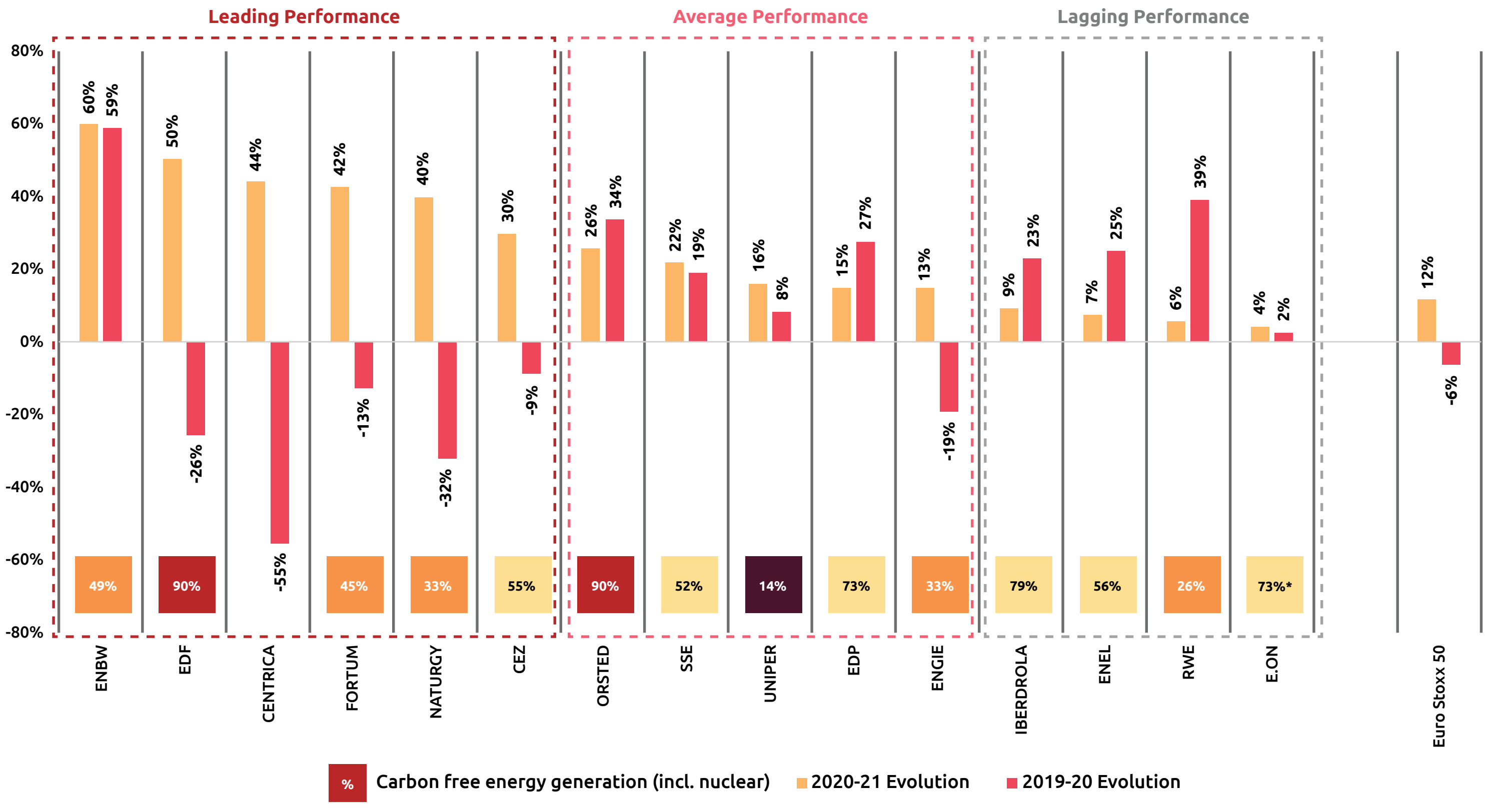
Net debt and EBITDA in € million and leverage ratios for 2019 and 2020

	2020 Net Debt [€l] (2019-2020 evolution)	2020 Net Debt [€l] (2019-2020 evolution)	Leverage ratio 2020	Leverage ratio 2019
UNIPER	0,763 (-22.62%)	1,942 (21.00%)	0.39x	0.61x
Ørsted	1,972 (-36.43%)	2,110 (-17.71%)	0.93x	1.21x
RWE	4,432 (27.32%)	3,116 (9.03%)	1.42x	1.22x
Vattenfall	6,182 (-18.25%)	4,726 (17.13%)	1.31x	1.87x
Centrica	4,530 (-15.86%)	1,718 (-18.46%)	2.64x	2.56x
EDF	48,484 (3.46%)	15,717 (2.72%)	3.08x	2.90x
CEZ	5,507 (-15.30%)	2,221 (0.54%)	2.48x	2.94x
Fortum	11,309 (105.36%)	2,670 (51.27%)	4.24x	3.12x
Engie	27,354 (-10.36%)	8,739 (-6.00%)	3.13x	3.28x
Enel	62,045 (-4.14%)	15,894 (-6.38%)	3.90x	3.81x
Naturgy	16,111 (-11.83%)	3,571 (-18.02%)	4.51x	4.19x
Iberdrola	47,961 (1.54%)	9,645 (-0.87%)	4.97x	4.85x
EnBw	12,360 (16.63%)	2,818 (42.54%)	4.39x	5.36x
EDP	19,553 (-3.31%)	2,860 (-13.49%)	6.84x	6.12x
E.ON	33,192 (2.22%)	8,119 (70.85%)	4.09x	6.83x
SSE	11,268 (8.54%)	1,814 (61.10%)	6.21x	9.22x
Average			3.26x	3.60x

Source: Thomson Reuters EIKON data 2021

FIGURE 5

Utilities' Stock Performance



*Generation is outside E.ON's core business and it is phasing out its nuclear production

Sources: Thomson Reuters EIKON data, companies' annual reports

Utilities' stock performance

Despite the COVID-19 crisis, 2020 has been a year of growth for most utilities stocks.

The trends observed in Q1 2020 continued throughout the full year. Most of the utilities in the panel showed excellent resilience in the markets with respect to the COVID crisis as measured through year-over-year growth. The markets sanction strong growth for utilities with a clearly defined renewable-focused development roadmap, or even investments already made in renewable energy (offshore/onshore wind, photovoltaic, etc.). As of July 2021, some utilities on our panel have already reached their highest valuation since 2012. This observation is, once again, the privilege of the companies most invested in the development of renewable energy.

European utilities rise in stock value is globally in line with their operational performance

Overall, increase in stock valuation has also been triggered by the demonstrated ability of utilities to generate a growing EBITDA in times of crisis, mainly thanks to:

- Focusing on "ensured" revenue activities, such as grid operations or renewables, which are less exposed to market pressure because of renewables priority on the grid as well as the constant need for the grid to be used to deliver electricity to end users; and
- Managing their operational expenditures (for the first time in years, net debt level decreased on average) within the context of energy demand contraction. This enhanced investors' confidence in utilities ability to generate cash no matter the economic situation.

However, as can be seen from the chart, the various players' stock growth is very uneven. Although correlated to the level of decarbonized energy produced, we note that the clarity of the long-term strategy also significantly impacts the evolution of the prices.

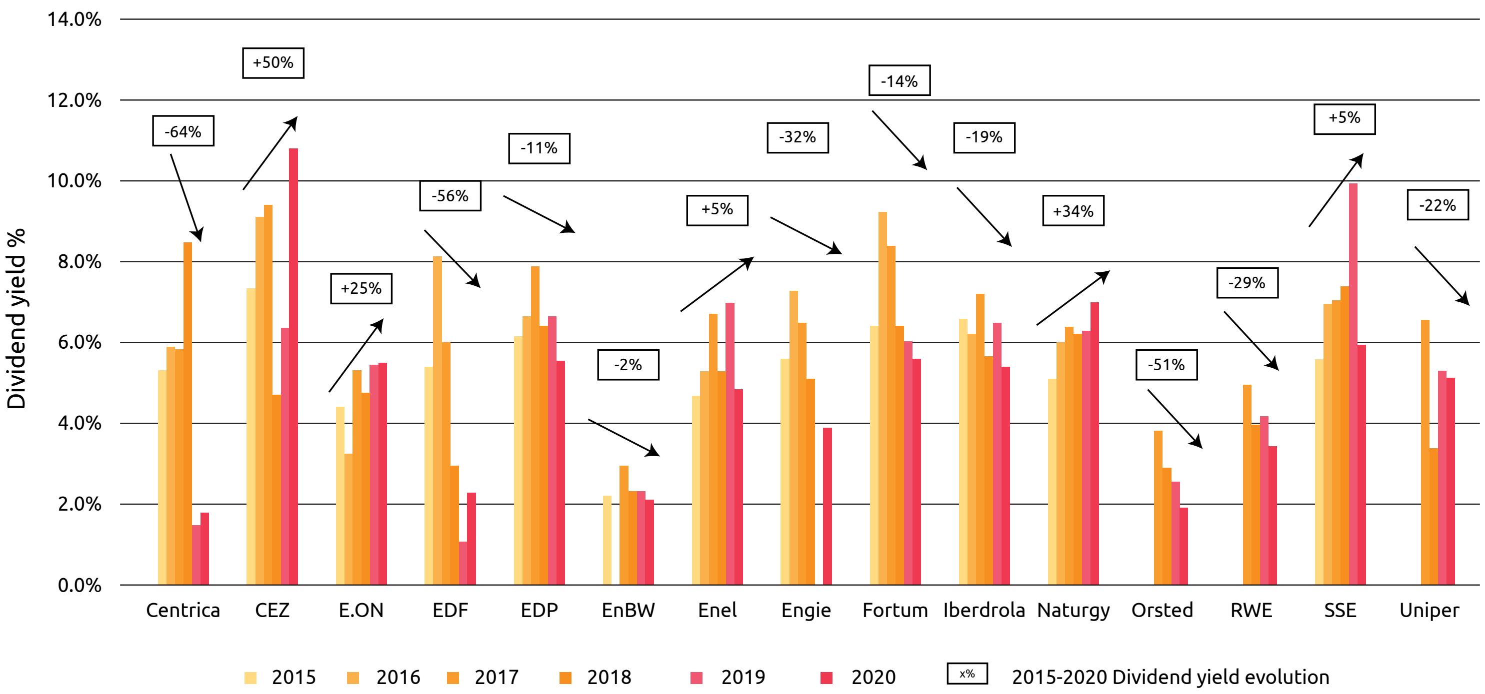
Focus topics:

- **EnBW** stock price strongly increased for the second year in a row. German MPs passed a law to abandon coal as a source of electricity generation for Germany to meet its climate targets. The law provides for the allocation of more than €50 billion to the operators of coal-fired power plants and lignite producers. On the other hand, Germany is revisiting its roadmap towards energy mix decarbonation, in reducing carbon emissions by 65% (instead of 55%) by 2030.
- **Orsted** strongly leveraged its 90% renewables based fuel-mix to perform a significant growth of its market value for the third year in a row. Financial markets are welcoming the current operational performance while ensuring a bright future given that renewable electricity is a priority on the grid. Moreover, the company announced significant investments to extend its installed renewables capacity (aiming to reach 99%) to 2025.

  Orsted stock prices reached a high point of more than 180€ (Jan 2021) before dropping by 33%, close to the current value. The stock didn't reach the peak value from Jan. 2021 again, which may be due to financial speculation.
- **Fortum** is taking the best from its new stakes acquisition of Uniper. This increases the consortium installed base (and client portfolio) as well as the presence of the company in the Europe, thus improving the market confidence in Fortum.
- **Centrica** stock performance improved over 2021. The disposal of Centrica's U.S. business for £2.85 billion is transformative and increased the stock price. The acquisition of Robin Hood Energy (112.000 residential customers, 2.600 professionals and 10.000 sites) also increased Centrica client's base.

FIGURE 6

Dividend yield in % and 2015-2020 evolution



1 based on scheduled dividend per share
2 2017-2020 Evolution

Sources: Thomson Reuters EIKON data 2021

FIGURE 7

Dividend yield, 2019-2020 and 2020-2021 evolution

	Stock price			Δ 2019-2020 %	Δ 2020-2021 %	DPS		Δ 2019-2020 %	Dividend Yield		Δ 2019-2020 %
	2019	2020	2021			2019	2020		2019	2020	
ØRSTED	86,51	115,75	145,59	34%	26%	1,41	1,54	9%	1,9%	1,6%	-18,4%
EDP	3,71	4,73	5,44	27%	15%	0,19	0,19	0%	6,1%	4,8%	-21,6%
IBERDOLA	8,93	10,97	12,00	23%	9%	0,40	0,42	5%	5,3%	4,6%	-14,1%
RWE	24,85	34,56	36,54	39%	6%	0,80	0,85	6%	3,8%	2,9%	-23,6%
EDF	12,46	9,28	13,93	-26%	50%	0,15	0,21	40%	1,4%	2,7%	87,9 %
ENEL	6,94	8,67	9,32	25%	7%	0,33	0,33	-1%	5,7%	4,5%	-20,5%
ENBW	35,33	56,08	89,72	59%	60%	0,70	1,00	43%	2,4%	2,1%	-10,0%
SSE	14,37	17,08	20,81	19%	22%	1,11	0,92	-17%	9,2%	6,4%	-30,3%
UNIPER	30,02	32,41	37,55	8%	16%	1,15	1,37	19%	4,6%	5,0%	10,4%
CEZ	23,29	21,29	27,61	-9%	30%	1,28	2,03	59%	6,5%	11,4%	73,5%
E.ON	10,91	11,18	11,65	2%	4%	0,46	0,47	2%	5,0%	5,0%	-0,3%
FORTUM	22,13	19,32	27,53	-13%	42%	1,10	1,12	2%	5,9%	6,9%	16,6%
NATURGY	27,47	18,64	26,06	-32%	40%	1,37	1,44	5%	5,9%	9,2%	54,9%
ENGIE	15,22	12,30	13,92	-19%	13%	0,00	0,53		0,0%	5,1%	
CENTRICA	1,12	0,50	0,72	-55%	44%	0,02	0,02	-13%	2,1%	4,2%	96,0%
AVERAGE				5,5%	25,6%				4,4%	5,1%	

1 based on scheduled dividend per share
2 2017-2020 Evolution

Source: Thomson Reuters EIKON data 2021

Dividend yield in % and 2015-2020 evolution

Reminder: The dividend yield is calculated by dividing the DPS by the share price at the time of payment.

For the studied panel, the average dividend yield has remained stable on a year-over-year basis, hiding substantial disparities.

1. **Orsted, EDP, Iberdrola, RWE & Enel:** Companies for which market capitalization increased strongly in 2020 and 2021 (mainly based on renewables generation mix, well-defined strategy to fit on-going energy transition, and good operational results) are reducing their dividend yield (since stock's value increase is superior to DPS increase). These companies' stocks might be seen as "investment grade" and are therefore not required to pay lots of dividends since investors are earning value in capital. This feeling of investing in secured stocks is sufficient (at least for now) to ensure financial stability (i.e., avoiding important turnover) and enhancing these companies' ability to reach the target as defined in their strategy.

2. **CEZ, E.ON, Fortum, Naturgy, SSE & Uniper:** Companies for which market capitalization didn't increase a lot in the previous years, these companies are performing quite well from an operational point of view but are suffering from a lack of consistency from a long-term strategy point of view (especially regarding the way they are going to face energy transition). Giving a high dividend yield is a way to protect investors' capital from potential devaluation (market volatility) as well as generating comfortable cash flows and securing their financial structure, thus reducing stockholders' turnover.

3. **Centrica, ENGIE:** Companies facing market capitalization attrition over the last two years due to weak operational performance (reinforced by the COVID crisis), sold lots of assets to generate new cash-ins and are in trouble to generate money from continuous operations. Dividends are paid (and increasing in value despite a decreasing stock price) in order to ensure a bit of financial stability. Paying a high dividend yield might also help these companies raise money from the market to finance their upcoming investments, especially in renewables.

4. **EDF, EnBW:** These two companies are a bit different from the others since they are mainly owned by public institutions (i.e., state owned). Despite showing a strong operational performance and a good financial position, dividend yield are lagging around 2%. EnBW stock prices increased a lot over the past years, mainly due to German government allocations to help coal/lignite-involved companies shift toward a carbon-less emitting generation mix and compensating coal/lignite powerplant closure. These companies need to reconcile with the decisions taken by the majority stakeholders:
   - Which are not necessarily looking for maximizing the dividend perceived, but for the public interest.
   - Which are not facing the same difficulties in raising money from stakeholders.

   NB: French government announced in July 2021 that the project "Grand EDF" will be postponed. This might impact the stock price (as well as the market capitalization) as well as the financial parameters of the company.

Finally, the magnitude of the necessary investments to be performed by utilities to shift their generation mix transition toward zero carbon will require new investments. Indeed, utilities won't be able to only focus on rising debts in order to keep their leverage ratio at a reasonable level.

Standard & Poor (S&P) credit ratings

FIGURE 8

Credit ratings in the utilities sector remained stable on average.

Overview

- In 2021, ratings remained broadly stable. One company saw its ratings improved from BBB- to BBB.
- European utilities are more resilient to the effects of COVID-19 than most other sectors, given the essential service they provide, the regulated or long-term contracted nature of a portion of their activities, and their relatively better access to capital markets. Operationally, most utilities have developed and unveiled contingency plans to manage such a disruption and protect critical infrastructure.

EDP received a better credit rating.

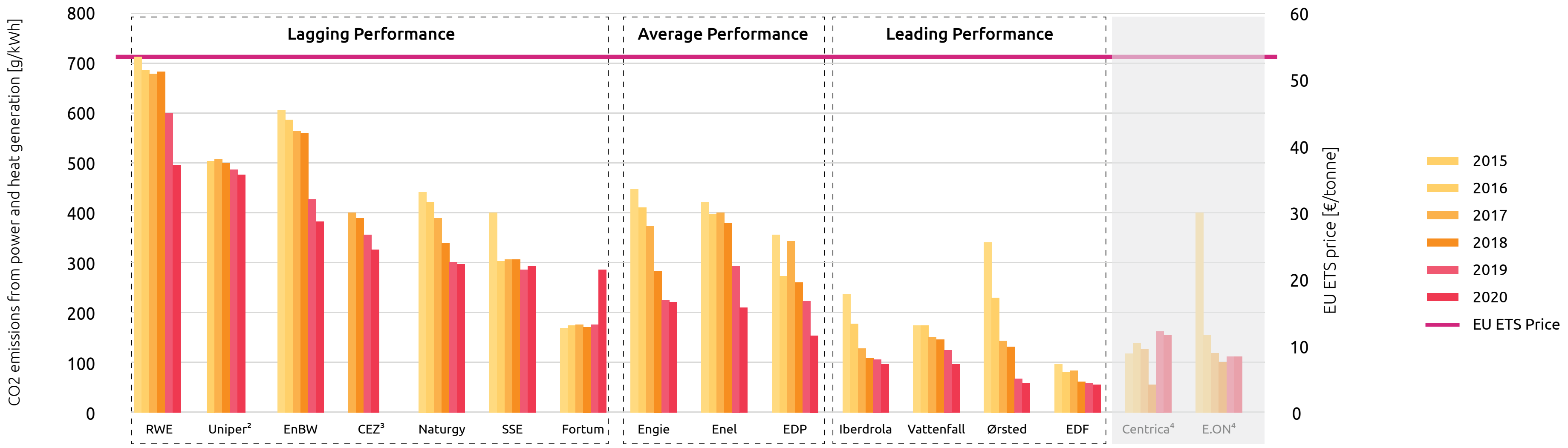
- EDP's long-term corporate credit was upgraded from BBB- to BBB in 2021 by S&P. In a nutshell, S&P expects a positive outlook for the company, considering its strategy of accelerating growth in lower risk renewables and regulated networks, with an investment target of €24 billion in energy transition until 2025.

Company	31/12/2015	31/12/2016	27/07/2017	27/07/2018	27/07/2019	21/07/2020	20/07/2021
EnBW	A-	A-	A-	A-	A-	A-	A-
CEZ	A-	A-	A-	A-	A-	A-	A-
EDF	A+	A-	A-	A-	A-	BBB+	BBB+
Engie	A	A-	A-	A-	A-	BBB+	BBB+
SSE	A	A-	A-	A-	BBB+	BBB+	BBB+
Vattenfall	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+
Ørsted	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+
Iberdrola	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+
Enel	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+
Centrica	BBB+	BBB+	BBB+	BBB+	BBB	BBB	BBB
Fortum	BBB+	BBB+	BBB+	BBB	BBB	BBB	BBB
E.ON	BBB+	BBB+	BBB	BBB	BBB	BBB	BBB
Naturgy	BBB	BBB	BBB	BBB	BBB	BBB	BBB
Uniper	N/A	BBB -	BBB -	BBB	BBB	BBB	BBB
EDP	BB+	BB+	BB+	BBB-	BBB-	BBB-	BBB
RWE[1]	BBB	BBB-	BBB-				

Source: Companies' websites

FIGURE 9

CO2 intensity from heat and power generation



	RWE	Uniper	EnBW	CEZ	Naturgy	SSE	Fortum	Engie	Enel	EDP	Iberdrola	Vattenfall	Ørsted	EDF	Centrica	E.ON
2019 – 2020 evolution	-17%	-1%	-11%	-8%	-1%	-1%	52%	-3%	-29%	-32%	-11%	-25%	-11%	-7%	-1%	0%
2016 – 2020 CAGR	-8%	-2%	-10%	-6%	-8%	-1%	12%	-14%	-15%	-14%	-14%	-14%	-29%	-10%	+3%	-6%

1. The chart displays CO2 intensity resulting from scope 1 emissions
2. CAGR 2016-2020 for Uniper for which only 5 years of data have been considered
3. CAGR 2017-2020 for CEZ for which only 4 years of data have been published in annual reports
4. Centrica and E.ON’s core businesses no longer includes power production

Sources: Thomson Reuters EIKON data 2021

CO2 intensity from heat and power generation[1]

The impact of COVID-19 during 2020 naturally helped European utilities reduce their carbon intensity. However, companies kept making important efforts towards decarbonization.

2020 saw a continuous trend toward significant carbon intensity reductions for the European power sector. Utilities' decarbonization programs have been helped by a 4–5% power consumption reduction in Europe due to the 2020 COVID-19 crisis. This reduction has naturally boosted the renewable power share on networks, with renewable power having priority in the merit order compared to conventional power production, thus leading to a carbon intensity reduction. However, European utilities from the studied panel have pursued their efforts toward carbon emissions reductions as all of them intend to be major energy transition actors.

EDF, Orsted, Iberdrola and Vattenfall are showing the lowest carbon intensity among the panel. All those utilities are indeed established on a strong low carbon installed capacity share with renewables and nuclear being the backbone of their asset production. In order to keep reducing their environmental impact, they still aim to phase-out conventional power plants as quickly as possible with coal-fired plants being the priority.

Engie, EDP and Enel belong to the average performance group. Enel and EDP are showing remarkable performances toward low carbon intensity with a 29% and 35% reduction rate respectively as compared to 2019.

Enel's performance relies on a drastic reduction of their coal-fired production in 2020 compared to 2019 (-65%), as well as a remarkable production share from renewable energy, which, for the first time, exceeded conventional production.

EDP is also making a strong move towards coal phase-out with a sensitive reduction of its coal-based production in 2020, resulting in early planned closures for two of their thermal power plants.

RWE, Uniper, EnBW CEZ, Naturgy, SSE, and Fortum are following the same strategy as previously mentioned companies to phase out coal production. Naturgy is closing all its remaining coal-fired power plants in 2020.

With coal phasing-out ongoing, those utilities achieved sensitive carbon intensity decrease during 2020. As a result, even for those who increased their power production in 2020, as was the case with SSE and EnBW, the shift toward lower carbon fuels and technologies enabled carbon intensity reduction.

With the integration of Uniper's assets as of Q2 2020, Fortum's carbon intensity has been increasing in 2020 compared to previous years. However, Fortum restated its strong engagement toward carbon emissions reduction through coal phasing-out and strong renewable capacities development.

European carbon prices hit the €50/TCO2 bar in May 2021 and should keep rising in the coming years.

Since March 2020, European carbon prices have been constantly rising from around €20/TCO2 and crossed the €50/TCO2 line in May 2021. This rise is due to a combination of factors from EU's policy support to financial speculation following the analysts' consensus toward a continuing increase in the coming years.

If this symbolic line is not yet enough to trigger massive emission cuts in the industrial sector, it is already enough to make coal-fired power plants less and less competitive. As a response, some European utilities started to realize a coal to gas switch for power production plants and accelerated coal-based production plants closures. The rise of European carbon prices is then recognized as a very strong tool to cut carbon emissions from the power sector, enabling significant reductions for carbon intensity.

1 This study includes scope 1 & 2 emissions only. Scope 3 emissions have not been included.

Conclusion

- Good operational performance from the panel revealed a strong resilience despite harsh market conditions, especially due to the COVID-19 crisis. Even though revenues went down globally, utilities managed to put in place efficient cost-killing strategies, preserving, and in some cases even increasing, their EBITDA. Net margin strongly decreased across the panel.
- Utilities' performance in the stock market demonstrated that investors are getting more and more confident in utilities' ability to be profitable even in hard times. A company's value is mainly driven by operational results, as well as the clarity of the environmental strategy defined for the next 5-10 years. Ensured revenue activities (renewables and network) are seen as proof of revenue stability by investors.
- European utilities' CO2 intensity has decreased for all companies, mainly because of the increasing share of renewables energy within utilities' generation mix. A strongly increasing EU ETS price in the last month, which is expected to keep going up, is putting the financial stability of the most important emitters of the panel at risk.

07 Finance

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07 Finance

North America Finance

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U.S. tax credits and clean energy investment: The $900 billion COVID-19 recovery package could inject at least $34 billion in new spending on decarbonization into the U.S. economy over the next decade

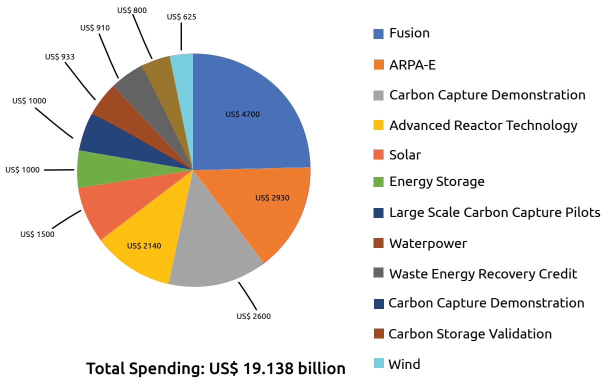
The US$900 billion COVID-19 relief package approved by Congress in December 2020 includes provisions supporting solar, wind, energy storage, and energy efficiency

- The omnibus legislation included a one-year extension of the production tax credit/investment tax credit for land-based wind at 60% of their full value and a 30% offshore wind investment tax credit for projects that commence construction any time between January 1, 2017 and December 31, 2025.
- The bill also features a two-year extension of the solar Investment Tax Credit (ITC). The tax credit will remain at 26% for projects that begin construction in 2021 and 2022, and will then drop to 22% in 2023. In 2024, the tax credit will drop to 10% for commercial projects, while the residential credit will end completely.
- The package set aside more than $1 billion over 5 years for investments in energy storage technology research, development, and demonstration (RD&D) and includes the Better Energy Storage Technology (BEST) Act.
- Furthermore, the bill features several key provisions for advancing energy efficiency, including: a permanent extension of the Sec. 179D tax deduction for energy-efficient commercial buildings; funding increases for initiatives such as ENERGY STAR and the Building Technologies Office; and provisions for reducing energy waste in the federal government, accelerating smart building technology, encouraging waste-heat to power, and strengthening the Weatherization Assistance Program.

FIGURE 1

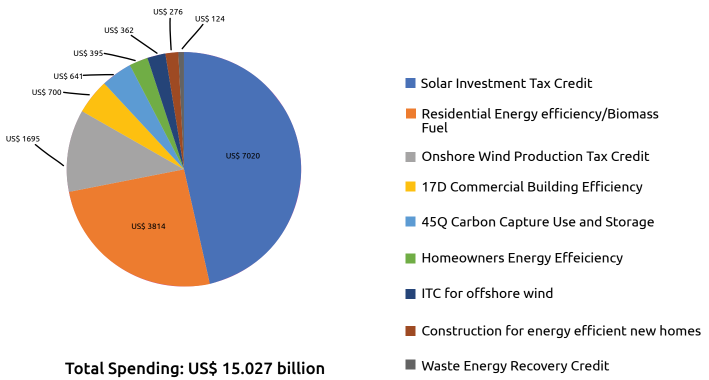
US ~ Tax credits and clean energy investment

Energy RD&D spending in U.S. stimulus bill (US$ millions)



Total Spending: US$ 19.138 billion

Energy tax credit enhancements, 2021-2030 (US$ millions)



Total Spending: US$ 15.027 billion

Source: BNEF ~ Sustainable Energy in America Factbook, 2021
Link: http://www.bcse.org/factbook/#
World Energy Markets Observatory 2021

U.S. utilities revenue: U.S. utilities have mitigated the effects of COVID-19 in their 2020 sales performance by cost cutting and increased residential sales

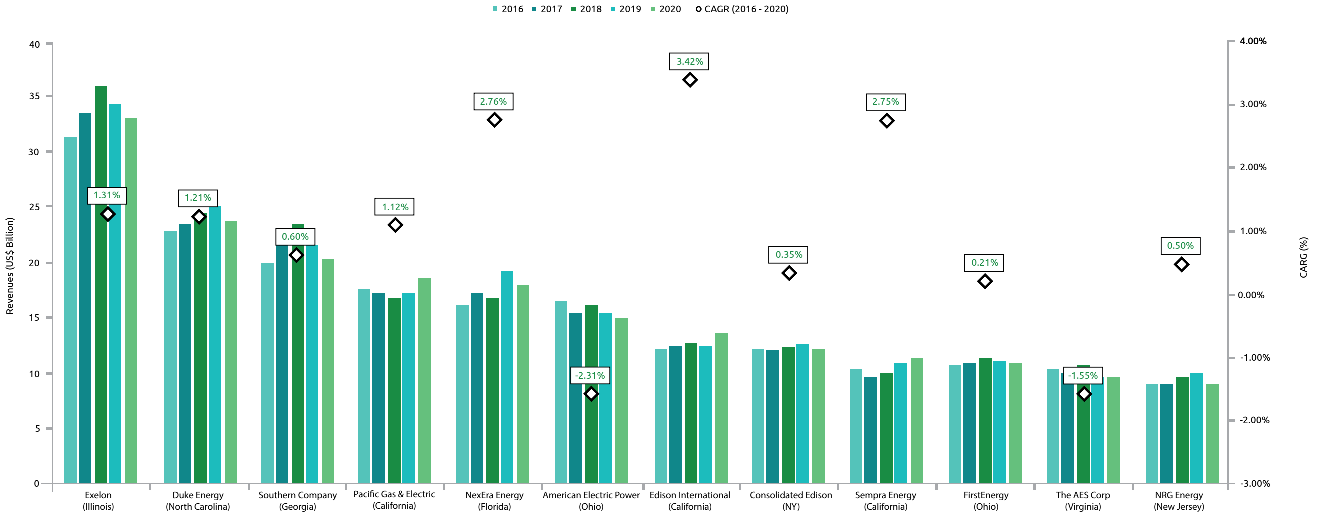
Due to the effects of COVID-19, the revenues of most U.S. utilities decreased in 2020 compared to 2019. However, major U.S. utilities reported that the financial impact of the pandemic was not as bad as initially feared.

- At NextEra Energy Inc., "the overall impacts of the pandemic on last year's retail sales were relatively muted," said Executive Vice President and CFO Rebecca Kujawa during the company's earnings presentation in January 2021.
- Xcel Energy Inc. Chairman and CEO Benjamin Fowke said on a company's earnings call in January 2021 that "overall, 2020 was truly a stellar year" for the utility. He noted that, in order to mitigate COVID-19 impacts, Xcel Energy reduced operations and maintenance costs by nearly 1%.
- On the company's fourth-quarter earnings call in January 2021, AEP Executive Vice President and CFO Julie Sloat said its utilities' service territories were "less impacted by the virus and had fewer restrictions on businesses than other parts of the country," citing successful operations and maintenance control as a strategy to offset COVID-related losses.

Chicago-based Exelon had the highest revenue in 2020 compared to other U.S. utilities. However, the revenue came in at $33 billion in 2020, down 4% year over year, and the net income was nearly $2 billion, a decrease of 33% from the year before.

FIGURE 2

US ~ Revenues and associated CAGR, 2016-2020 (US$ billion)



US ~ Revenues and associated CAGR, 2016-2020 (US$ billion)
World Energy Markets Observatory 2021

- Distribution revenue increased for the year ending on December 31, 2020 compared to the same period in 2019, primarily due to the impact of higher natural gas and electric distribution rates that became effective in December 2019.
- Transmission revenue decreased for the year ending on December 31, 2020 compared to the same period in 2019, primarily due to the settlement agreement of transmission-related income tax regulatory liabilities, partially offset by higher fully recoverable costs.

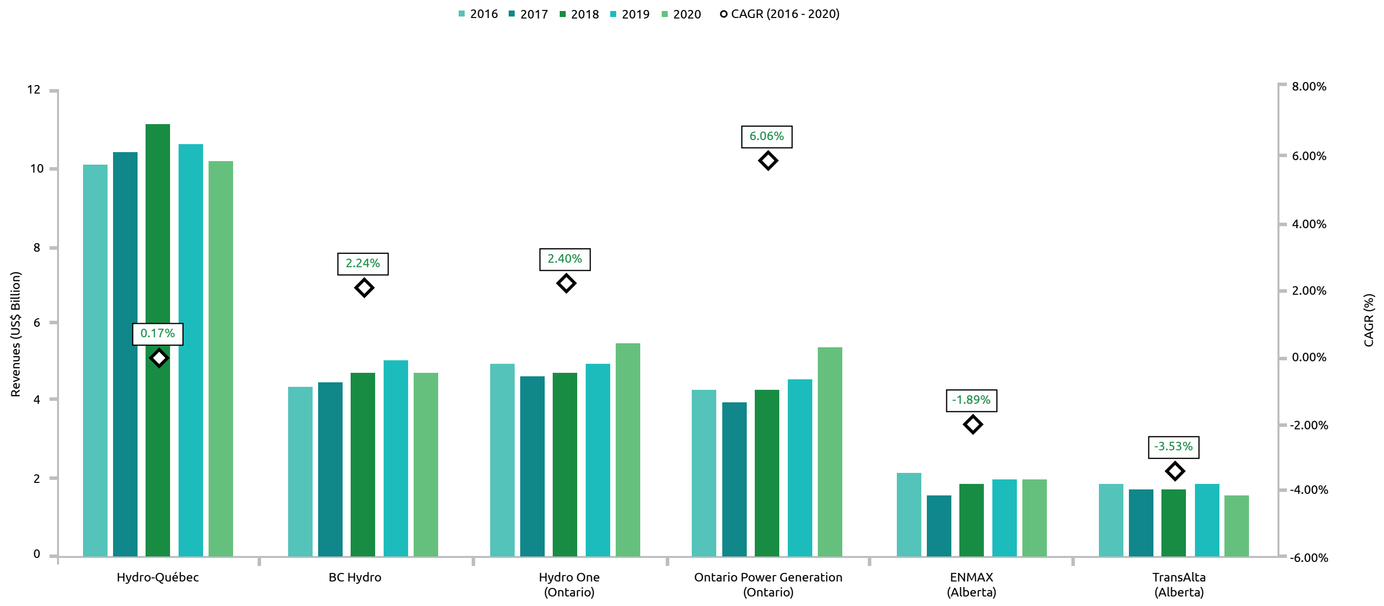
Canadian utilities revenue: Hydro Quebec recorded the highest revenue in 2020 amongst Canadian utilities

Hydro Quebec recorded the highest revenue amongst Canadian utilities in 2020. However, the company's revenue came in at U.S. $10 billion in 2020, down 4% year over year.

- Hydro Quebec (HQ) posted net income of U.S. $2.3 billion, down U.S. $620 million from 2019. This decrease is mainly due to the impact of the COVID-19 pandemic on the company's operations, as well as the mild temperatures recorded this past year.
- HQ has stable revenue sources, benefiting from a monopoly on its Quebec market, which represented 90% of its turnover in 2020.
- Net electricity exports from HQ's unregulated generation segment to wholesale markets outside of Quebec are subject to greater price and volume volatility. They represented only 10% of HQ's net operating revenue in 2020, limiting the risk to overall revenue generation. However, they accounted for 23% of HQ's net overall margin in 2020; as HQ aims to increase net exports' share in revenue in the coming years, it will increase revenue volatility.

FIGURE 3

Canada ~ Revenues and associated CAGR, 2016-2020 (US$ billion)



Source: Thomson Reuters EIKON Data ("Total Revenue"), Capgemini Analysis
World Energy Markets Observatory 2021

U.S. EBITDA margin: NextEra Energy and Duke Energy have maintained high EBITDA margins in the last few years

NextEra Energy Inc. 's EBITDA margin improved by 80 basis points compared to 2019, and stood at 50.4% in 2020.

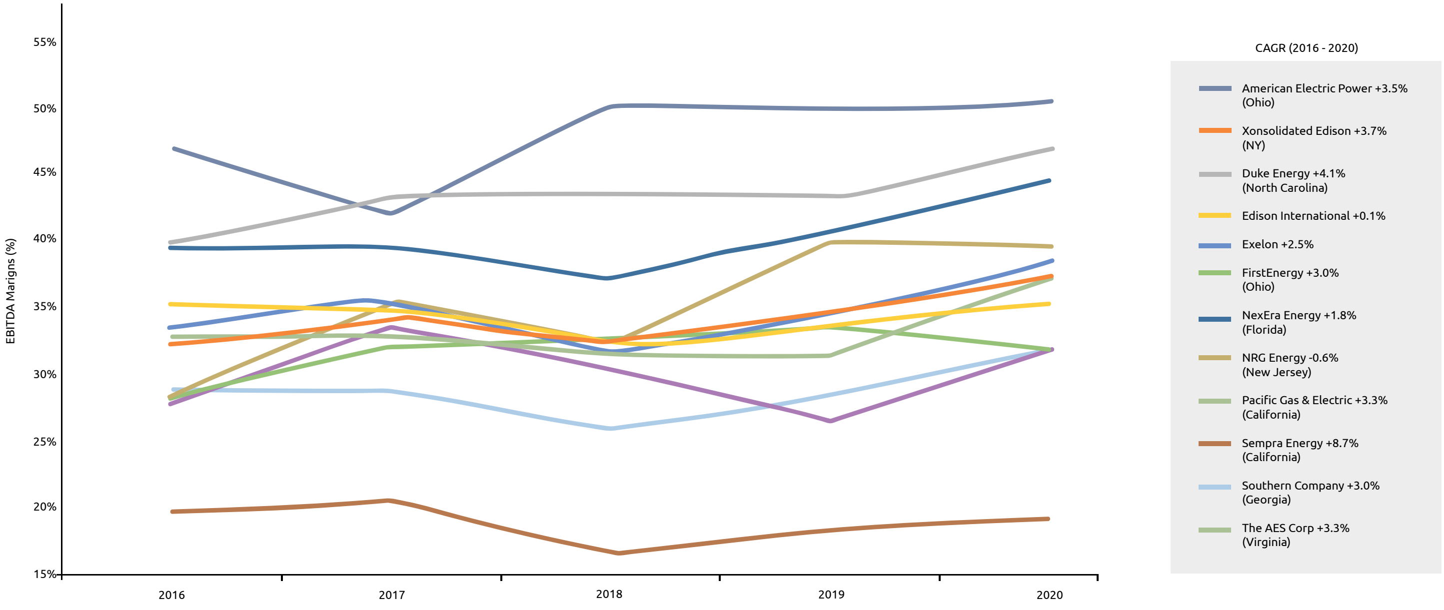
- The company has reported its highest EBITDA margin in the last 5 years amongst U.S. utilities, despite operating revenues falling year over year.
- NextEra continues to bet on the build-out of renewables in the U.S., striking deals for electric transmission companies like GridLiance Holdco and GridLiance GP LLC.

Duke Energy also recorded a high EBITDA margin of 46.9% in 2020.

- While Duke Energy was impacted by the cancellation of the Atlantic Coast Pipeline LLC project in the second half of 2020 – in addition to COVID-19 and unfavorable weather – the organization anticipates resolution of key rate case activity and potential favorable policy changes in the near term.
- Duke Energy Chair, President and CEO Lynn Good said on the third-quarter 2020 earnings call, "As I look at 2021, there is so much clarity. We will have all of this behind us, the uncertainties that have been a challenge for us".

FIGURE 4

US ~ EBITDA Margins and associated CAGR, 2016-2020



Source: Thomson Reuters EIKON Data ("Total Revenue"), Capgemini Analysis
World Energy Markets Observatory 2021

Canadian EBITDA margin: Hydro-Québec reported the highest EBITDA margin in 2020 amongst Canadian utilities

Hydro-Québec reported net profit of U.S. $2.3 billion in 2020, amid the pandemic and mild temperatures.

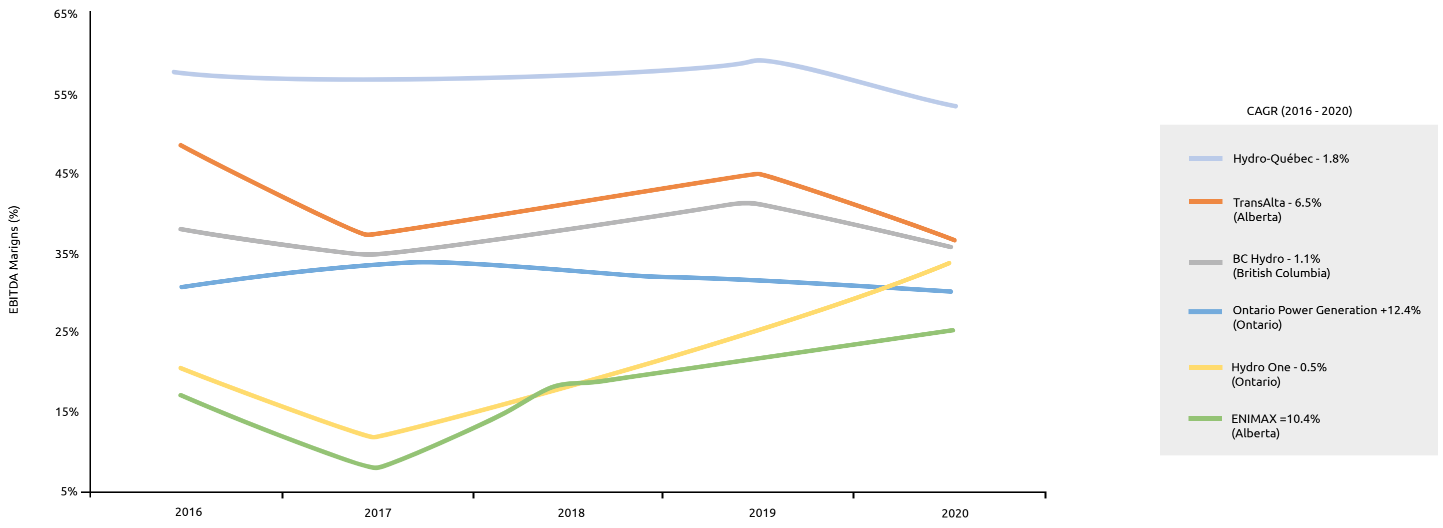
- In 2020, HQ delivered 31.3 TWh to neighboring markets, including New England, New York State, Ontario and New Brunswick. These net sales of green, renewable power made a sizeable contribution to company's bottom line, accounting for a net income of U.S. $537 million.

In 2020, there was a U.S. $620 million decrease in net profit compared to the previous year, which is due to two main factors:

- First, temperatures were milder in 2020 than they were in 2019, particularly during the months when heating requirements affect customers' energy consumption.
- Second, 2020 was marked by the COVID-19 pandemic throughout the world, and Québec and its economy were no exception. The resulting public health crisis curbed the activities of many companies and had an adverse effect on Hydro-Québec's operations and financial performance, especially with respect to the volume of electricity sales both within and outside Québec, the rate at which investments were made, and the allowance related to the collectability risk for certain accounts receivable

FIGURE 5

Canada ~ EBITDA Margins and associated CAGR, 2016-2020



Source: Thomson Reuters EIKON Data ("Total Revenue"), Capgemini Analysis
World Energy Markets Observatory 2021

U.S. and Canadian dividend per share (DPS): Utility dividend growth in 2020 has kept pace with 2019 despite the ongoing coronavirus pandemic

- U.S. utilities are known to be quite generous with their dividends. They tend to distribute roughly 50% of their available cash flow to their shareholders.
- Although U.S. utilities have been affected by COVID-19, they are investing in energy transmission and clean business in order to generate additional growth for the future.
- Overall, the companies are offering a decent yield and their dividend growth policies cover inflation.
- Due to stable and predicable cash flows, the U.S. utilities have been able to provide good dividends over past few years.

NRG Energy experienced a compound annual growth rate (CAGR) of 400% in DPS from 2016 to 2020

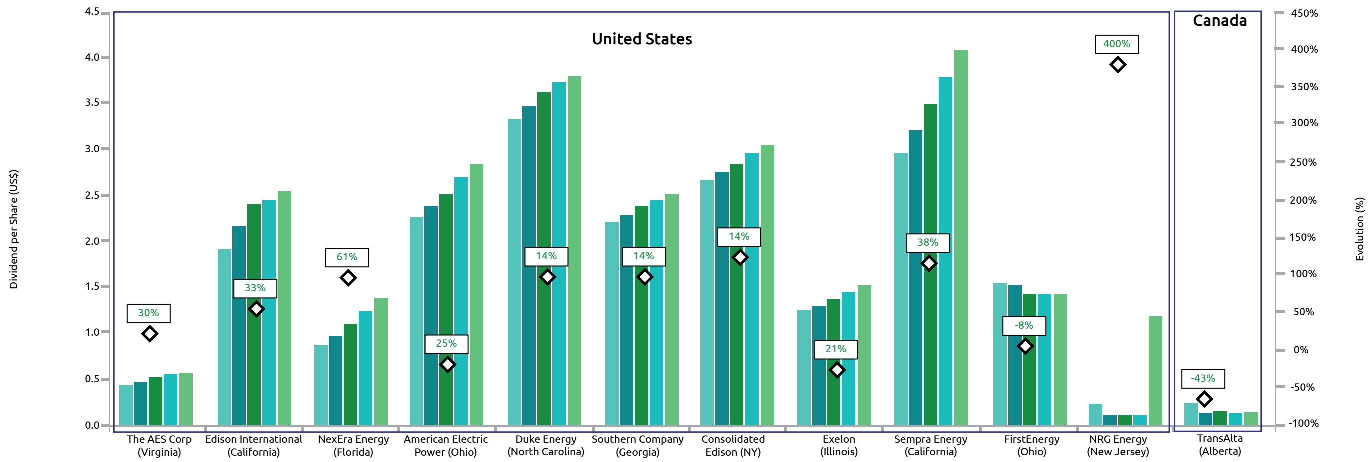
- Over the past years, NRG Energy has experienced an overall upward trend regarding its dividend payouts and yields.
- On January 31, 2020, the company's payout was $0.3, which has since grown by $0.03. Similarly, NRG Energy's dividend yield last year was 3.11%, which has since grown by 0.09%.

Sempra Energy had the highest DPS in 2020

- Over the past decade, the company has increased their dividend at a compound annual growth rate of approximately 9%.
- The 2020 DPS demonstrates the company's continued commitment to generating value for shareholders.

FIGURE 6

US and Canada ~ Dividend per Share in US$ and 2016-2020 Evolution



Source: Thomson Reuters EIKON Data ("Dividend per Share DPS"), Company Annual Reports, Capgemini Analysis
World Energy Markets Observatory 2021

U.S. utilities leverage: In 2020, most of the U.S. utilities showed high leverages of more than 1, indicating high debt levels

U.S. Utilities like AES Corp. and First Energy had high debt/equity in 2020, suggesting that these companies have taken an aggressive financing approach to debt

- The leverage or D/E ratio, which is a key metric for evaluating a company's overall financial health, is high for these utilities since they carry high debt levels due to large, periodic capital expenditures related to infrastructure investments.
  - U.S. Utilities have been investing in their networks, maintaining and extending these assets, and improving their efficiency and safety, as well as building new assets for transmission of renewable energy.

Sempra Energy has a comparatively low leverage amongst U.S. utilities.

- The company had stable earnings and cash flows from regulated utility business in California and Texas, as well as from long-term contracted infrastructure investments in the U.S. and Mexico.
- Regulated utilities represent 80% of the total EBITDA. They enjoy favorable regulatory treatment in California and Texas, as well as robust customer growth in Texas.
- Asset sales in recent years have reduced business risk and enhanced financial flexibility.
- The sale of a 20% equity stake in Sempra Infrastructure Partners (SIP) to KKR allows the company to strengthen its balance sheet, focus on utility growth, and alleviate funding needs from future LNG development.
- Sempra Energy had US$23.4 billion of debt in March 2021, down from US$27.2 billion, one year before. However, it does have US$725.0 million in cash offsetting this, leading to net debt of about US$22.6 billion.

FIGURE 7

US ~ Leverage (Debt/Equity), 2019-2020 Evolution

Utilities	2019	2020	Evolution
American Electric Power (Ohio)	1.52	1.64	↑
Consolidated Edison	1.20	1.29	↑
Duke Energy (North Carolina)	1.37	1.36	↓
Edison International (California)	1.42	1.64	↑
Exelon (Illinois)	1.17	1.21	↑
First Energy (Ohio)	3.01	3.38	↑
Next Era Energy (Florida)	1.15	1.32	↑
Pacific Gas & Electric (California)	0.30	1.44	↑
Sempra Energy (California)	1.46	1.20	↓
Southern Company (Georgia)	1.70	1.76	↑
The AES Corp (Virginia)	6.73	7.55	↑

Source: Thomson Reuters EIKON Data ("Debt/Equity"), Company Annual Reports, Capgemini Analysis World Energy Markets Observatory 2021

U.S. regulated utilities have benefited from a confluence of circumstances which has enabled them to enjoy sustained high rates of rate base growth and allowed returns well above their cost of capital, all without raising prices to their customers

U.S. Utilities have a rare combination of low interest rates, generous allowed returns, and solid rate base growth. Although this situation has persisted for several years, the risks of a reversal are likely to increase.

- In the U.S., each state has its own regulatory agency and the Federal Energy Regulatory Commission regulates interstate transmission assets. As a result, there is a degree of variability in the utilities' authorised rate of return earned on invested capital.
- U.S. Utilities that deliver the services of transmitting essential commodities like gas, electricity, and water earn a return on invested capital as determined by a regulator while their fuel, operational and maintenance costs are generally passed-through directly to the consumer.
- Utilities invest in their networks, maintaining and extending these assets, and improving their efficiency and safety, as well as building new assets for, say, transmission of renewable energy. The more the utility can invest in its infrastructure, the more revenue it can generate.
- Some of the areas of network and generation investment add to the rate base, and at the same time reduce operations and maintenance expense (O&M) which is a pass-through cost to customers. These areas of investment include:
  - Installing advanced metering infrastructure, which dramatically improves workforce efficiency.
  - Phasing out coal plants in favour of gas and renewable generation (renewable assets add to the rate base and eliminate the variable fossil fuel costs).
  - Retrofitting existing generation assets to reduce emissions.
  - Building out transmission networks to interconnect regions.

U.S. utilities have enjoyed a widening spread over the risk-free rate since the early 1980s, as allowed returns have declined less than bond yields, a trend that accelerated in the ultra-low rate environment of the last decade. However, regulators will not allow them to over-earn forever.

- Ultimately, it is likely that ongoing high levels of capital expenditure (and rate base growth) will flow through to customer utility bills, and regulators will need to consider curbing rate base growth or lowering utilities' allowed rate of return.

07 Finance

07

07 Finance

Australia Finance

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Power Generation: The Australian power generation market is lead by the "Big 3" Retailers and Snowy Hydro

Each National Electricity Market (NEM) region is dominated by a few players. In New South Wales (NSW), Victoria (VIC) and South Australia (SA), private entities hold the majority share in generation capacity, while Government-owned entities control generation capacity in Queensland (QLD) and Tasmania (TAS).

A few large participants control a significant proportion of generation in each NEM region.

- The two largest generators in each state accounted for more than 40% of total local capacity and for more than 60% of total generation in all regions except SA.

Private entities are holding majority market share for generation capacity in NSW, VIC, and SA.

- In VIC, AGL Energy holds 27% share, followed by EnergyAustralia with 19% and Snowy Hydro with 16%.
- In SA, AGL Energy generates 30% of total capacity, followed by Engie (18%), Origin Energy (14%) and EnergyAustralia (6%).
- In NSW, AGL Energy holds 26% share, followed by Origin Energy (20%), Snowy Hydro (16%), EnergyAustralia (10%), and Sunset Power (7%).
- AGL Energy is the largest participant by capacity and generation in NSW, VIC and SA. On a NEM-wide basis, it accounted for 19% of total capacity and 25% of generation in 2020.
- Snowy Hydro contributed only 3.7% of generation in NSW and 4.4% in VIC, despite holding over 16% of the capacity in each region. This was caused by limited water supply for Snowy Hydro's hydroelectric generators and infrequent operation of its gas plants due to fewer periods of peak demand.

Government-owned corporations own and control the majority of generation capacity in QLD and TAS.

- In QLD, state-owned corporations Stanwell Corporation and CS Energy control 46% of generation capacity.
- State-owned Hydro Tasmania owns all generation capacity in the state. The Office of the Tasmanian Economic Regulator regulates the prices of the safety net contract products offered by Hydro Tasmania and ensures adequate volumes of these products are available for the market.

FIGURE 1

Total Market Share of AGL, Origin Energy and EnergyAustralia, by State

State	Market Share (Electricity)
NSW	79.1%
VIC	54%
QLD	49.8%
SA	72%

Source: Australian Energy Regulator (AER) Retail Energy Market Performance Update for Quarter 2, 2020-21.
Essential Services Commision (ESC), Victorian Energy Market Report 2019-20.
Link: http://www.canstarblue.com.au/electricity/largest-energy-companies-australia/

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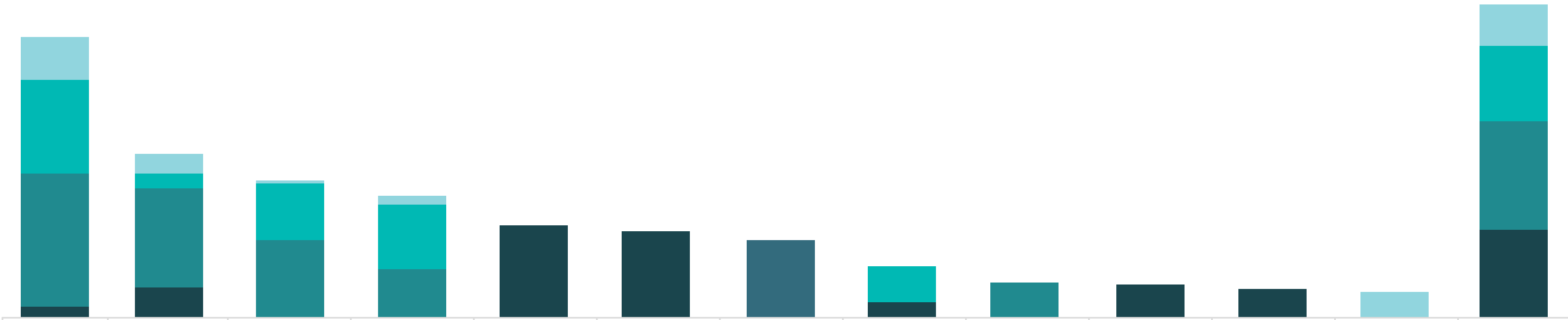
FIGURE 2

Electricity generation capacity 2020, by state

MEGAWATT HOURS



	AGL Energy	Origin Energy	Snowy Hydro	Energy Australia	CS Energy	Stanwell	Hydro Tasmania	Alinta Energy	Sunset Power	InterGen	CleanCo	Engie	Other
Tasmania							2,972						
South Australia	1,632	759	129	347								979	1,565
Victoria	3,534	566	2,112	2,472				1,300					2,880
NSW	5,043	3,784	2,980	1,840					1,320				4,102
Queensland	452	1,143			3,544	3,333		629		1,272	1,099		3,371

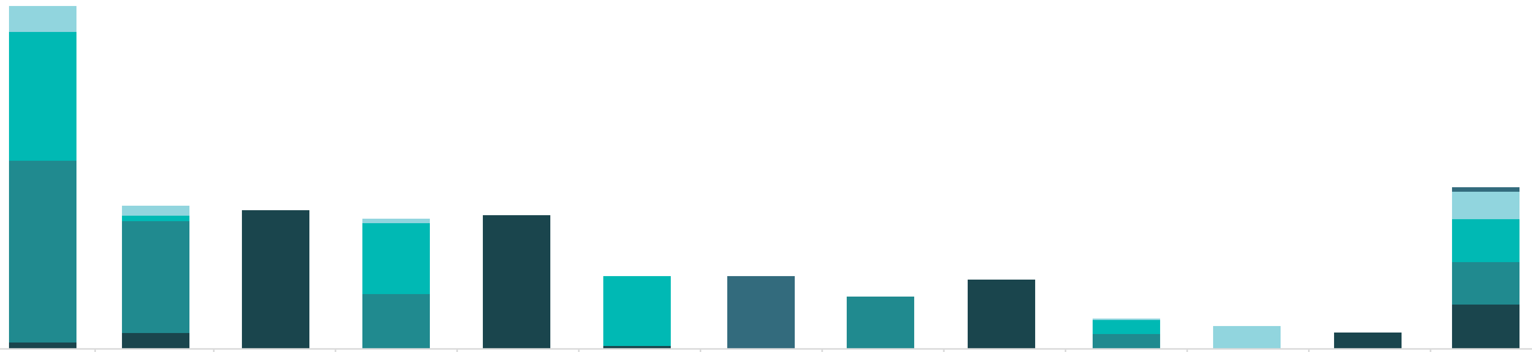
Queensland NSW Victoria South Australia Tasmania

Source: AER State of the energy market report 2021 – data;
Generation capacity based on registered capacity of market scheduled and semi-scheduled generators at 31 January 2021. Market shares are attributed to the owner of the plant or the intermediary
Link: https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2021-data

FIGURE 3

Electricity Generation Output 2020 by state

TERAWATT HOURS



	AGL Energy	Origin Energy	Stanwell	Energy Australia	CS Energy	Alinta Energy	Hydro Tasmania	Sunset Power	InterGen	Snowy Hydro	Engie	CleanCo	Other
Tasmania							1,00,63,979						4,89,248
South Australia	35,08,324	12,12,062		5,23,861						4,096	32,40,308		38,34,238
Victoria	1,76,14,925	8,47,792		96,83,053		95,22,612				19,02,005			58,07,270
NSW	2,48,54,506	1,52,73,357		76,41,013				72,94,135		22,24,614			57,96,011
Queensland	9,90,991	22,83,654	1,90,31,764		1,83,79,298	5,52,616			96,26,245			22,85,448	62,44,656

Queensland NSW Victoria South Australia Tasmania

Source: AER State of the energy market report 2021 – data; Output in 2020. Market shares are attributed to the owner of the plant or the intermediary (should one be declared to AEMO). Output is split on a pro rata basis if the owner or intermediary changed in 2020. Data exclude output from rooftop solar PV systems and interconnectors.
Link: https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2021-data

Energy Retail: The retail market shares of AGL Energy, Origin Energy and EnergyAustralia have gradually declined, but Origin Energy and AGL Energy recorded net growth in electricity customer numbers in 2020

Tier 1 retailers are dominant across both the electricity and gas markets in Australia. Healthy competition is seen to drive significant benefits for end-consumers by promoting price competition, service offerings and heightened awareness of consumption activities and alternatives.

Electricity markets show healthy competition across South-East QLD, NSW, and SA. Contestability is less effective in the Australian Capital Territory (ACT), TAS and regional QLD.

- Competitive markets are characterized by a high level of diversity in service providers and offers, intensive marketing activity and considerable customer switching of retailers.
- Less competitive markets usually show less available retailers and offers, and a higher degree of government intervention.

- The market share of Tier 1 retailers like AGL Energy, Origin Energy and EnergyAustralia has gradually declined over the past decade.
  - However, Origin Energy and AGL Energy recorded net growth in electricity customer numbers in 2020.
  - AGL Energy's customer numbers increased significantly with its acquisition of Amaysim's energy business (including Click Energy) in September 2020.
- Retailers Snowy Hydro (Lumo Energy and Red Energy), Alinta Energy and Simply Energy have solidified their market position in 2020 and are leading the "Tier 2" market.
  - Simply Energy supplied up to 7% of electricity customers and 9% of gas customers in the NEM. Its market share is highest in VIC, supplying 13% of electricity customers and 14% of gas customers.
  - Alinta Energy supplied 5% of electricity customers and 3% of gas customers in the NEM. The retailer's market share is highest in QLD and SA where it served 6% of the electricity market and 5% of the gas market.
  - Simply Energy served 4% of all electricity customers and 6% of all gas customers in the NEM, and around 10% of all customers in VIC and SA.
- Most retailers operate across multiple regions although only half of all retailers operate in all regions i.e., South-east QLD, NSW, VIC and SA.

Gas markets are generally less competitive than electricity markets, given their smaller scale and limitations in sourcing gas and pipeline services in some regions.

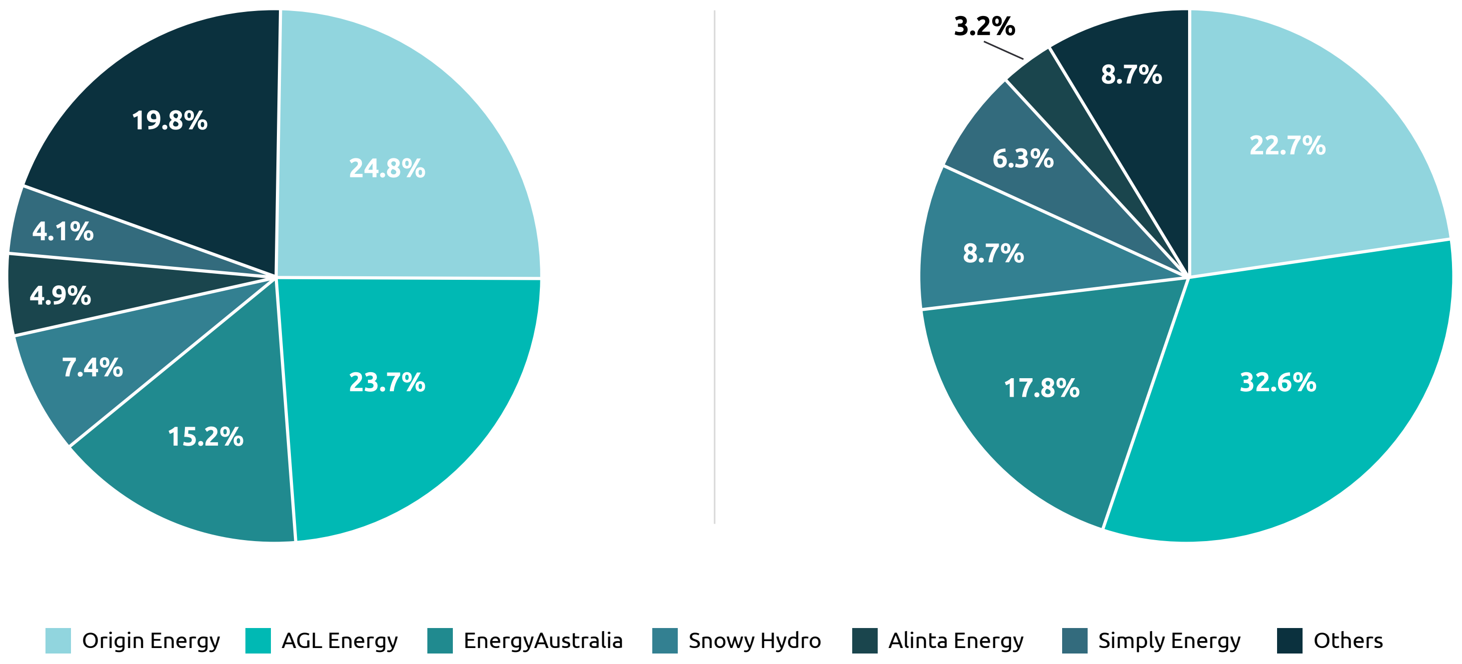
- The gas market is more disconnected than the electricity market. Most retailers are engaged in the Victorian market, followed by NSW and SA.
- In the gas market, smaller retailers accounted for 5.9% of small customers in 2020, up from 4.4% in 2019. Smaller retailers have made more inroads in VIC than elsewhere, supplying 15% of all small electricity customers and 10% of all small gas customers.

"The Australian Energy Market Commission's Retail Competition Review found that one in three Aussies has moved on from the big three to smaller players for their electricity supply"

- Mozo Energy

FIGURE 4

Energy retail market share (small customers)



Source: AER State of the energy market report 2021 - data
Link: https://www.aer.gov.au/publications/state-of-the-energy-market-reports/state-of-the-energy-market-2021-data

Like any other industry globally, Australian utilities have engaged in cost cutting and efficiency initiatives to mitigate the financial impacts of COVID-19

With large changes in demand patterns and load profiles during 2020, Australian utilities had to reassess their business models to ensure financial viability. Australian utilities are looking to accelerate digital initiatives to increase efficiencies and reduce costs across business operation

Most Australian power utilities engaged in cost cutting measures in 2020.

- ***Origin Energy:*** To address lower earnings in the near-term, Origin Energy communicated to its investors that it would focus on continued capital discipline, aiming to achieve $100-$150 million in retail cost savings by FY2024. Origin has achieved its previous cost out target of $100 million by 2021.
- ***AGL Energy:*** In February 2021, AGL announced a plan to cut costs and adjust its business model after posting a $2.3 billion loss in the first half of 2021 against a backdrop of plunging wholesale energy prices. The company also warned of an unexpectedly rapid deterioration of business conditions as renewables flood a market where demand has been softened by mild weather and the COVID-19 pandemic. In response, AGL reduced Opex by $150 million in FY2020 and engaged a sale process for select assets, including the Newcastle Gas Storage Facility and the Silver Springs gas project.
- ***Ausgrid:*** In October 2020, Ausgrid announced further cost reduction measures to keep downward pressure on energy prices as part of its previously announced plan to optimise its workforce by 2024.
- ***AusNet Services:*** AusNet Services continues to apply strong focus on increasing efficiency and managing cost. In 2020, it commenced a LiDAR program to build a 3D digital network model to deliver business benefits through automated assessment of vegetation. It also implemented a fully outsourced field services delivery model.
- ***Hydro Tasmania:*** In March 2021, Tasmania's state-owned electricity provider announced it would reduce its workforce by 5% in the next 12 months to help elevate some of the ongoing company cost pressures.

"Energy organisations are pursuing significant reductions in their cost bases through restructuring, reducing fixed costs and realising process efficiencies, however traditional cost reduction levers have mostly been exhausted. There needs to be a growing focus on digital strategies and transformation agendas e.g., AI and RPA".

- Alexandra Luxton, Energy & Utilities Transformation Director, Capgemini Australia

Cost implications of COVID-19

- Many power distribution companies need significant, immediate liquidity support, causing serious concerns for investors. In more liberalized markets, the drop in demand has resulted in the collapse of electricity market prices, hurting power generation companies.

- Utilities are developing models to assess their possible revenue loss and are engaging in conversations with regulatory bodies and policy makers to evaluate options for government support.

- Grid operators often have limited ability to compensate for unexpected losses due to their regionally restricted and regulated business models. Also, while the generation cost to produce electricity has fallen, the cost for transmission and distribution remains almost fixed.

- Overall, increased call center activity volume and complexity of inquiries is likely to continue if unemployment remains high, and more people remain at risk of getting into payment difficulties. Smaller retailers will likely experience higher impacts than Tier 1 players. Companies will therefore accelerate digital innovation initiatives to increase efficiency and secure required government support.

Market feedback on COVID-19 cost impacts

- According to AGL, Origin Energy and Powershop, COVID-19 significantly changed energy usage patterns, resulting in decreased commercial and increased residential demand as well as changes in load profiles. This has impacted wholesale costs, revenue, and profit. The trend continues in 2021.

Building long-term resilience

- The COVID-19 pandemic has put the energy system in a challenging position and exposed vulnerabilities. Responding to these types of changes in demand patterns requires the development of more reliable and safe operational mechanisms and supporting policies.

- Australia should adopt energy resiliency policies and develop an integrated resource and resilience planning process, which should cover capacity expansion, transmission and distribution build-out as well as end customer support.

The Australian Government has rendered support to reduce the impact of the COVID-19 crisis on the utilities sector

The Australian utilities sector had a tough 2020 and 2021 so far. The sector is having to face increased cost pressures, significantly increased economic uncertainty, lockdown restriction disruptions, increased customer bad debt and reduced revenue.

Financial distress for retailers increased due to COVID-19. They experienced increased costs, increased customer debt and reduced revenue.

- In early 2021, Origin Energy downgraded its full year profit guidance, citing subdued energy demand due to the impacts of COVID-19.
- AGL and Origin Energy warned investors about weaker earnings due to the pandemic.
  - Origin Energy's share price dropped by 6.9% to $4.62 after the company reduced its earnings forecast for its energy markets division because of weaker demand for oil and gas.
  - AGL Energy's share price dropped by 3.6% to $11.42. AGL has further announced an impairment of over $2.6 billion, partially driven by reduced revenue outlook due to COVID-19.
- EnergyAustralia increased its bad debt provisions to $91 million from $65 million as customers' financial strength decreased.
- CleanCo's revenue was reduced due to lower electricity market prices and reduced peak demand.
  - CleanCo's EBITDA for FY2020 reflected a loss of $49.7 million driven by lower wholesale electricity prices.
- Attributed to financial pressure, four retail energy brands exited the market in the year to March 2021, according to AER's State of the energy market 2021 report.
  - In September 2020, AGL acquired the customers of Amaysim (branded as Amaysim and Click Energy).
  - In July 2021, M2 Energy retired its business-to-customer focused Commander Power & Gas brand and migrated its electricity services to Dodo Power and Gas.

The renewable power sector has been impacted by COVID.

- In 2020, lower energy demand led to lower wholesales prices and therefore reduced revenue for renewable generators.

The Australian Government's COVID recovery plans support the stabilization of the utilities sector.

- In October 2020, Australia released its 2020-21 budget, which included a COVID-19 response package of $25 billion.
- The budget includes investment in new energy technologies to create jobs and boost economic growth. These investments include:
  - $1.9 billion to lower emissions and improve the sustainability of Australia's energy supply.
  - A $50 million fund for carbon capture use and storage development.
  - $70.2 million for a hydrogen export hub.
  - $67 million for micro-grid development to deliver sustainable and reliable power to remote communities.

"The growth in renewable energy is also contributing to financial stress on fossil fuel generators, risking earlier than scheduled plant exits from the market"

- AER State of the energy market 2021

The majority of the winners among ASX listed utilities are smaller players in the renewable energy space. Grid operators experienced lower revenue due to a reduced regulated rate of return.

Everyone needs gas and electricity. Despite the challenges of the global pandemic, Australian ASX listed utilities remained strong and renewable energy companies tended to outperform their peers.

The 24 ASX listed utilities remained strong overall against a weak share market in 2020.

- Utilities stocks include companies that provide gas, electricity and water to consumers. This covers the whole utilities value chain from generation over transport to retail services.
- While the ASX 200 lost 8% in 2020, the average utilities stock lost only 2% in the same timeframe.

Nevertheless, share performance for AGL Energy and Origin Energy has been unsatisfactory in recent years.

- Origin Energy and AGL share prices continue their negative trend over the last few years.
- Both companies have been hit hard by the drop in wholesale prices triggered by surging renewables.
- Analysts cite the lack of a clear de-carbonisation strategy and inability to build a steady growth business for the ongoing downward trend.

ASX listed renewable energy companies substantially outperformed the rest of the sector.

- **Tilt Renewables (Wind Generation) up by 43%**
  - Tilt Renewables develops and operates wind farms across Australia and New Zealand.
  - Tilt generated $478 million net profit after tax in FY2020, though this was dominated by the one-off profit of the sales of a wind farm substantially above book value.
- **Infigen Energy delivered a 38% increase**
  - The company has active renewable energy projects in wind and solar.
  - The surge was driven by the company's takeover in June 2020 by Filipino conglomerate Ayala.
- **ReNu Energy went up over 30%**
  - ReNu Energy is a clean energy incubator and accelerator. After two disappointing years with consecutive annual losses and underperforming assets, in 2021 ReNu Energy streamlined its portfolio and developed a fresh merger and acquisition strategy which saw strong returns. ReNu has invested in Enosi Australia with a first-of-its-kind grid scale renewable energy trading and tracing platform, and Uniflow Power with its biomass powered micro renewable generation solution.

Lower wholesale prices reduced the earnings of power generators and retailers in Australia and this trend is likely to continue.

- Pressure on electricity prices began to ease during 2020 as reductions in wholesale prices started to flow through to consumers. Prices fell significantly across all regions in 2020, declining by between 23% and 58% compared to 2019 averages. The longer-term outlook for prices remains relatively subdued.

- This will continue to impact the fossil-fuel power generators and GenTailers – like AGL, Origin and EnergyAustralia, especially considering the recently encountered increase in coal and gas prices.
- In addition, Australian customers are increasingly "shopping around" to look for better offers from retailers. The Government's transparency initiative and default offerings have made it much simpler for consumers to compare offers.

Electricity distribution and transmission businesses in Australia generated a total of $12.4 billion in revenue.

- Of this, transmission network businesses earned $2.7 billion, which was 0.6% less than in the previous year and 18% less than the peak in 2013.
- Distributors earned around $9.7 billion, which was 1.5% less than in the previous year and 25% less than the peak in 2015.
- The key driver behind lower revenues for the majority of the transmission and distribution networks is their reduced return on capital. The rate of return was reduced for most companies by the regulator. The AER considers that lower market interest rates will allow grid operators, who are usually debt-heavy, to operate their businesses a lower cost level.

"Renewable power investment continues to outperform fossil fuel investment across the globe. Global renewables investment return is 7 times higher than fossil fuels"

- Felicia Jackson, Forbes Sustainability Contributor 2021

Key Takeaways

The Power Generation market is led by the big three retailers and Snowy Hydro, though other renewables companies are now becoming more prominent as well.

- AGL Energy is the largest participant by capacity and output in NSW, VIC, and SA. NEM wide it accounted for 19% capacity and 25% of output in 2020.
- Lower wholesale energy prices will continue to stress especially traditional, fossil-fuel power generators, especially in light of the recently encountered increase in coal and gas prices.

The retail market shares of the big three have gradually declined, but Origin Energy and AGL Energy recorded net growth in electricity customer numbers over 2020.

- Retail competition and customer churn varies considerably across states, due to their sizes, available offers and local government regulation.
- While market share of the Big 3 retailers has continually declined over the past decade, Origin Energy and AGL were able to record net growth in customer numbers.

Australian utilities have engaged cost cutting initiatives to mitigate the financial impacts of COVID-19.

- Due to their regulated nature, utilities often have limited means to compensate falling revenues and other performance impacts. Their focus in 2020 was therefore on operational efficiency, adjustment of policies, and accessing government crisis support funds.
- The majority of GenTailers and grid operators have engaged in programs to apply increased capital discipline, take cost out and increase operational efficiency using digital innovation.
- The Government has established various funds and commitment to support the sector not just with financial "care packages" but also investment funding that will support the long-term energy transition journey.

While listed utilities generally perform stable on the ASX, Origin and AGL shares continue their downward trend. The big winners are the up-and-coming renewables companies.

- While the ASX 200 lost 8% overall in 2020, utilities shares only lost 2% on average.
- Renewables companies Tilt (+43%), Infigen (+38%), Renu Energy (+30%) and Volt Power (+30%) are the biggest winners in the sector.
- AGL and Origin have been heavily hit by the drop in wholesale prices and respective share prices continue their downward trend.

The regulator reduced the rate of return for most Grid Operators.

- Grid operators generated less revenue in 2020. This was mostly driven by a reduced rate of return: the regulator considers that low international interest rates will allow debt-heavy grid operators to reduce their operating cost base.

"As renewables uptake accelerates and consumers shift their expectations towards net-zero, the business models of the large energy providers in Australia are heavily challenged. The response will require urgency to accelerate automation and intelligence across operations."

- Emilie Ditton, Energy, Utilities and Resources Consulting Lead, Capgemini Australia

07 Finance

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07 Finance

Inter-Regional Finance Comparison

Augustin Danneaux
Florian Schall
Charles Dagicour

Panel

FIGURE 1

Europe

- Centrica
- CEZ
- E.ON
- EDF
- EDP
- ENEL
- ENBW
- Engie
- Fortum
- Iberdrola
- Naturgy
- Orsted
- RWE
- SSE
- Uniper
- Vattenfallen

North America

- American Electric
- Consolidated Edison
- Duke Energy
- Edison International
- Exelon
- FirstEnergy
- NextEra Energy
- NRG Energy
- Pacific Gas & Electric
- Sempra Energy
- Southern Company
- The AES Corp
- Hydro-Québec
- TransAlta
- BC Hydro
- Ontario Power Generation
- Hydro One
- ENMAX

The pandemic has decreased utilities' revenue on both sides of the Atlantic, although the effect is more intense in Europe

The pandemic was characterized in Europe by stronger and longer health measures than in the States. Prolonged lockdowns had a strong influence on energy demand and, in turn, on utilities' revenues.

North American utilities were also impacted by COVID-19, albeit to a lesser extent because of milder restrictions.

FIGURE 2

Annual revenue evolution of companies in the panel

Revenue evolution				
	2017	2018	2019	2020
Utilities' average in Europe[1]	-8.2%	0.5%	1.8%[2]	-9.7%[3]
Trend in Europe	↓	↑	↑	↓
Utilities' average in North America[1]	2.5%	3.3%	-0.1%	-1.5%
Trend in North America	↑	↑	↓	↓

1 Weighted by company revenue
2 Excluding SSE
3 Excluding E.ON, Fortum and Uniper

Source: Thomson Reuters EIKON data, companies' annual reports

Utilities in both North America and Europe were resilient during the COVID-19 pandemic and raised their EBITDA margins

EBITDA margins are structurally higher in the U.S. and Canada than Europe due to:

- A regulated energy market in most states / provinces.
- A greater number of players incentivizing a precise costs discipline.

In 2020, utilities in both Europe and North America proved to be very resilient. Increasing EBITDA margins (in %) demonstrate their high control over operational costs and the high production time of their assets. But, at the same time, when revenues decrease, so too does the gross margin (in $).

FIGURE 3

EBITDA margin evolution

	EBITDA margin			
	2017	2018	2019	2020
Utilities' average in Europe[1]	19.0%	18.9%	21.0%	21.7%
Trend in Europe	↓	→	↑	↑
Utilities' average in North America[1]	37.4%	37.2%	38.6%	40.0%
Trend in North America	→	→	↑	↑

1 Weighted by company revenue

Source: Thomson Reuters EIKON data, companies' annual reports

In 2020 the leverage ratio of North American utilities increased from levels already higher than those of European utilities

North American utilities (Duke and NextEra, in particular) are more indebted than their European counterparts. Companies in the U.S. and Canada have a higher risk appetite as long as cashflow is generated. They were willing to take advantage of low interest rates to invest in infrastructure. In Europe, many investments have been postponed to manage risks.

However, the European trend of reducing leverage ratio is far from homogeneous, as demonstrated by companies like Fortum which strongly increased its net debt to make major acquisitions.

FIGURE 4

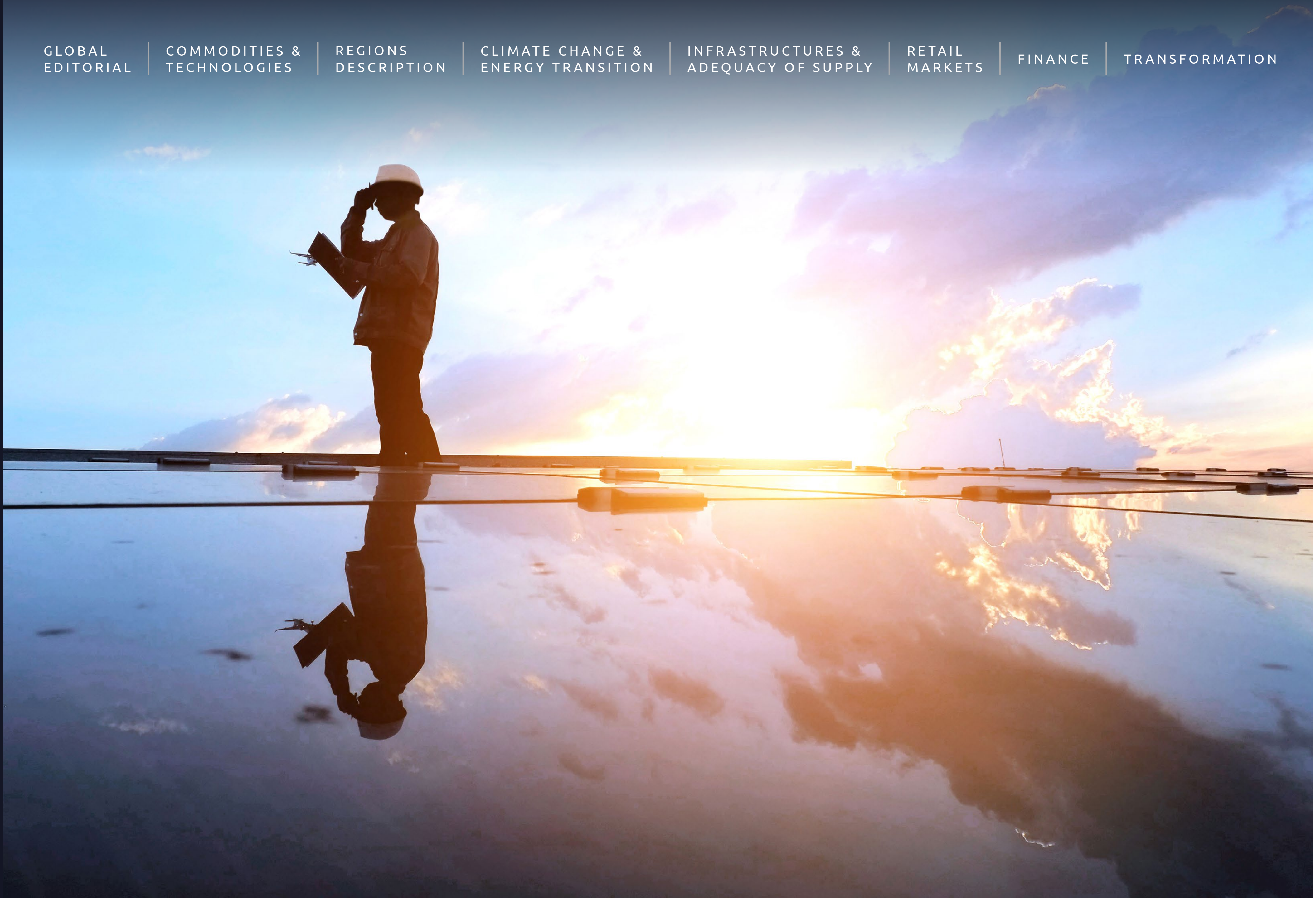
Leverage ratio (net debt/EBITDA) evolution

	Leverage ratio			
	2017	2018	2019	2020
Utilities' average in Europe[1]	2.93	2.78	3.50	3.37
Trend in Europe	↓	↓	↑	↓
Utilities' average in North America[1]	5.01	5.12	4.90	5.56
Trend in North America	↓	↑	↓	↑

1 Weighted by company revenue

Source: Thomson Reuters EIKON data, companies' annual reports

08 Transformation



08 Transformation

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Mergers and Acquisitions (M&A)

Augustin Danneaux

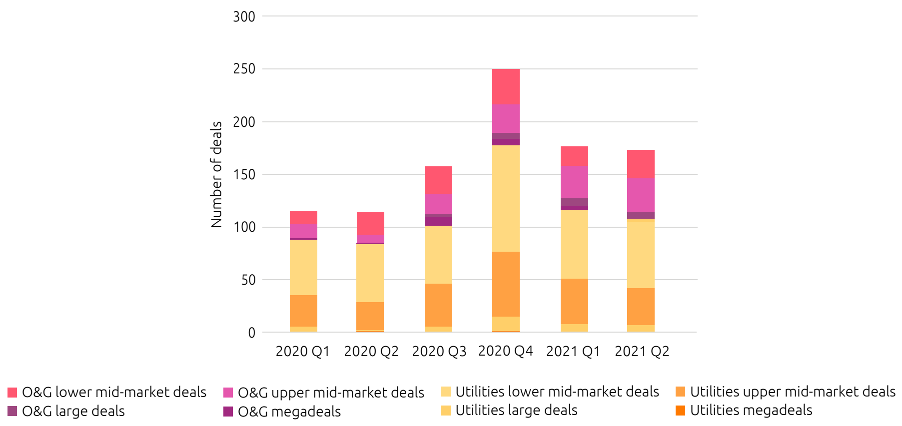
Mergers and Acquisitions (M&A)

After a drop in M&A activity during the first several months of the pandemic, recovery has been strong, as driven by sustainability concerns

- COVID-19 slowed M&A deals in the first quarters of 2020.
- However, as economies restarted, M&A activities resumed, as driven by a reshuffling of market positions and an increased concern over sustainability issues.
- The collapse of oil prices in April 2020 has resulted in consolidation of the U.S. shale market later in the year. As crude prices have reverted to normal levels, M&A in the sector should continue to slow, as was the case since Q3 2020.
- Massive investments were made in the European utilities sector after the first waves of COVID-19.
- Energy transition is a key driver for M&A deals as companies in the sector are selling off large numbers of carbon-intensive assets (rather than decommissioning).
- European IOCs, in their effort to become more diverse energy companies, are investing directly in large wind and solar farms.
- However, oil majors have not abandoned upstream acquisitions as shown by the activity in and around the Permian basin, as well as TotalEnergies's acquisition of Tullow's assets in Uganda.

FIGURE 1

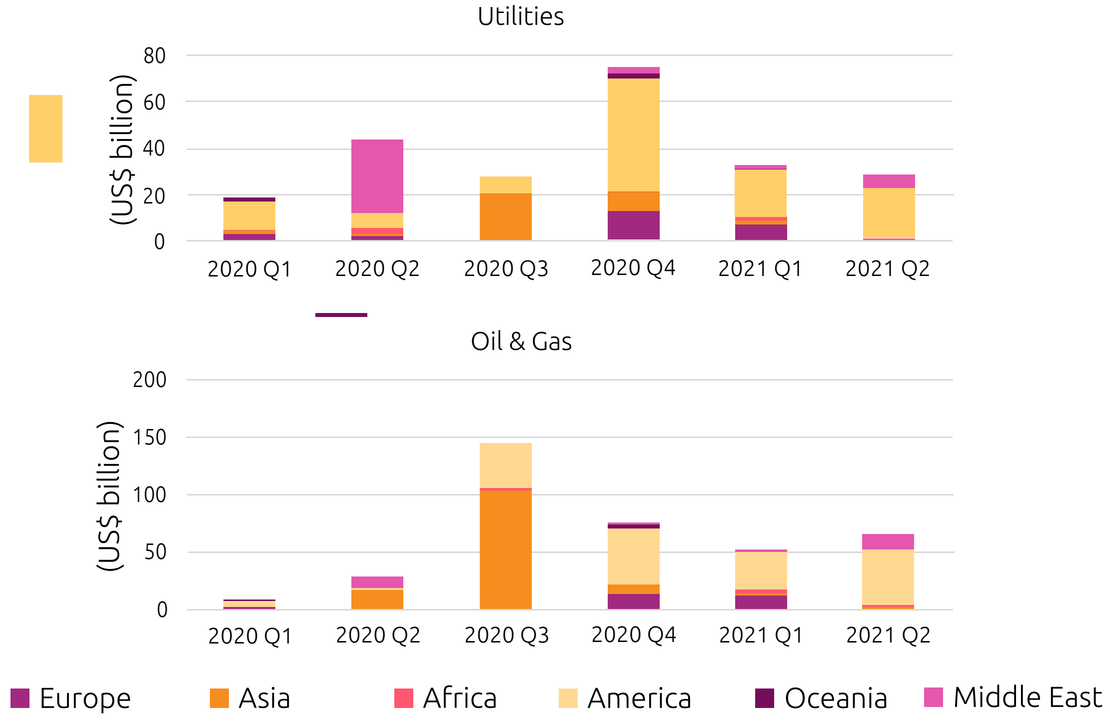
Volume of M&A deals between 2020Q1 and 2021Q2



Source: White & Case (2021)

FIGURE 2

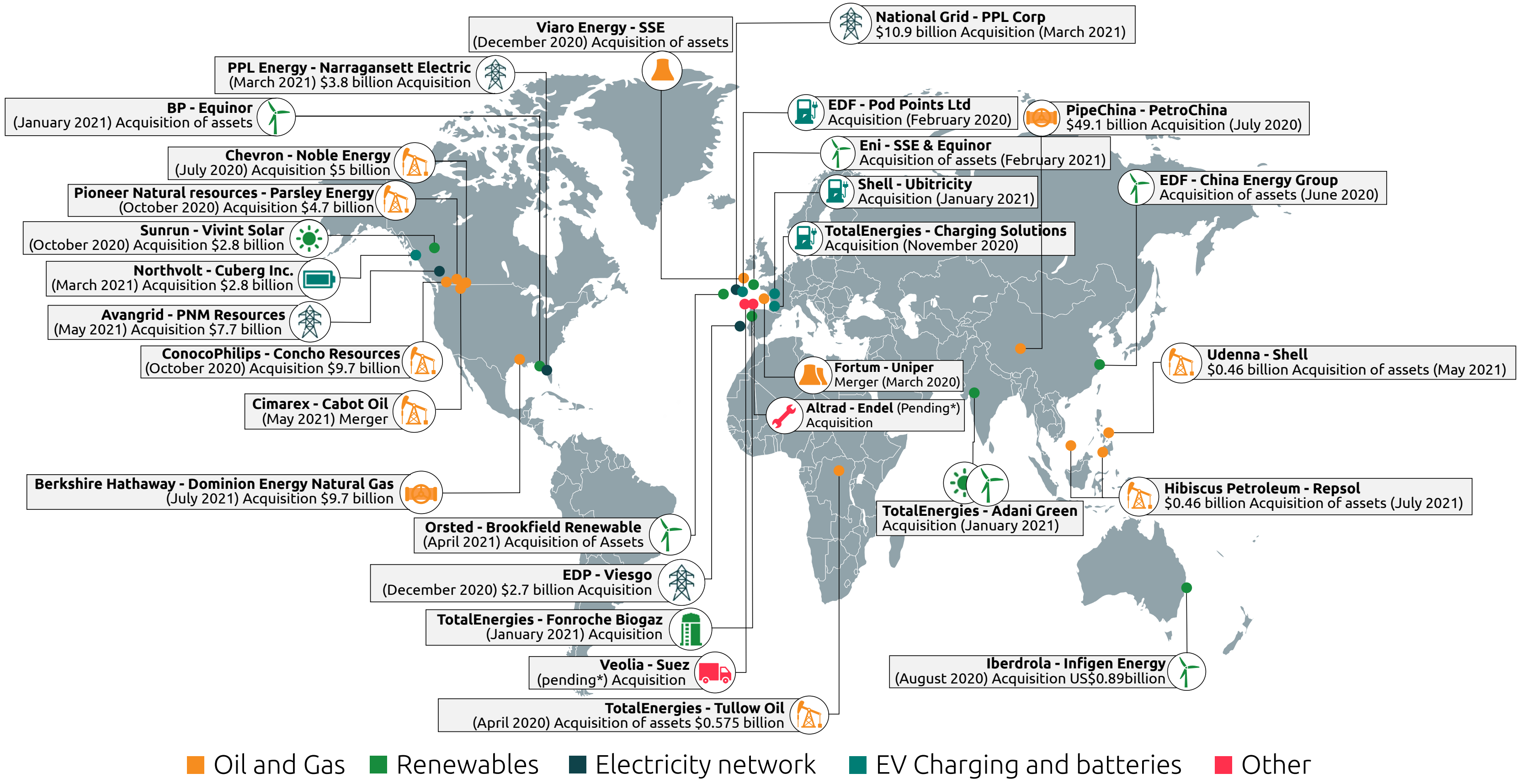
Value M&A deal by region and by sector



Source: White & Case (2021)

FIGURE 3

Map of major M&A deals in 2020 and 2021 (January to August)



Source: Reuters, S&P Global, Capgemini Analysis

2020 and 2021 have been characterized by large deals in renewables, assets divestments, and the rise of SPACS

The acquisition of renewable assets through M&A is at the heart of IOCs sustainability strategies:

- The sustainability push in the Energy and Utilities sectors has increased the number of M&As in renewables in the last few years, a trend continued through 2020 and the first half of 2021.
- Front and center are wind and solar assets.
- In particular, European IOCs are investing heavily in wind farm (both onshore and offshore). Examples include BP’s $1.1 billion deal at Empire Wind or Eni at Dogger Bank A and B.
- Other acquisitions in additional renewables, such as TotalEnergie’s investment in biogas in France, have occurred.

Utilities are making major investments in networks:

- Investment in networks are also being driven by the sustainability push, as evidenced by National Grid’s move into the electric grid through their $11 billion acquisition of PPL Corp. Activities in the U.K. are linked to decarbonation objectives.
- In its $1.03 billion acquisition of Viesgo, EDP gained 52,000 km of network and 500MW of renewable generation, as well as thermal generation capacity.

Large utilities and O&G players are investing in new technologies to benefit from electrification of transports:

- European IOCs are moving fast to buy EV charging companies.
- Shell and TotalEnergies have both acquired German companies with expertise in this field.
- EV charging remains a very fragmented market. OEMs have a similar appetite to invest in this area.
- Other large M&A movements in new technologies are also centered around energy storage and batteries.

2020 and 2021 have been characterized by large deals in renewables, assets divestments, and the rise of SPACS

SPACs are rising in the energy and utilities sector:

- Special purpose acquisition companies, known as SPACs, through which companies go public after an M&A deal have become a largely used mechanism in the U.S. technology sector.
- This is extending into the clean tech space as well. For example, the fuel cell manufacturer Advent Technologies announced a SPAC merger in late 2020 and Li-Cycle Corp., which specializes in li-ion batteries recycling, announced a SPAC merger deal in February 2021.
- ArcLight Capital Partners has set up SPACs with specific interest in renewable energy.
- Although regulations differ from the U.S., SPACs are making an appearance on the European market. The first, named "Transition" has launched in June of 2021.

From upstream asset to non-core businesses, energy companies and utilities are divesting to reduce debt:

- Large IOCs are divesting from upstream assets. These assets are being bought by smaller local players.
- This is a key trend in the Southeast Asia market where Hibiscus Petroleum as bought Repsol's Vietnamese and Malaysian assets, as well as Udenna Shell's Philippine assets.
- Despite significant M&A activity upstream, majors should hold onto their refining assets as demand for petrochemicals is not set to decrease.
- There is a similar trend for utilities to sell off thermal assets, as evidenced by British utility SSE selling thermal power plants to Viaro Energy.
- Engie is now considering divesting from some its subsidiaries in the service industry such as Endel.

2020 has seen an exceptional level of M&A activity in the shale industry. America saw $90 billion of O&G deals in the second half of 2020:

- Low oil prices in the first months of the COVID-19 crisis have resulted in adverse conditions for smaller actors in the US.
- This shift in the shale industry has led to consolidation with large actors such as Chevron and ConocoPhillips acquiring upstream assets and companies for $5 billion and $9.7 billion, respectively.

08 Transformation

08

08 Transformation

Digital & Data

James Lally
David Butcher
Rahoul Bhansali
Chris Zeyen
Ryan Brown
Louis Grey-Edwards

Why data and digitalization are central to energy transition

Data and digitalization as key enablers for energy transition

The changing energy market is making global energy organizations rethink their business models and the way that they operate. This provides the opportunity to rethink the role that digital and data plays – going from a back office, supporting role to being a core enabler for the future success of the business. Data and digitalization are a boardroom concern, as they have a demonstrable role in enhancing customer and consumer value, improving operations and ultimately driving the road to net zero.

System coordination

The energy landscape of the future starts with networks. The grid needs to adapt if we are to realize the ambition of smart, achieving clean cities and ultimately a net zero world. Building a data-enabled and digitalized network is a key step towards enabling flexibility and delivering on the promise of a whole systems approach.

More effective protection, control, automation, and communication systems are needed, not just to manage the grid itself, but also to manage the myriad of devices that are connected to it, both now and in the future.

Technology can be used to manage and optimize operations at the grid edge – the point of power consumption and production. Solar and energy storage systems (ESS) are growing in use; asset aggregation software can connect these systems to provide the right power at the right times in front of and behind the meter. Vertical integration of the technology stack – ESS, software, and distributed energy resource management systems (DERMs) – can enable grid edge renewables to offer baseload power and be dispatchable.

Harnessing AI

As the grid gets smarter, there is going to be increasing demand for AI solutions to manage the complexity of operations. This will enable greener operations in implementing predictive maintenance of solar and wind arrays. In addition, it could have a significant role in the corporate energy market, enabling companies to reduce energy use and even supporting a decrease in emissions through managing a dynamic network of energy sources. This could support not just the management of cost, but also the carbon profile of energy sources.

Consumer-Side

There is a massive, and largely untapped, flexibility potential on the demand side: various electric appliances can adjust their consumption by reacting to changes in weather and renewable production. Unfortunately, it requires a huge number of individual appliances to make small adjustments. Therefore, demand response from connected devices will need to be aggregated and automated. This is especially important for electrified transport: uncontrolled charging of electric cars may coincide with peak periods when the marginal electricity source is gas or even coal. Car owners are unlikely to have the information they need to adjust their charging (even if financial incentives are in place). In the future energy system, it is almost certain that a smart phone app or even a smart speaker would have to do that for its owner.

Leveraging the Internet of Things (IoT)

The increased use of electricity requires the expansion of transmission and distribution networks, but building new lines is difficult in many countries. The systematic application of IoT on electricity networks could enable operators to more precisely understand conditions and electricity flows on the lines, allowing them to expand transmission capacity without increasing the physical footprint.

Digital and data drivers –regulation, customers, industry, and technology

What will be the pacesetters for digital uptake?

Across the globe, the effective deployment and use of digital technologies continues to create substantive advancements in both productivity and profitability. Ongoing investment in digital assets has increased by almost 500% in the last fifteen years, with media, finance, and professional services sectors seeing the greatest levels of digital capability and resultant increases in organizational success.

In light of this trend, the Energy & Utilities sector stands to benefit substantially from focusing on digital tooling and collaboration. At the current moment, the emergence of renewables, distributed generation, and smart grids are leveraging advancements in technology, though we are yet to see the full benefits of digital along the value chain. Upstream demand forecasting and modeling will benefit from more informed decision-making amongst a growing richness of data availability and rapid, complex analysis. Critical, real-time operations will benefit from the near-immediacy of data availability, enabling rapid responses to changes in demand and increased learnings from direct application of digital twin technology.

Regulation

Historically, the Energy & Utilities sector has been relatively slow to adopt new technologies. They have focused (rightly) on stability and resilience, but have missed potential gains in efficiency and effectiveness through emerging technology; frustrations have been felt by regulatory bodies, market participants, and end consumers alike.

However, as we shift into the next phase of energy and resource distribution, governing regulatory bodies are taking a more active role in encouraging and even mandating the pursuit of digital solutions by their industry participants.

In the U.K., for example, the energy regulator has introduced the need for regulated organizations to publish detailed digitalization and data strategies and, as part of the current regulatory business planning cycle, they must commit to delivering against those plans.

Cost and customer satisfaction

Digitalization provides the opportunity to reduce both CAPEX and OPEX costs through efficiency improvements, automation, and use of shared resources. At the same time, digital can dramatically improve the customer experience through convenient services and higher standards of customer service.

Digital has the power to allow employees to focus on value-creating activities and be happier at work. Automating manual tasks improves process efficiency and allows workers to focus on what they do best. Digital collaboration tools allow for seamless interaction and data sharing within and across teams, removing friction and breaking down silos in the organization.

Industry collaboration

Coupled with the increase of digital assets and tooling within the industry, heightened collaboration and data sharing between market participants and governing bodies will generate levels of insight previously unseen. As an area of the industry that has historically been underutilized, a robust construct for fair and equal sharing of mutually beneficial data between organizations will enable greater levels of cross-medium analysis and complementary responsiveness.

Technological advances

The International Energy Agency (IEA) has observed that nearly half of the technologies necessary to decarbonize energy are still in development. While the uptake of smart meters and EVs are already mainstream, the exploitation of technologies such as AI, ML, and RPA is still in its infancy in the energy sector, meaning that technology companies themselves will be part of the driving force of energy digitalization in the sector.

Net zero changes everything: New business models and digital platforms to thrive

The organizations that thrive and grow will be the ones that embrace new business models and invest in new digital platforms – the ones that can make the winning connection between future business and the digital capabilities that enable it.

New business models

The new ecosystem creates both room and demand for new business models, which should be launched at pace to gain a competitive advantage. Established actors will need to join this race in order to stay relevant and, increasingly, to fulfill their regulatory obligations.

Those new business models can be in the area of energy demand, e.g. smarter management of the grid to avoid reinforcement; they could also optimize demand and supply balancing or provide integrated energy services. The further the market develops, the more opportunities will arise.

New digital platforms

What is clear is that whoever is to win the race will increasingly win on the basis of having the right digital platforms. Those platforms need to cover key capabilities of an energy actor in a net zero world, e.g. customer service, asset management, system control, forecasting and balancing as well as energy data.

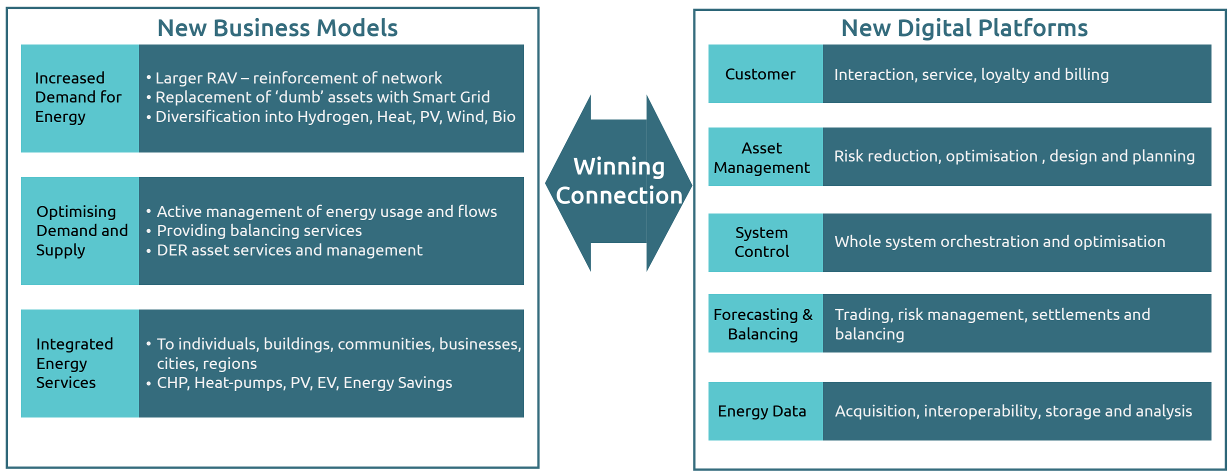
The nature of good platforms needs to be that they can act as the central hub for those capabilities and that they can provide coordinated and consistent but flexible access to data and its processing. The old-school approach of siloed systems and replicated data and processing rules will no longer be fit for purpose, as it can't move fast enough.

Actors like Octopus Energy in the U.K. are now offering flexible half-hourly tariffs to consumers, and are thus able to drive demand and supply in new ways. This is one example of a customer and an energy data platform coming together to drive new customer and competitive advantage. Through the remainder of this chapter, we will explore some of the major digital platforms and themes:

- ***Real-time network control***
- ***Digital assets and asset management***
- ***The digital 'tipping point' for wholesale customer behavior change***
- ***How Open Data will enable the digital future of the industry***
- ***Approaches to digital trans-formation: frame your thinking***
- ***Roadmap for success: Getting started with digitalization***

FIGURE 1

New Business Models and New Digital Platforms



World Energy Markets Observatory 2021

Real-time network control

Network operators are responding with multiple technologies to support the transformation. Operating systems are changing in order to automate and optimize their networks, leverage open data, and enable the move towards the DSO model.

Automating the supervision system

Network control rooms are linked to increasingly advanced data and analytics software, such as Supervisory Control and Data Acquisition (SCADA), Advanced Distribution Management Systems (ADMS), and Distributed Energy Resource Management Systems (DERMS). These systems provide situational awareness at a network level and enable the monitoring and control of distributed and intermittent renewables. With these tools, network operators can automate the control room and integrate a variable share of distributed energy resources (DER).

Optimizing energy availability

An AI/ML-based outage management system (OMS) is an essential part of a smart distribution network, particularly as DER plays an increasingly important role in outage management. To recover from an outage (or reduce its impact), the OMS can employ DER to restore the power more effectively, to minimize the affected area, and to decrease the cost (operational and regulatory) of the outage.

Real time asset management

Moving to an analytics-based asset management model can improve operations in several ways. For example, this type of model can:

- identify operations that can be reduced
- remove or reduce wear to keep assets in service for longer
- plan additional maintenance work for assets to prevent outages or safety incidents.

An analytics-based asset management system needs several data sources: asset health measures, asset environmental information (e.g. vegetation), asset criticality measures, and a decision making framework (e.g. weighting asset availability versus efficiency). Using a decision model, the system can create an optimized plan for asset maintenance and replacement.

Enabling DSO functions - flexibility

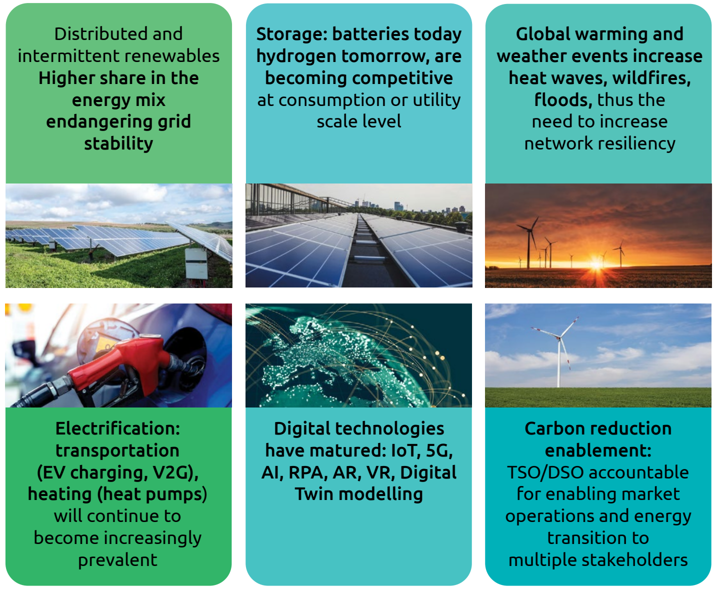
The DSO is required to balance the network in terms of both supply and demand. An active way to do this is by using customer generation flexibility. Influencing energy generation patterns can be done through signals (e.g., price signal or request) in order to provide services to the DSO. By providing attractive opportunities for customers of all scales to respond to requests for flexibility, through a "Neutral Market Facilitator" role, it will also allow existing and new renewables to be fully used.

Project LEO – Local Energy Oxfordshire

One of the UK's most innovative energy trials, Project Leo aims to build reliable evidence of the technological, market, and social conditions needed for a more flexible electricity system whilst managing the network, DERMS, and the flexibility market in real time.

FIGURE 2

Destabilizing factors



World Energy Markets Observatory 2021

Digital assets and asset management

The DSO destination: 'Ultimate Smart Grid' for real-time asset management

The term 'Industry 5.0' for the DSO refers to people working alongside smart assets. It's about enabling assets to work better and faster by leveraging advanced technologies, including integrated technologies via the IoT and big data. With Industry 5.0, the wider market will be able to better automate the asset management process with real-time data from the field to create the 'Ultimate Smart Grid.'

The Ultimate Smart Grid needs to function as a unified and interoperable network, linking workforce devices, like mobile phones and tablets, and network devices, such as sensors and switches. It must be able to flex and have capacity for network events, planned or unplanned. This places new requirements on these networks to be more intelligent than they are today – with the capability to distribute intelligence to the edges of the network. The connectivity and data management side is the key for getting value from the Ultimate Smart Grid, as it will provide meaningful insights from the infrastructure.

Industry 5.0 and the Ultimate Smart Grid: The building blocks

A The Ultimate Smart Grid is the culmination of a journey that has several building blocks, as illustrated by the figure:

Core Smart Grid

At the heart of the Smart Grid are four elements which should be developed iteratively:

- ***Advanced asset management*** will improve power quality (thus extending the life of assets) and incorporate predictive maintenance, while also optimizing costs of asset ownership and securing availability.
- ***Refinement of grid operations*** will increase grid performance and efficiency, ensuring stability, resiliency, and cybersecurity.
- ***Network instrumentation*** through installation of connect sensors and smart substations, including edge-of-grid computing.
- ***An enhanced data-enabled grid*** by setting the technical foundations and human capabilities to leverage data for grid optimization, asset planning and modelling, and edge-of-grid management.

Once these are in an advanced state, the DSO can deploy cloudification and digital twin technology to create the Ultimate Smart Grid.

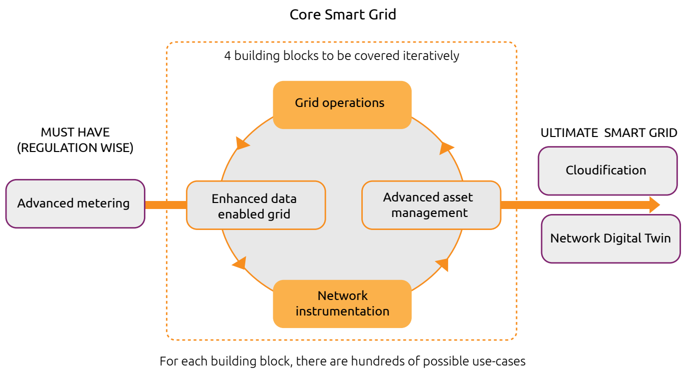
Cloudification and network digital twin

Network function virtualization is a critical step, whereby traditional network appliances are replaced with highly efficient virtualized functions delivered using industry-standard IT equipment. Through virtualization, DSOs can harness AI and automation to begin realizing the vision of an entirely self-adapting network.

The network digital twin offers the DSO a tool where raw data, data models, and AI/ML come together. The digital twin opens up enormous possibilities for the Ultimate Smart Grid, such as improving the implementation of operational processes through to executing strategic grid simulations.

FIGURE 3

Building blocks of the new smart grid



World Energy Markets Observatory 2021

The digital 'tipping point' for wholesale customer behavior change

Consumer behaviors and drivers

The digital drive is also happening from the consumer side, where energy consumers are adopting digital technologies that allow them to meet their own needs and alter their relationship with suppliers. There are a range of consumer types adopting digital through behavioral changes, from those employing digital to improve the way they consume energy, to those investing in small-scale energy generation for their own use, to consumers who monetize their investments by selling energy back to the wider grid ecosystem.

Evolution of the future energy consumer

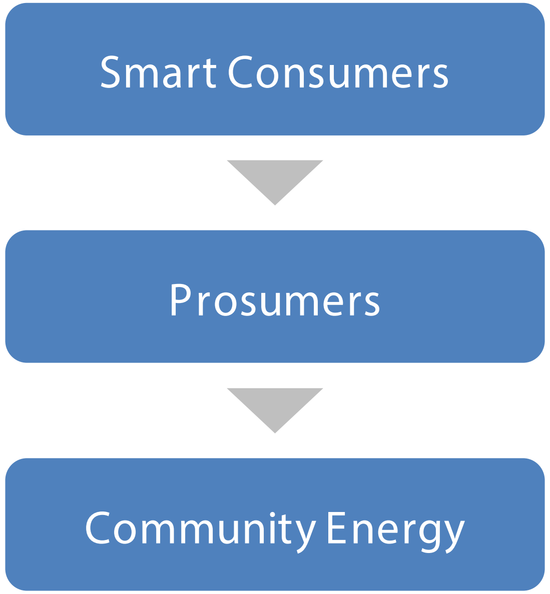
Smart consumers may not yet be generating their own energy, but they are harnessing the power of digital to improve the way they use energy in their day-to-day lives, both personally and professionally. The connected home includes devices to monitor and optimise energy usage, allowing users to switch appliances on and off more easily around the house, which allows them manage their daily consumption of energy more closely. As a result, the immediacy of personally relevant consumption data is leading to consumers who have a greater degree of personal awareness of and responsibility for managing their energy usage, making them more likely to reduce waste. In contrast, prosumers are those who produce, consume, and control their energy use – resulting in a two-way directional flow of power. Some prosumers generate energy for their own use, while others will sell a portion back to the grid for wider distribution and usage.

The next advancement of prosumer behavior is community generation, wherein those generating energy will share it with their local community, creating micro-networks combining both household-produced energy and medium-scale local energy generation, such as windfarms. Consumers can work together to design systems for their local communities, optimizing cost, increasing reliability and enabling greater local connectivity through smart neighborhoods.

Preparing for the tipping point

So when will the prosumer phenomenon scale? Financial motivation is the main incentive to become a prosumer, as individuals seek to reduce the financial impact of their energy expenditure; availability of technology and government incentives are also key factors. Finland has been found to be a standout in Europe for prosumers.1 Prosumers in Finland are motivated by tariff and tax avoidance, while aggregators make it easy to connect production and consumption of energy from small-scale sources.

As household energy generation becomes more prevalent, suppliers must adapt to a future customer-driven model, where people expect highly customized services. The new model also creates opportunities for energy companies to venture beyond their current business models, facilitating better monetization for prosumers, as well as more transformative technologies. This generally requires the ability to anticipate consumer needs and develop digital services quickly, while also questioning the fundamental assumptions underlying existing business models within the industry.



How Open Data will enable the digital future of the industry

What is Open Data?

“Open Data and content can be freely used, modified, and shared by anyone for any purpose.”

Being able to freely use, modify, and share data across the sector and beyond is fundamental to enabling system coordination, which in turn is required to achieve national and global decarbonization ambitions.

Opening data up freely, particularly for customer data or critical national infrastructure, like energy infrastructure, requires careful validation and an understanding of the potential risks of this decision.

How must each type of industry actor adapt to Open Data?

Industry actors need to understand and actively balance the opportunities and risks of Open Data.

However, this requires data to be available to share, which is the biggest gap we are seeing at present. Data is either not captured at all, not searchable, not available in a timely fashion, not available in a consistent and suitable format, or it can’t be secured appropriately. Actors need to build a culture that promotes data as well as the underlying technology platforms required to make data more readily available and usable.

Furthermore, market participants need to understand that Open Data will continue to evolve in the near-term and the medium-term. This requires an iterative and collaborative approach across industry actors and the entire stakeholder ecosystem in order to develop Energy Open Data to its fullest potential.

What are the business opportunities that come with access to a wider data set?

Combining energy data enables actors to improve the operation of their systems as well as the whole system across different energy vectors. It further unlocks flexibility markets on both the supply-side and the demand-side. Combining the datasets with artificial intelligence and machine learning promises even further optimization potential through increases in efficiency, near-immediate responsiveness to consumption and supply patterns, and the availability of richer insights for day-to-day and strategic decision-making.

Looking beyond current actors, Energy Open Data will pave the way towards the democratization of energy by enabling the prosumer and driving production and consumption decisions of both large and small energy users.
Finally, Open Data can unlock new business models that drive both innovation and economic value.

Where is this already being done?

While Open Data is generally still in its infancy compared to its potential, there are some examples where Open Data has significantly benefitted society. Transport for London (TfL) in the UK is openly sharing their data with the general public, which is resulting in annual economic benefits and savings of up to £130 million for travelers, the City of London and TfL itself. A recent study has found that 42% of Londoners used apps powered by this data – apps that were developed by third parties, which have created new business models, e.g. Citymapper.

Organizations like the World Bank, the WHO, or the European Union are offering Open Data, which can be used by educators, researchers, journalists or entrepreneurs. Those datasets have significantly contributed to fighting poverty and creating new business models in the for-profit and non-profit domains.

Approaches to digital transformation: frame your thinking

Digital transformation

Beginning on the road to digitalization or changing course on an existing journey is a major undertaking, and as such, it requires starting with the right mindset and approach. It requires a strategy, not a plan. Given the interconnected nature of digital, it should be addressed as an integrated part of the overall organization's strategy rather than being an afterthought or a separate strategy that is being developed on the back of the corporate strategy.

Our Strategic Choice Framework provides structure for an effective digitalization process, beginning with the fundamental 'why' questions (purpose, ambition) before going through the 'what' (focus, success) and the 'how' (capabilities, change).

Established actors in the market will have a purpose that is hardly defined by digital. However, decarbonization presents ample opportunity for digital start-ups to define a new purpose. For example, in the U.K., Kaluza's purpose is to provide an intelligent energy platform that introduces new flexibility into the energy system by optimizing individual devices.

Every actor should look to challenge their ambition in light of digital, however in the U.K. market, the latest regulatory funding cycle has placed significant focus on digital; organizations had to outline how data and digitalization will drive their ambition towards net zero. This is likely to gain importance globally over the coming years.
Questions to ask are:

- How can we develop a new asset platform that integrates IT and OT data, while providing relevant data to an Open Data platform and optimizing our asset estate?

- How can we adjust energy pricing for consumers to drive demand-side flexibility?

The question of focus is highly relevant in two ways. On one hand, digital opens new areas of focus for the organization, e.g. through different channels. On the other, actors need to further define where to focus their digitalization efforts. We have seen digital transformations lose momentum due to a lack of focus all too often. Once these are decided, it's importance to clearly define what success looks like, and how the organization will differentiate itself in order to deliver on those metrics.

Capabilities are at the heart of digital transformation. Ultimately, building new or enhanced capabilities is what digital is all about. Those capabilities, however, are complex to build. They require a combination of technology, new ways of working, and data, all of which need to be developed in sync. The more a player succeeds in developing their capability, the better they are positioned for an uncertain future. Technologies include OT, cloud, AI and machine learning, AR/VR, mobile, and others. Being able to oversee those technologies and apply them to complex problems requires a different operating model within teams and at an organizational level – as well as a new way of governance.

This transformation requires significant changes in the way organizations work and a new understating of what is important. To successfully navigate this, change needs to be managed proactively. This includes building new skillsets, hiring new talent to fill gaps, partnering with mature organizations, as well as coordinating and measuring maturity along the way. Throughout the process, actors will be able to adjust and refine the plan as required.

Actors need an appreciation that no plan is perfect – it will change over time and this will require constant iteration of the cycle.

Roadmap for success: Getting started with digitalization

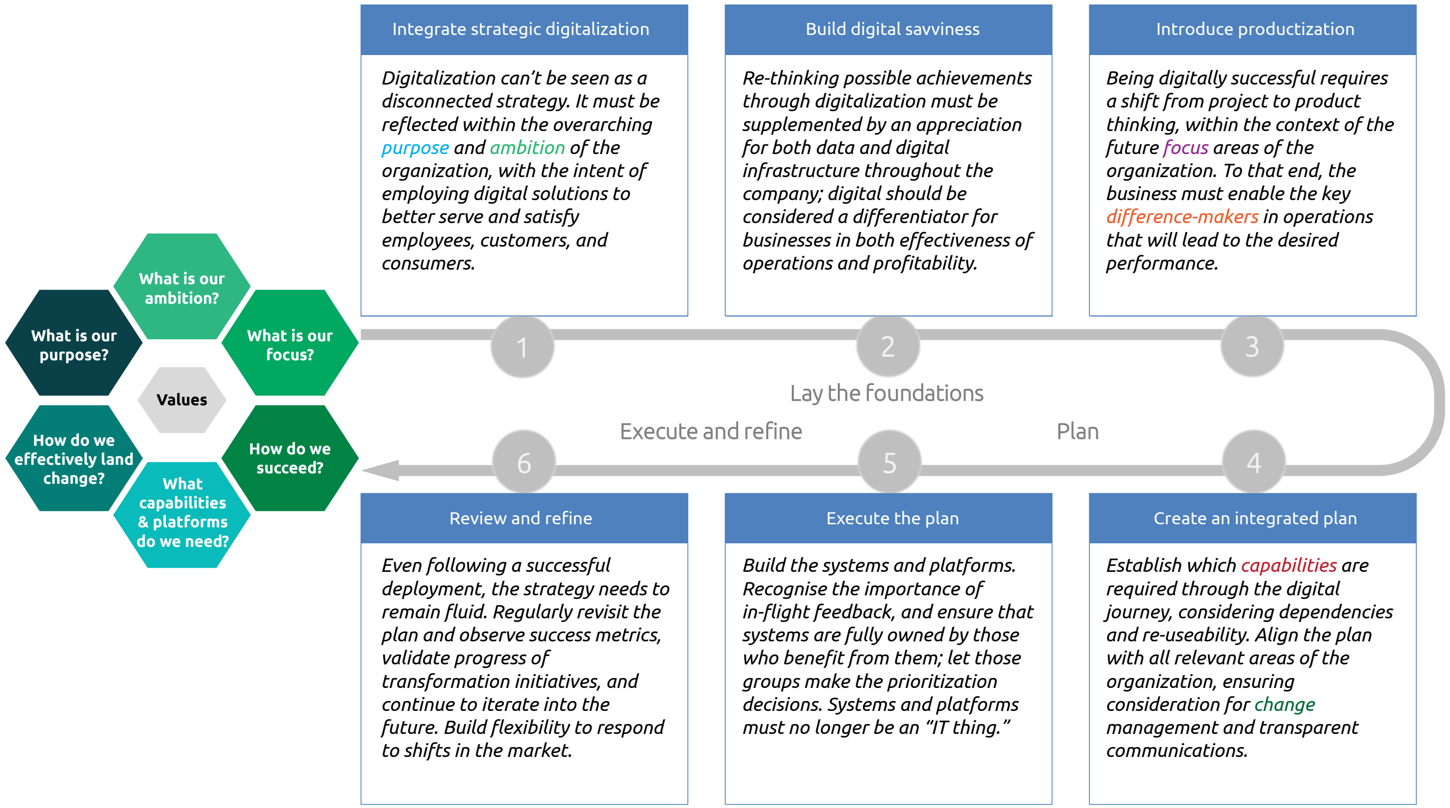
Getting started

Across the industry, the refresh of strategic intentions has seen the creation of ambitious organizational and whole-network plans, requiring significant investment in digital to build the capability required.

However, this investment can't be made and governed in pre-digital ways. Not only is every business a technology business, every project is a technology project. The integration of IT and OT is crucial both for internal decision-making and for providing Open Data. The development of platforms can't be left to the IT department if they are to provide maximum business and consumer value.

Finally, organizations need to appreciate that core systems and platforms will never be right the first time round – ongoing and agile development and ownership is crucial.

FIGURE 4



08 Transformation

08

08 Transformation

Energy Transition Needs A Workforce Transition

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Energy transition needs a workforce transition

Since the 2015 Paris Agreement, many nations have passed legally binding commitments to reduce emissions of greenhouse gases to net zero by 2050. New technologies and green innovations will be required to reduce emissions from homes, transport, agriculture and industry. To deliver this, governments are committing billions in investments, with more expected to flow from the private sector.

As well as the obvious benefits to net zero ambitions, this investment also creates job opportunities.

But does the talent exist? Do we have the right skills in the right volumes to fill the jobs we need, and quickly?

Skill shortages and challenges to creating jobs

In the U.K., National Grid's research, 'Net zero energy work-force report', shows that the U.K. energy industry needs to create 400,000 new jobs by 2050 to meet the net zero target.

The U.K. economy has longfaced significant challenges in terms of skill shortages and regional inequalities. Some 91% of businesses recently said that they face a skills deficit, with economies in the center and north of England growing at less than half the rate of London's economy between 1998 and 2016. The COVID-19 crisis has amplified these challeng-es and brought with it an increase in unemployment and, in particular, youth unemployment. The energy sector isn't immune to this. It also faces the additional challenge of an ageing workforce, with one-fifth of people currently working in the sector due to retire by 2030.

117,000 of the 400,000 new jobs in the energy industry are needed by 2030. Therefore, we need to act now and deploy a range of different strategies, if we are to deliver the jobs required to drive our global net zero ambitions.

In this chapter, we will explore the workforce transition that is required to enable the energy transition. We will also identify some of the challenges and opportunities that the sector is facing and the tools and frameworks that will help us to address these issues.

Implementing a workforce strategy to meet the talent demand

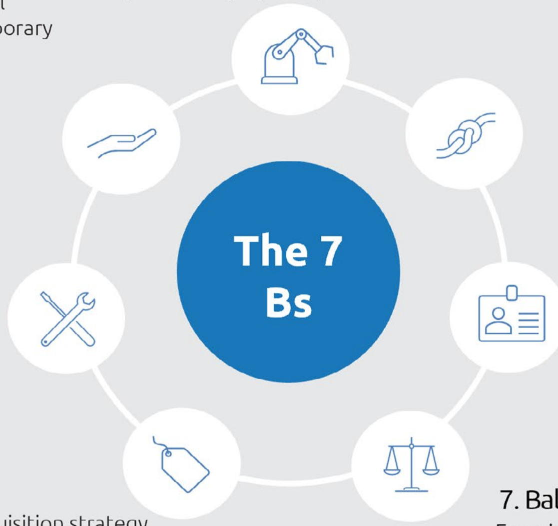
At Capgemini, we have developed a framework for the Energy & Utilities sector, to help combat the net zero workforce challenge. We call it the '7 Bs':

1. **Buy**
2. **Build**
3. **Borrow**
4. **Bot**
5. **Bind**
6. **Bounce**
7. **Balance**

Individually, the 'Bs' are ways to acquire, develop or augment talent. Together, they form the workforce strategy required to meet the sector and business demand for new jobs and capabilities.

To demonstrate how the 'Bs' can be applied to the global Energy & Utility sector, we will explore **5 global themes** throughout the rest of this chapter:

1. **Sustainability and green jobs**
2. **Automation and simplification of roles**
3. **Workforce reskilling and job corridors**
4. **Digitalization and human factors**
5. **New normal**



1. Buy
Creating a best-in-class talent acquisition strategy through competition with all other sectors enables us to attract talent across five generations. This is possibly the most challenging of the channels. But with an authentic employer brand, effective marketing, engaging recruitment process, and innovative early careers programmes, there is huge opportunity here.

2. Build
This channel is often the least invested in, but potentially the most impactful. By building a Learning & Development Centre of Expertise, a range of reskilling & upskilling programmes are created. This is achieved through digital, personalised and experiential training, which not only develops a big proportion of the required talent, but also has a major impact on attraction and retention too.

3. Borrow
Utilising a contingent workforce is often the most expensive channel. However, through evolving a data driven, total talent management approach, temporary and contract spending can become targeted, delivering business value.

4. Bot
Business process automation offers great potential in reducing the talent gap. However, it is a contentious topic. When integrated into this framework, we explore how automation can augment roles and support upskilling programs. Through this, we can increase profit while delivering an improved employee experience.

5. Bind
Continually identifying the critical skills we need (over a three to five-year horizon) and securing retention strategies is vital in ensuring all the previous efforts are not in vain.

6. Bounce
Identifying skills that are not aligned with a short-medium term demand and creating outplacement and alumni programs that are focused on sharing and re-engaging talent between companies (that may consider themselves as competitors), can have a hugely positive impact across the sector.

7. Balance
Ensuring the previous '6 Bs' converge harmoniously is challenging. Having the right systems to dynamically deploy skills and talent is therefore the final piece of this framework. Being both innovative and collaborative in creating a partnership ecosystem and talent marketplace across the sector will further help solve the risk of losing talent to other sectors.

Theme 1: Sustainability and green jobs

Delivering net zero targets globally requires a large-scale transformation in the energy workforce. The International Energy Agency's (IEA) net zero pathway estimates a 14 million net increase by 2030 worldwide.[1] The UK will need to fill 400,000 new roles,[2] and the EU projects a net gain of five million jobs.[3]

To realize these workforce growth ambitions, the energy sector needs to overcome the following long-standing strategic challenges:

- ***Loss of talent:*** The energy sector's highly-skilled and experienced workforce faces a risk of shrinking in the next decade. This is largely due to an impending retirement crunch in major economies. 20% of the UK's energy workforce is set to retire in the next decade, with the US projecting a 10-year retirement rate of at least 26%.[4] Rigid working hours have also impacted retention, with 75% of women reporting that inflexible working hours were a barrier to returning to engineering after maternity and career breaks.

- ***Difficulties in attracting new talent:*** Competition for STEM talent is fierce across all sectors, evidenced by the energy industry historically losing out to high-paying sectors such as banking and technology.

- ***Lack of diversity:*** Poor performance in diversity metrics can inhibit innovation, diminish values, and create a risk of losing talent. The IEA estimates that women only account for 22% of the global energy workforce, despite being 48% of the total workforce.[5] Furthermore, only one in five respondents in the Global Energy Talent Index (GETI) 2021 recognized Diversity and Inclusion (D&I), suggesting the benefits of D&I are not widely recognized.[6]

Talent acquisition and retainment strategies revolve around Buy and Bind.[7] For energy companies, attracting talent requires authentic branding, effective marketing, and an engaging recruitment process. Bind requires a more nuanced understanding of the current workforce, developing Employee Value Propositions and retention strategies.

Changing attitudes among the adult population (especially young adults) presents great opportunities for the sector. 40% of millennials say the employer's performance on sustainability is a critical factor when choosing jobs.[8] Companies must seize the opportunity to create value-driven employee propositions. An untapped motivator for the workforce is the desire to be directly involved in tackling climate change. Exploiting this through savvy campaigns would make for effective talent acquisition and retainment strategies. National Grid's case study (next page) highlights the importance of effective framing when recruiting talent.

A simple framework can be laid out for retention strategies by formulating effective Employee Value Propositions. The following levers should be considered:

- ***SUSTAINABLE DIGITAL WORKPLACE:*** The hybrid revolution presents an excellent opportunity to introduce flexible working across the workforce. Championing a sustainable and digital workplace will reduce both costs and CO_2 emissions, without impeding productivity.

- ***COOPERATION AND ENGAGEMENTS:*** The path to net zero is one of interdisciplinary collaboration. Harnessing peoples' passion means empowering them to engage in outreach programmes and cooperate across sectors (with a focus on attraction into the industry). This has multiple benefits, including instilling a sense of community into the company culture, and stopping wage wars.

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1 https://www.iea.org/reports/net-zero-by-2050
2 https://www.nationalgrid.com/stories/journey-to-net-zero/net-zero-energy-workforce
3 https://www.mckinsey.com/business-functions/sustainability/our-insights/how-the-european-union-could-achieve-net-zero-emissions-at-net-zero-cost
4 https://cewd.org/wp-content/uploads/2020/12/2019-GapsintheEnergyWorkforce-SurveyResults.pdf - Center for Energy Workforce Development
5 https://www.iea.org/topics/energy-and-gender
6 https://www.theengineer.co.uk/attracting-talent-net-zero-workforce/
7 https://www.capgemini.com/gb-en/2021/06/building-the-net-zero-uk-workforce/
8 https://www.capgemini.com/2020/08/generation-green-is-leading-the-sustainability-agenda/

PERFORMANCE METRICS: Developing effective sustainability metrics (and tracking them) will be key for companies to differentiate themselves. Organisations that have vague sustainability goals are often perceived by Generation Z as 'green-washing' and are in turn less trusted.

Case study: National Grid's 'A Job That Can't Wait'

National Grid's recruitment campaign, 'A job that can't wait', framed careers within the company as being at the forefront of climate change. This proved to be successful, increasing interest in National Grid's talent scheme by 760%. Incorporating diversity and inclusion is also critical to Buy strategies.

National Grid has also rolled out its industry flagship program 'Grid for Good'[1] across both the U.K. and U.S. With both countries facing rising youth unemployment and workforce disengagement, the 'Grid for Good' programme aims to support young people with training and employment opportunities. The pilot trials have already helped 1,000 young people across both countries, with the aim of impacting 22,500 people by 2030.

Theme 2: Automation and the simplification of roles

The energy sector is experiencing a period of unprecedented change. Following decades of underinvestment, energy systems are increasingly becoming a focal point for building national critical infrastructure and empowering consumers, while also facilitating the wider goal of achieving a net zero economy. Coupled with the accelerating pace of technology, companies are seeking to automate and optimize their business processes to stay competitive and align with customer expectations. Within the sector, there are already several prevalent examples of how automation has simplified business processes; namely:

- ***DIGITALIZED CONSUMER EXPERIENCE:*** The online user experience is becoming increasingly important in the sector. The expected norm for customers today is a fast and intuitive onboarding experience when setting up their online accounts. This includes self-service options and smart phone compatibility. There is also an expectation of ongoing customer communication and user feedback, through push notifications and paperless billing.

- ***SMART METERS:*** Access to accurate customer data is essential for companies to understand and manage their customer base. Whereas previously, there was a reliance on the collection of manual reads from field staff, who may not be able to access residential and commercial premises easily and safely. Smart meter devices are therefore able to optimize the collecting and monitoring of customer data.

- ***IOT-ENABLED ASSET MAINTENANCE:*** Ensuring energy assets and equipment are working safely and effectively is fundamental to running a competitive energy business. However, the manual process of monitoring assets for faults is slow and laborious. Companies are increasingly starting to use a combination of IoT and automation, enabling both predictive and preventative maintenance. In doing so, companies can identify potential risks and manage assets' down time before faults occur.

Automation and simplification has a profound impact on future skills and capabilities of employees. A recent study by Capgemini Invent[2] showed that:

- 29% of employees believe that their skill set is now redundant.

- 38% of employees believe that their skill set will be redundant over the next 4-5 years.

- 47% of Gen Y and Gen Z believe that their skill set will be redundant in the next 4-5 years.

1 https://www.nationalgrid.com/responsibility/community/grid-for-good
2 https://www.capgemini.com/gb-en/resources/digital-talent-gap/

How can companies respond?

- First, companies need to plan for the impact that automation and simplification of roles will have on their businesses. This should be done through the creation of a 'build' strategy. This means investing in employee learning and development in both reskilling and upskilling, through digital, personalized and experiential training. Such an approach not only develops the required talent, but also supports retention and attracts new talent.

- Second, one of the main issues facing the industry (in terms of adopting greater automation) is transitioning the workforce to support technology uptake. The workforce's reluctance or resistance to the adoption of technologies stems from the fear of how changes in capabilities, business models and company culture can impact an employee's job stability. It is also important for companies to manage expectations on what solutions they can deliver, and identify processes that can and cannot be automated and simplified. Both strategies can be adopted to overcome this challenge, by highlighting how automation augments roles, and how it aligns with upskilling programmes.

Case study: Faethm and the German utility provider

Capgemini partnered with Faethm – a globally unique AI analytics platform that predicts the impact of emerging technologies on the workforce.

This technology enables scenario planning that, unlike static reports and studies, can be made specific to any economy at any time, such as industry, geography, company, business unit, team or job.

Capgemini was asked to measure the impact of technology on the workforce, of which 30% is set to be eliminated by 2025. Using the Faethm tool helped to analyze the data, define the future competency framework, set automation focus areas and identify the new roles, and career paths for impacted employees.

Theme 3: Workforce reskilling and job corridors

Changes within and external to the industry are giving rise to substantive changes in the capability demands of energy organisations. The continued acceleration of data-driven decision-making, new achievements in automation and rapid advancements in energy, increases demand for new roles with specialist and highly sought-after capabilities.

In parallel, the industry is also seeing its core, long-serving foundational workforce entering the latter stages of their individual careers. This has resulted in a continuously shortening runway in which embedded knowledge must be captured. Not only does this enable future innovation, but also ensures the continuity of existing services across the globe.

As an example, within the U.K., approximately 20% of the existing talent pool is set to retire by 2030, while a substantially smaller amount of STEM graduates are expected to enter the workforce. Relevant candidates would need to increase by at least 30% in order to sustain the industry growth required.[1]

As a result of the pending changes to the resource landscape in the sector, approximately one-third of the roles currently in existence will either cease to exist or be transformed into new roles by 2030.[2] When coupled with expected retirement in the next decade, the urgency in reskilling and redeploying existing talent within the industry is quickly highlighted. Immediate enhancement of transferable skills, cross-pollination between and within firms, and the use of flexible career pathways, will be central to the ongoing success of energy organisations in the future.

The Bind and Bounce resourcing solutions are therefore becoming increasingly important. The global energy industry has historically faced continued challenges in attracting and retaining top talent. This is often attributed to more lucrative career options in other industries, and a lack of long-term career pathway visibility within the energy industry. Employing the methods associated with Bind and Bounce, and most crucially embracing and encouraging movement between organisations within the industry (both locally and globally), will not only stem the outflow of talent, but also continuously increase the richness of existing talent.

In order to continue leveraging its existing resource pool, the global energy industry is embarking on a journey through the Build resourcing solution. This journey sees the reskilling and redeployment of talent into existing and new roles, for which current and future demand is rising. Furthermore, organisations are using job corridors – skill sets that are assessed for roles and/or individuals – to derive a 'skill set match' metric to establish the degree to which existing skills may be transferred to required roles. This helps to maintain existing organisational and industry knowledge while filling required roles through existing personnel. Organisations pursuing strategic upskilling opportunities have reported tangible benefits, including increased productivity, higher levels of employee morale and career progression. This is the result of being entrusted with and executing new responsibilities.[3]

Alongside a widespread personal focus among individuals to contribute to more sustainable operations and outcomes, successes have been achieved, such as those witnessed by Iron & Earth in Canada in the case study. Cases like this are promising in the near-term and increase focus on talent retention and re-deployment. This will be crucial to the timely achievement of net zero ambitions.

Case study: Fossil fuel industry workers calling for a managed transition to a net zero carbon economy

Canada-based Iron & Earth were faced with a substantive fossil fuel workforce seeking a career in the net zero economy. As a result, they introduced their Renewable Skills/Upskilling Initiative, empowering indigenous and fossil fuel workers to enter the solar and wind energy market.

Iron & Earth have identified successes in the solar energy system installation, upskilling, and are actively pursuing opportunities to roll-out their program for over 1,000 workers in over 70 communities by 2026.[4]

1 https://www.power-technology.com/news/uk-energy-sector-workforce-boost/
2 https://www.euskills.co.uk/download/workforce-renewal-skills-strategy-2020-2025/
3 https://www.capgemini.com/gb-en/wp-content/uploads/sites/3/2018/10/Report-Upskilling-your-people-for-the-age-of-the-machine.pdf
4 https://www.ironandearth.org/

Theme 4: Digitalization and human factors

To deliver net zero, utilities' digital workplaces must become human-centred by design

The COVID-19 pandemic highlighted the need to accelerate the transition to a digital workplace. At Capgemini, we know that a human-centred approach is critical for the successful navigation of this transformation.

So, what does a human-centred digital workplace need to enhance collaboration and employee satisfaction, drive innovation, and reduce time-to-market in an energy and utilities context?

First and foremost, the digital workplace needs to break down siloes in both the ways of working, and the digital tools that underpin organisational processes.

Ways of working

Leaders should adopt 'matrix models' of working. This maximizes collaboration across a variety of functions and business areas/units (e.g. across the asset management and O&M functions, or across asset type-focussed operational teams [OHL vs. plant]). These cross-functional teams should explore 'design thinking' techniques, encouraging them to come together and crowd-source ideas from employees and partners. Homogenous group-thinking is best avoided by workplace diversity. More diverse viewpoints are more likely to lead to new and innovative solutions that are required to reach net zero.[1]

Digital tools

Digital tools enable these ways of working. These tools provide whiteboarding, communication and file sharing (like those available in Microsoft Office 365 and others) and are needed more than ever to bring geographically dispersed teams and ecosystem partners together. They also allow the workforce to organise (as needed) in a boundary-less way across specific issues, creating communities of practice.

Digital academy

Finally, investments in employee digital and leadership skills (at an industrial scale) is required. Utilities must equip their employees with the right skills to leverage digital tools through a digital academy model. This approach links strongly to the Build channel in the '7Bs' model. Although this channel is often least invested in, a digital academy will ultimately add to the employee value proposition of the energy and utilities sector in a substantial way. Getting this proposition right will be critical to recruiting, reskilling and retaining talent for net zero.

Case study: U.K. water utility

Capgemini is supporting the ambitious plans of a U.K. water utility to provide their workforce with the skills they need to close their digital skills gap. This will address the major risk to achieving net zero.

The overarching objective is to define a new digital skills framework and the underpinning learning journeys across three key thematic skills:

- ***Digital mindset:*** Harnessing the power of new collaborative ways of working.
- ***Data literacy:*** Using new analytical techniques and visualizations to improve decision-making.
- ***Tech savvy:*** Leveraging the maximum from investment in digital tools.

1 https://hbr.org/2016/11/why-diverse-teams-are-smarter

Theme 5: The new normal

COVID-19 has identified jobs within the energy industry as 'essential workers'. So, what does the new normal mean for jobs across offices, control centers and field forces in the sector?

The immediate response to the pandemic in the energy industry saw companies ensuring employees' safety while maintaining operational continuity (e.g. providing sleep pods for control center staff to allow for isolation time).

As we move towards the 'new normal', the trends for office workers are similar to other industries; ensuring people are safe continues to be the priority. The rapid roll-out of digital collaboration tools that enabled people to work together from home has proven to effectively simulate the office environment.

In addition to standard applications such as Office365 and Zoom, investment in increasing situational awareness is rising. The investment 'Bot' reduces the need for 'boots on the ground' as it resources options in active asset monitoring tools (often enhanced with AI and machine learning) and provides augmented and virtual reality capabilities.

With the ability to monitor assets remotely, there is a reduced need for physical inspections by engineers. Remote access to visual information through cameras (with visual information processed by AI/ML), asset data and insights such as predictions of asset failure and weather impacts, is minimising unnecessary or unplanned asset visits.

Additionally, the use of virtual and augmented reality provides an opportunity for knowledge-transfer and the capability of 'Build'. Pairing together remote experienced engineers with on-site junior engineers delivers benefits for both groups. It keeps experienced engineers safe whilst arming junior engineers (who have their ears and eyes on the ground) with expert coaching and advice on how to effectively intervene and complete their jobs.

More data is put in the hands of the field operator to increase situational awareness. Capabilities that enhance access to information in the field are now must-haves in procurement decisions (e.g. in mobile applications with pre-load options for critical elements to mitigate mobile network access issues).

In control centers, digital twins are enabling improved simulation, ex post facto decision or incident analysis, and accelerated and more effective training. These are critical for the long-term capabilities 'Build' and 'Bot'.

For many jobs in energy, the 'new normal' may not be a straightforward case of hybrid remote working – hybrid may just mean machine with human enhancements.

As a result of Capgemini's research on the new working paradigm, Energy & Utilities companies reported that, due to hybrid working, they are expecting to save 30% on facilities costs and 33% on operational costs. However, this requires a rethink of how to maintain employee engagement and a sense of community. Our research shows that 51% of Energy & Utilities employees feel disconnected due to remote working.[1]

1 https://www.capgemini.com/gb-en/research/the-future-of-work/ Reinventing work NSO, new working paradigm

08 Transformation

08

08 Transformation

Reinventing Energy Retail

Cyril Cortina
Alexandra Bonanni
Kilian Rouge

Reinventing Energy Retail

Challenges and threatens

Energy retailers are facing many challenges: huge churn rates, new entrants with more flexible business models, poor historical assets, low profitability, and more stringent regulations. In order to overcome these challenges, the rigidity of those historical players calls for profound changes in the business model. These changes focus on new, more client-centric offers across multiple business areas, the optimization of client efficiency and organizational functioning, as well as innovation and digitalization across all processes and activities.

A fundamental change is necessary in our relationship with energy

The recovery of our societies from the COVID-19 crisis has resulted in an expected economic rebound. This brings with it opportunities to address the intergenerational and global challenges of climate change with new capacities. In order to consider a transition towards a 2° trajectory (as foreseen by the 2015 Paris agreements), a fundamental change in our relationship to energy is necessary. A key factor influencing the radiative balance is limiting greenhouse gas emissions, and, in particular, CO_2 emissions. This is essential, particularly as the energy sector is, by far, the largest emitter.

It is therefore the role of decision-makers to initiate a transition towards more decarbonized energies. This will require, first and foremost, a restructuring of the energy mix towards a significant reduction in the use of fossil fuels, given equivalent consumption.

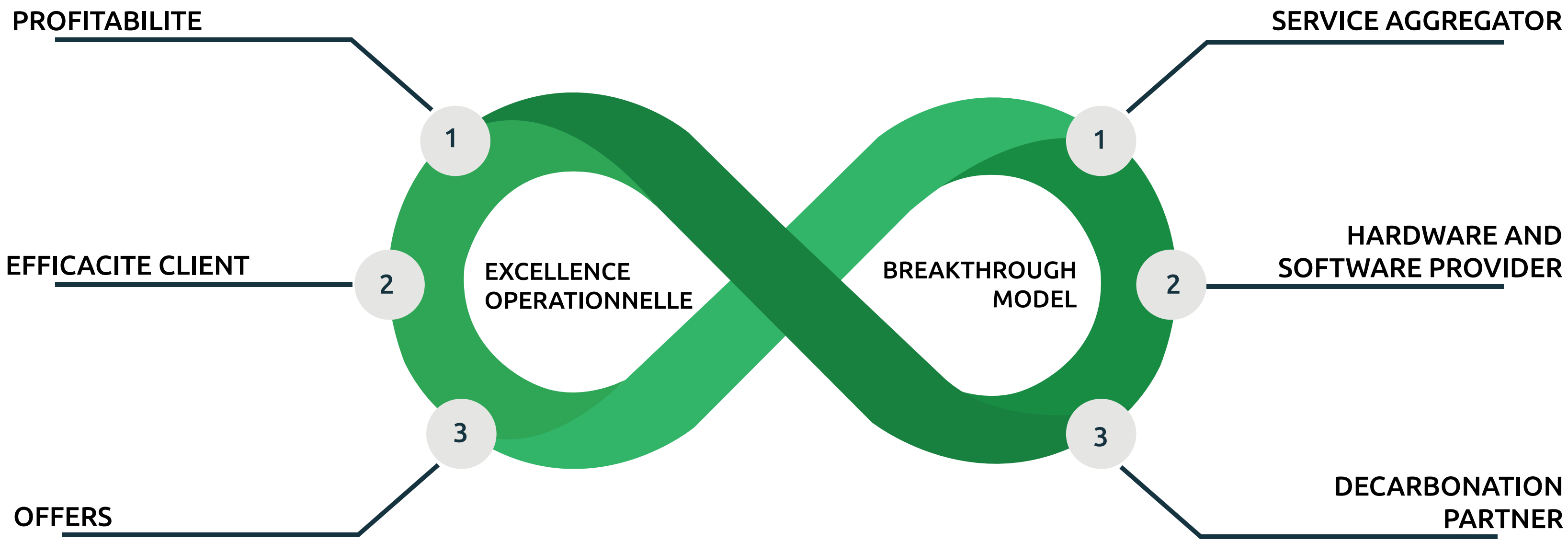
Many countries are already displaying strong ambitions for a decarbonized mix by 2050, with five of them (Sweden, France, Hungary, New Zealand, and the U.K.) incorporating these ambitions into the law. Still, there is still a long way to go before the decisions taken in recent years have a significant impact on the energy mix.

The role of energy suppliers is also essential, as they will ultimately be the ones on the front line who will have to comply with these objectives. Beyond the simple regulatory framework, there is an economic issue at stake for the incumbents, who are seeing the arrival of new players in the market (and sometimes in large numbers). These new players propose innovative and more diversified offers that better meet the increasingly demanding requirements of end consumers. For several years now, incumbents have been faced with high operating costs and increasingly low margins, while at the same time having to bear in mind their costly decarbonization of the energy mix.

So how should we see the inevitable transformation of incumbent energy suppliers? To cope with the pressure on revenues and the rise of competition along the value chain, they need to make two strategic moves: reduce costs through operational excellence and diversify activities through growth strategies.

FIGURE 1

The winning combination for energy retail



World Energy Markets Observatory 2021

Reaching operational excellence

Strategic levers are limited when reducing Kwh costs for final customers

There can either be a reduction in production, transmission and distribution costs, or in operational costs. Reducing the later requires an in-depth transformation of the entire value chain of energy retail.

In order to remain profitable, the levers of action are slim. It is a question of finding the best compromise between acquiring new customers while preserving the current base in an ultra-competitive market. This balance increases the customer lifetime value by decreasing margins without excess. This is far from a dead-end, but the gains that can be expected will be increasingly limited.

In this section we turn to other solutions, such as the development of new offers, maximizing customer efficiency and organizational restructuring.

Development phase

The development phase of a product or service is essential for an energy provider, as they do not just “sell energy”. Since the deregulation of the utility market, energy retail is a competitive market, since the final consumer is more likely to buy differentiated products than just a billing tariff. Like any retail company, it is therefore necessary to optimize the production steps. For example, reducing the time to market for new products while keeping costs low is essential. Indeed, the need for new hardware technologies and the gap between selling and billing still remains. This ultimately leads to longer development times. Key levers to face this issue would be finding synergy between own or third-party offers through better collaboration with partners; and the development of digital solutions that bridge selling and billing while ensuring compliance to regulations. Given the increased complexity of such offers, the structuring of a clear customer journey is essential both on the customer side and as it pertains to internal operations following customer actions. In addition to customer satisfaction, cost-to-serve can also be greatly improved through this process.

Client efficiency

To reduce costs, energy retailers have to maximize customer value. The first step in achieving this goal is to optimize the costs per customer. To remain profitable, energy retailers will need to optimize their upstream processes so they can achieve a cost to serve as low as €15, and a cost to acquire around €50. Such benchmarks are currently only achieved by new digital native entrants.

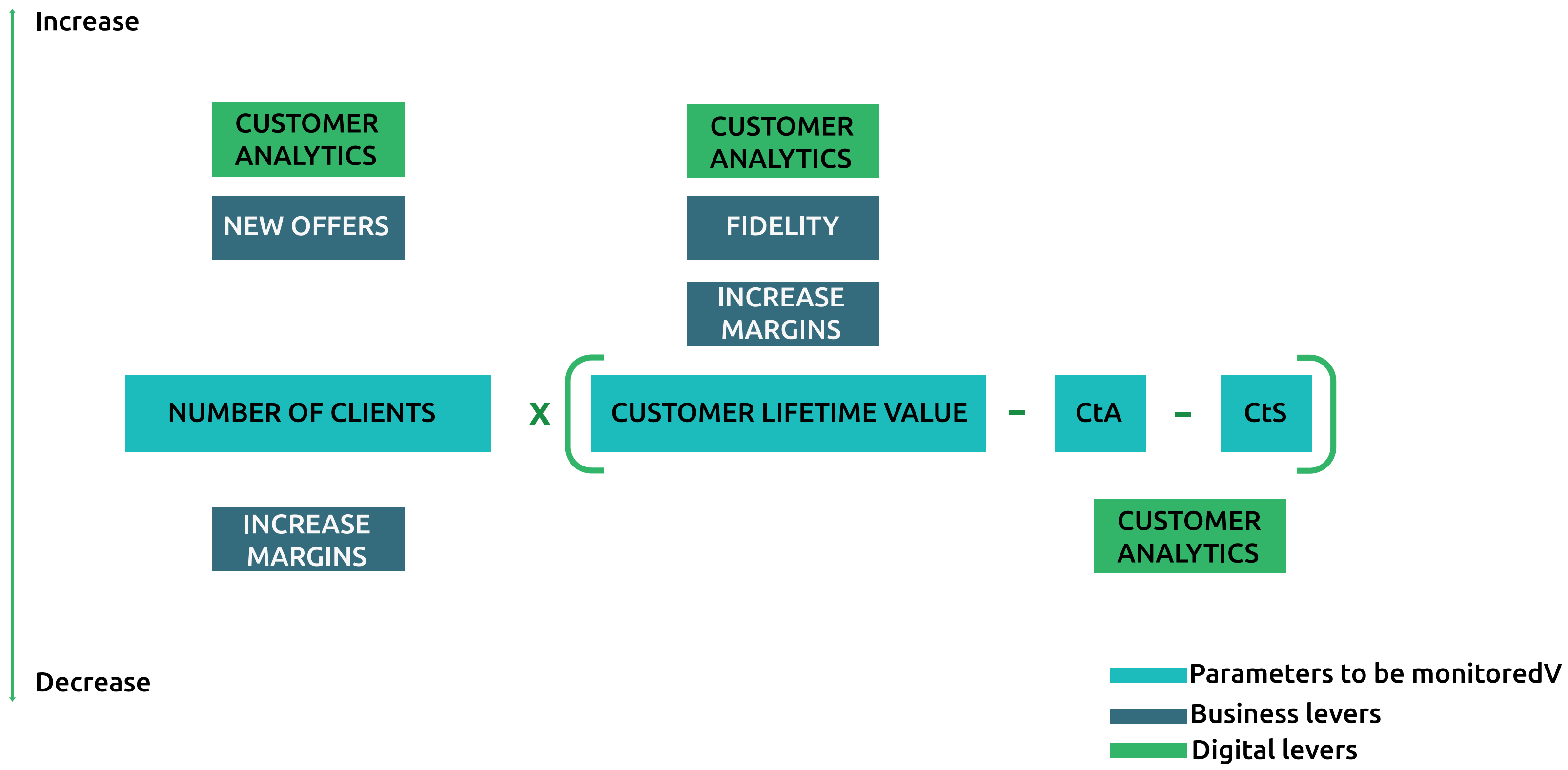
To differentiate customer offers in such a competitive market, retail companies also have to expand their marketing strategy and presence on social networks, reinforcing their corporate image.

The key lever is therefore to get a better understanding of customers’ needs through data analytics. It requires a wide range of data sources: billing analytics, customer feedback to customer account management, and coordination to ensure a rapid conversion of the information collected into concrete actions on the offers proposed. The energy retail sector has to rethink how raw data is turned into business insights, and how those are turned into scaled products that are created quickly, while ensuring control, security and flexibility of data.

Such an approach naturally makes it possible to limit the very significant and growing churn in this sector. This is done by offering increasingly personalized products at the right time to the right customer.

FIGURE 2

The “room for manoeuvre equation”



World Energy Markets Observatory 2021

Operational excellence for a supplier cannot only focus on the supply part. Other costs have to be taken in account such as taxes and transport & distribution costs. These last ones will probably increase due to the necessary investments in networks upgrading. At one point electricity prices acceptability by the end consumers will become an issue. “Bad debts” - difficult debts collection- are becoming a risk for the retailers performance.

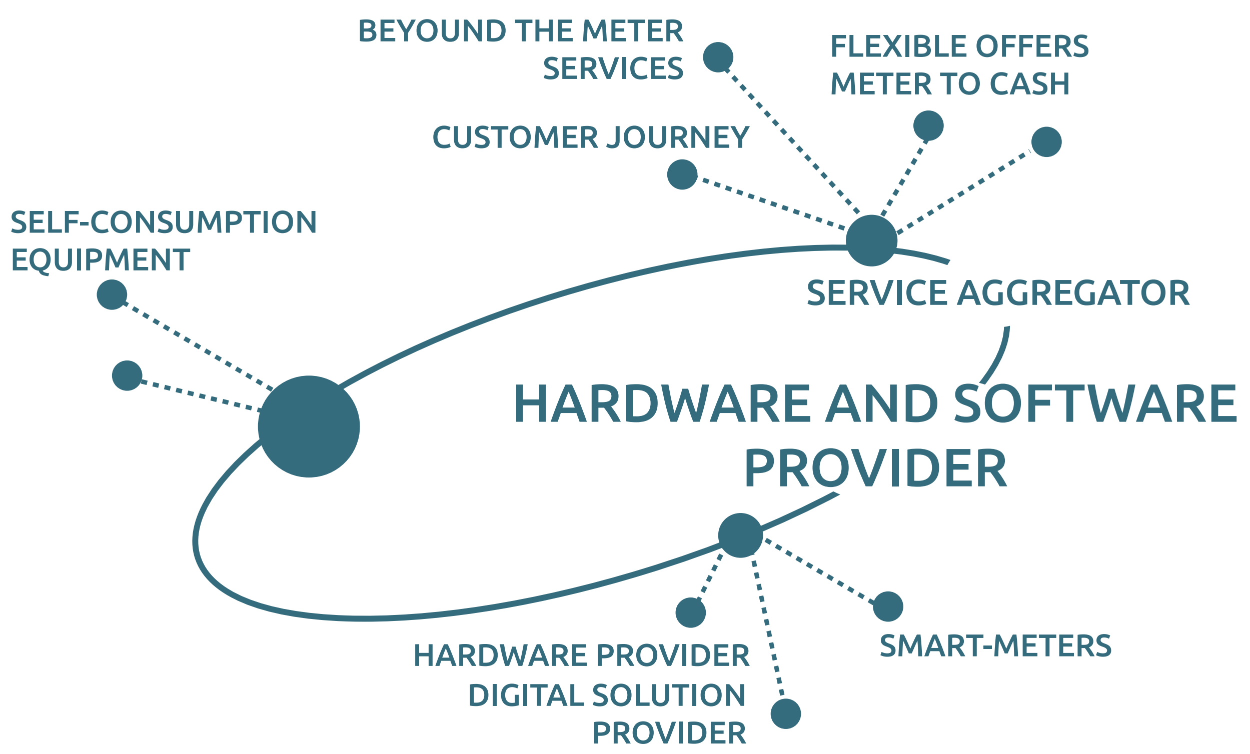
Organization

Hence, the reshaping of traditional retail energy providers seems necessary. This is to ensure flexibility and innovation, while further complying with the new requirements of a competitive market that supports constantly evolving business models. By empowering smaller teams through an agile way of working (that are gathered around consumer offers), traditional energy retailers allow for greater business dynamics, while still focusing on efficiency.

The transition to an agile organization thus amounts to allocating resources to short-term priority objectives, favoring an incremental approach to achieving an optimal result.

FIGURE 3

Overview of the key levers towards new energy retail offers



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Implementing growth strategies

Three breakthrough paradigms

Traditional energy retailers face more and more competition. This results in their position as current market leaders being undermined by digital or green retailers who bring new and innovative offers and bundles to the market. It is therefore inconceivable to grow as a single product company, selling only "energy at the pump". In this section, we explore three breakthrough paradigms for energy retailers to grow in this changing market.

Service aggregator

The process of getting energy services should be easy. However, energy supply and linked services still appear as a scattered set. With an Amazon-like transition towards a business model more centered on links between all these services, energy retailers can become more competitive in the market. The goal is to create an ecosystem around an energy brand that enables a network effect across a wide range of services. One key pillar of this transformation is digital solutions and platforms. The goal is to imagine flexible information and management experiences for clients, as those are more attractive and centralized, reducing FTE. Furthermore, digital solutions allow the launch of "meter-to-cash" solutions, by coupling digital solutions with new generation smart-meters. This positioning is inspired by digital brands such as Uber, who developed a unique platform across a wide range of services.

Clients (whether they are private individuals, companies or communities) want to get "energy as a service". This is where the consumer pays for what they consume and not the customer service nor the hardware behind it. They want to be free to cancel and adjust their subscription anytime, controlling their consumption. British electricity retailer, Octopus Energy, specializes in highly flexible prices to capitalize on low consumption days where supply is at its highest.

Furthermore, "energy as a service" enables a deeper link between different products, whether they are from their own energy provider or third-parties. In order to bring together these proprietary and third party end-to-end offers within the same ecosystem, marketplace platforms could then be considered. This is so they can be easily used by the end customer (likened to Apple's 'AppStore' on an iPhone).

For the energy retailer, "energy as a service" allows for a more efficient management of demand and production and can easily be linked with off-grid solutions.

Hardware and software providers

As part of the search for diversification of the offers provided by traditional energy retailers and client efficiency, hardware and software innovation can be growth levers since they can attract and retain clients.

Whether it is through software platforms that manage customers and associate raw data, or through software that administrates new energy offers, the energy supplier market will be at the forefront of software innovation in the upcoming years. The use of these new internal assets by energy retailers represents a new (and little explored) growth lever.

Energy retailers have a real strength in software, allowing them to diversify their services. For example, this can be done through commercialization to competitors or adapting the technologies developed for new customer services. This positioning is inspired by Amazon's AWS – which was first developed as an internal service that was then commercialized but has now become a cloud leader.

Similarly, the introduction of new customized offers on the market requires the renewal of hardware assets on both the sides of the customer and supplier. Therefore, it is essential to see these necessary investments as levers for growth. Energy retailers should not deprive themselves of an efficient ecosystem of technology partners and startups in order to guarantee rapid innovation around a panel of proprietary offers. It is also important to keep an eye on innovation in other sectors and capitalize on extensive research, in order to anticipate technological developments and market changes.

Decarbonation partner

The growing awareness of climate change allows energy retailers to play a key part in helping their customers lower their impact on the environment.

The first step in achieving this, is to offer the consumer the choice of their energy mix. Several companies already offer the possibility to choose 100% guaranteed renewable energy or proximity energy. Energy retailers can go way further in promoting local energy loops by supplying customers with battery storage or solar roof panels. This, for example, allows the reinjection in the grid of overhanging energy. In turn, this would enable a more efficient management of fossil fuel and energy on the grid, empowering customers. On a larger scale, bigger customers (like cities or large companies) could valorize their residual energies, such as wastewater or waste. Simultaneously, this would increase their resilience and energy efficiency management, while lowering the cost of energy.

The second step, would be to encourage the inevitable need for a reduction in energy consumption. This step is apparently paradoxical for a company whose turnover increases linearly with its customers' consumption. However, it is important that this is foreseen, as the market will shrink progressively. An example of this new kind of business model is the Norwegian company, Tibber. Their business model is to sell renewable energy at purchase cost, making benefits from the monthly cost of the energy management app, available to the customer. Furthermore, energy providers have to adapt their business model to this pattern, offering new kinds of "beyond the meter" services related to the consumer ecosystems.

Only radical changes can propel incumbent energy suppliers towards a sustainable business strategy, for years to come

Changes take the form of a fundamental focus on operational excellence, in a quest to increase customer loyalty and optimize revenue per customer. Notably, this is through the implementation of more digital solutions and better use of data.

However, even with all the operational excellence in the world, incumbent energy suppliers can not stop there. They will have to revolutionize their offer by proposing real disruptive models.

We have identified three of these models, each one responding to the following current and future market issues: the diffuse nature of customer offerings, the exploitation of internal hardware and software solutions, and the need to consume better and less.

The implementation of these models requires profound changes in operating methods and a long-term vision of the energy retail landscape. Furthermore, they are essential as a springboard for catching up and facing many challenges in the future.

Glossary

ACER
Agency for the Cooperation of Energy Regulators, created under the EU Third Legislative Package, adopted in April 2009

ACORE
Stands for American Council on Renewable Energy, is a national non-profit organization that unites finance, policy and technology to accelerate the transition to a renewable energy economy.

AEMC
Set up by the Council of Australian Governments through the Ministerial Council on Energy in 2005, the Australian Energy Market Commission makes and amends the National Electricity Rules, National Gas Rules and National Energy Retail Rules, and also provides market development advice to governments.

AEMO
The Australian Energy Market Operator is responsible for operating Australia's largest gas and electricity markets and power systems, including the NEM and Wholesale Electricity Market (WEM) and power system in Western Australia.

AGA
American Gas Association Representing more than 200 local energy companies that deliver clean natural gas throughout the United States.

AMI
Stands for Advanced Metering Infrastructure, it is the collective term to describe the whole infrastructure from Smart Meter to two way-communication network to control center equipment and all the applications that enable the gathering and transfer of energy usage information in near real-time.

Backwardation/Contango
"Contango" means that long-term prices are more expensive than short-term prices, depicting a relaxed short-term market, whereas "backwardation" reveals more tension in the short-term reflected in higher short-term prices than in the long-term

Base load
The minimum amount of electricity delivered or required over a given period, at a constant rate

Battery of the Nation
The Battery of the Nation initiative is investigating and developing a pathway of future development opportunities for Tasmania to make a greater contribution to the NEM.

Bilateral contracts/OTC
A contractual system between a buyer and a seller agreed directly without using a third party (exchanges, etc.). Also named as OTC for Over The Counter

Black Certificates
Exchangeable or tradable CO_2 allowances or quotas within the European Trading Scheme and Kyoto protocol (see EUA)

CAISO
Stands for California Independent System Operator is the non-profit Independent System Operator serving California that oversees the operation of California's bulk electric power system, transmission lines, and electricity market generated and transmitted by its member utilities.

CAPEX
Capital Expenditure, funds used by a company to acquire or upgrade physical assets

Carbon Budget
Carbon budget' is the cumulative quantity of CO_2 emissions that are allowed in order to keep global warming below a certain warming threshold

Carbon Cost Coalition
A multi-state coalition of state legislators from 12 states of the USA, who are focused on reducing carbon emissions, ensuring equity in policy proposals, developing market-based solutions, creating a resilient local economy and improving public health.

CCGT/Combined cycle power plant
Combined Cycle Gas Turbine. Thermal power plant, usually running on gas-fired turbines, where electricity is generated at two consecutive levels: firstly by gas combustion in the turbines, and secondly by using energy from the product of the gas combustion process in boilers, which supply heat to steam turbo-generators.

This process provides high levels of thermal output (55 to 60%, compared with only 33 to 35% for conventional thermal power plants)

CCS
Carbon Capture and Storage. Technologies used for isolating carbon dioxide from fuel gas (at combustion plants) and storing it. This means that a significantly lower amount of CO_2 is emitted into the atmosphere

CDM
Clean Development Mechanisms, a mechanism under the Kyoto Protocol through which developed countries may finance greenhouse-gas emission reduction or removal projects in developing countries, and receive credits for doing so which they may apply towards meeting mandatory limits on their own emissions

CEER/ERGEG
Council of the European Energy Regulators and European Regulators Group for Electricity and Gas. ERGEG was dissolved with the creation of ACER, all ERGEG works are found in CEER website

CER
Certified Emission Reduction. Quotas issued for emission reductions from Clean Development Mechanism (CDM) project activities

CHP/Cogeneration
Combined Heat and Power. System of simultaneous generation of electricity and heat. The output from cogeneration plants is substantially better than it would be if they produced only electricity

Churn/Switch
Free (by choice) movement of a customer from one supplier to another

Clean Coal
New technologies and processes allowing electricity generation from coal while lowering CO_2 emissions

Clean Dark Spread/Clean Spark Spread
The Clean Dark Spread is the difference between electricity's spot market price and the cost of electricity produced with coal plus the price of related carbon dioxide allowances while the Clean Spark Spread is the same indicator but with electricity produced with natural gas

Climate Change
Climate change is any significant long-term change in the expected patterns of average weather of a region (or the whole Earth) over a significant period of time.

Climate Risk Index
Climate Risk Index is released by Germanwatch which analyses to what extent countries and regions have been affected by impacts of weather-related loss events (storms, floods, heat waves etc.)

Copenhagen Accord
A voluntary agreement between the United States, China, Japan, Canada, Mexico, Russia and hundreds more making up over 80% of the global population and over 85% of global emissions that is based on goodwill of each member country assuming that each country will live up to their part in saving the climate by reducing greenhouse gases.

CSIRO
Commonwealth Scientific and Industrial Research Organization is an independent Australian federal government agency responsible for scientific research.

Decentralised generation
Production of electricity near the point of use, irrespective of size and technology, capacity and energy sources

Demand response
Any program which communicates with the end-users regarding price changes in the energy market and encourages them to reduce or shift their consumption

DER
Distributed Energy Resources refer to distribution level resources that produce electricity or actively manage consumer demand such as solar rooftop PVs, batteries; and demand response activities that manage hot water systems, pool pumps, smart appliances and air conditioning control.

Deregulated Market
A "deregulated electricity market" allows for the entrance of competitors to buy and sell electricity by permitting market participants to invest in power plants and transmission lines

DG Competition
European Union's Directorate General for Competition which role is to enforce the competition rules of the Community Treaties

DG TREN
European Union's Directorate General for Transport & Energy that develops EU policies in the energy and transport sectors

Distributed generation
Any technology that provides electricity closer to an end-user's site. It may involve a small on-site generating plant or fuel cell technology

Distribution System Loss
Distribution System Losses are losses pertaining to distribution of electricity. While technical losses are at times under the control of utilities, non-technical losses are external forces that impact the efficiency of the system and lead to revenue leakage

Dividend per share
Dividend per share (DPS) is the sum of declared dividends issued by a company for every ordinary share outstanding. The figure is calculated by dividing the total dividends paid out by a business, including interim dividends, over a period of time by the number of outstanding ordinary shares issued

DMO
Default market offers also known as the 'standing offers' are default, government-regulated energy offers which do not include any discount.

DOE (Philippines)
The Philippines' Department of Energy is the executive department of the Philippine Government responsible for preparing, integrating, manipulating, organizing, coordinating, supervising and controlling all plans, programs, projects and activities of the Government relative to energy exploration, development, utilization, distribution and conservation

Domestic consumers
Residential customers

Dual Monopoly
A situation wherein; two companies dominate the market . In other words two companies control production and supply of a product

EBIT
Earnings Before Interest and Taxes. EBIT may also be called operating income; i.e. the product of the company's industrial and commercial activities before its financing operations are taken into account. EBIT is a key ratio for gauging the financial performance of companies

EBITDA
Earnings Before Interest, Taxes, Depreciation and Amortization. EBITDA is a key ratio for gauging the cash flow of companies

EERS
Stands for Energy Efficiency Resource Standards establishes specific, long-term targets for energy savings that utilities or non-utility program administrators must meet through customer energy efficiency programs.

Electricity Tariffs
The amount of money frame by the supplier for the supply of electrical energy to various types of consumers in known as an electricity tariff

Eligible customer
Electricity or gas consumer authorised to turn to one or more electricity or gas suppliers of his choice

Energy Efficiency
Energy efficiency means using less energy to perform the same task

Energy Innovation and Carbon Dividend Act of 2019
The Energy Innovation and Carbon Dividend Act of 2019 is a bill in the United States House of Representatives that proposes a fee on carbon at the point of extraction to encourage market-driven innovation of clean energy technologies to reduce greenhouse gas emissions.

Energy Mix
Refers to the combination of the various primary energy sources used to meet energy needs in a given geographic region. It includes fossil fuels (oil, natural gas and coal), nuclear energy, non-renewable waste and the many sources of renewable energy (wood, biofuel, hydro, wind, solar, geothermal, heat from heat pumps, renewable waste and biogas).

Energy Regulatory Commission
Power Generation in Philippines is regulated by Energy Regulatory Commission (ERC). It is an independent electric power industry regulator that equitably promotes and protects the interests of consumers and other stakeholders, to enable the delivery of long-term benefits that contribute to sustained economic growth and an improved quality of life

Energy Transition Index
The Energy Transition Index(ETI) benchmarks countries on the performance of their energy system, as well as their readiness for transition to a secure and sustainable energy future. The ETI aggregates indicators from 40 different energy, economic and environmental datasets in order to provide a comprehensive of the world's energy system

Energy Trilemma Index
The World Energy Trilemma Index is an annual comparative ranking of 125 countries on their ability to balance energy priorities

ENSO
Stands for El Niño-Southern Oscillation which is a recurring climate pattern involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean, affecting the climate of much of the tropics and subtropics. The warming phase of the sea temperature is known as El Niño and the cooling phase as La Niña.

ENTSO-E
European Network of Transmission System Operators for Electricity. ENTSO-E, the unique association of all European TSOs, was created at the end of 2008 and is operational since July 1, 2009. All former TSOs associations such as UCTE or ETSO are now part of ENTSO-E

ENTSO-G
European Network of Transmission System Operators for Gas. ENTSO-G was created at the end of 2009 and comprises 32 gas TSOs from 22 European countries

EPIC
Stands for Energy Policy Institute at Chicago, it is an interdisciplinary research and training institute focused on the economic and social consequences of energy policies.

EPR
European Pressurized Reactor. Third generation of nuclear plant technology using advanced Pressurized Water Reactor (PWR)

ERU
European Reduction Unit. A unit referring to the reduction of greenhouse gases, particularly under the Joint Implementation where it represents one ton of CO_2 reduced

ETS
Emissions Trading Scheme. An administrative approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants. The European Union Emissions Trading Scheme has been in operation since January 1, 2005

EUA
European Union Allowances. Quotas allocated by the National Allocation Plans in compliance with the European Trading Scheme

Eurelectric
Professional association which represents the common interests of the Electricity industry at pan-European level

European Commission (EC)
A governing body of the European Union that oversees the organization’s treaties, recommends actions under the treaties, and issues independent decisions on EU matters

European Council
A body formed when the heads of state or government of European Union member states meet. Held at least twice a year, these meetings determine the major guidelines for the EU’s future development

European Parliament (EP)
The assembly of the representatives of the Union citizens

European Union (EU)
The European Union (EU) is a group of 28 countries that operates as a cohesive economic and political block

EVs
Electric vehicles is an alternative fuel automobile that uses electric motors and motor controllers for propulsion, in place of more common propulsion methods such as the internal combustion engine (ICE).

EWEA
European Wind Energy Association

FERC
Stands for The Federal Energy Regulatory Commission, is the United States federal agency that regulates the transmission and wholesale sale of electricity and natural gas in interstate commerce and regulates the transportation of oil by pipeline in interstate commerce.

FID
Final Investment Decision

FLNG
Stands for Floating Liquefied Natural Gas, efers to water-based liquefied natural gas (LNG) operations employing technologies designed to enable the development of offshore natural gas resources

Forwards
A standard contract agreement for delivery of a given quantity at a given price, for a given maturity (OTC markets)

Futures
A standard contract agreement for delivery of a given quantity at a given price, for a given maturity (organized exchanges). The maturities may differ across power exchanges (weekly, half-yearly, quarterly, monthly, annually).

Maturity Y+1 corresponds to the calendar year after the current year

GCF
The Green Climate Fund is a global fund that was formed to support climate change vulnerable nations, especially the "Least Developed Countries" to fulfil their climate change goals and lower their GHG emissions.

GDP
Stands for Gross Domestic Product, is a monetary measure of the market value of all the final goods and services produced in a country over a specific time period, often annually.

GECF
Gas Exporting Countries Forum. GECF is a gathering of the world's leading gas producers

GIE
Gas Infrastructure Europe. GIE is the association representing gas transmission companies (GTE), storage system operators (GSE) and LNG terminal operators (GLE) in Europe

Green Bond
A green bond is a bond specifically earmarked to be used for climate and environmental projects. These bonds are typically asset-linked and backed by the issuer's balance sheet, and are also referred to as climate bonds

Green Certificates
A Guarantee of Origin certificate associated with renewable targets fixed by national governments. Green Certificates are often tradable

Greenhouse effect
The warming of the atmosphere caused by the build up of 'greenhouse' gases, which allow sunlight to heat the earth while absorbing the infrared radiation returning to space, preventing the heat from escaping. Excessive human emissions including carbon dioxide, methane and other gases contribute to climate change

Grid
An electrical grid, electric grid or power grid, is an interconnected network for delivering electricity from producers to consumers.

Grid 2.0
Grid 2.0 refers to the grid system which will transform how gas, solar and thermal energy is managed into a single intelligent network efficiently. This builds on Singapore's past investments in smart meters, grid storage, solar photovoltaics, as well as various energy efficiency and demand management solutions to address Singapore's unique energy challenges, and also grow the base of capabilities.

Guarantee of Origin
A certificate stating a volume of electricity that was generated from renewable sources. In this way the quality of the electricity is decoupled from the actual physical volume. It can be used within feed in tariffs or Green Certificate systems

HHI
Herfindahl-Hirschman Index, a commonly accepted measure of market concentration. It is calculated by squaring the market share of each firm competing in a market, and then summing the resulting numbers. The HHI number can range from close to zero to 10,000

Hub (gas)
Physical or virtual entry/exit points for natural Gas

Hub (retail)
Inter Company Data Exchange platform primarily enabling Suppliers and Distribution companies to exchange client related data and making supplier's switching more reliable

ICPT Mechanism
The ICPT is a mechanism approved by the Government and implemented by ST since 1 January 2014 as part of a wider regulatory reform called the Incentive Based Regulation ("IBR"). ICPT mechanism allows TNB to reflect changes in fuel and generation costs in consumer's electricity tariff every six months. This mechanism is implemented according to Section 26 of Electricity Supply Act 1990 [Act 447]. The impact of ICPT implementation is neutral on TNB and will not have any effect to its business operations and financial position

IED
Industrial Emissions Directive, a European Union Directive that sets strict limits on the pollutants that industrial installations are allowed to spew into the air, water and soil. Installations have until 2016 to comply with the limits

Incentive Based Regulation
An incentive-based regulatory approach aims to reduce environmentally-harmful pollutants by offering inducements to polluters who limit their emissions

Installed capacity
The installed capacity represents the maximum potential net generating capacity of electric utility companies and auto-producers in the countries concerned

International Energy Consultants
IEC is a Perth-based consulting firm which specializes in providing power market advisory services to companies operating in and associated with the IPP sector within the Asia-Pacific region

Investment Tax Credits
A tax related incentive that allows individuals or entities to deduct a certain percentage of specific investment related costs from their tax liability apart from usual allowances for depreciation.

IPCC
Intergovernmental Panel on Climate Change, the leading body for the assessment of climate change, established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide a clear scientific view on the current state of climate change and its potential environmental and socio- economic consequences

IUS
Stands for the Integrated Utility Services, developed by Rocky Mountain Institute wherein utility companies could seamlessly blend an array of products, services and financing tools that have not previously been integrated.

JI
Joint Implementation, a mechanism under the Kyoto Protocol allowing industrialised countries with a greenhouse gas reduction commitment to invest in emission reducing projects in another industrialised country as an alternative to emission reductions in their own countries

Kyoto Protocol
The United Nations regulatory frame for greenhouse gases management, adopted in December 1997 and entered into force in February 2005. It encompasses 6 greenhouse gases: CO_2, CH_4, N_2O, HFC, PFC, SF_6

LCOE (levelized cost of energy)
LCOE is the cost of electricity produced by a generator calculated by accounting for all of a system's expected lifetime costs (including construction, financing, fuel, maintenance, taxes, insurance and incentives), which are then divided by the system's lifetime expected power output (kWh).

LCOS (levelized cost of storage)
It quantifies the discounted cost per unit of discharged electricity for a specific storage technology and application.

LCPD
Large Combustion Plant Directive, a European Union Directive that aims to reduce acidification, ground level ozone and particulates by controlling the emissions of sulphur dioxide, oxides of nitrogen and dust from large combustion plant. All combustion plant built after 1987 must comply with the emission limits in LCPD. Those power stations in operation before 1987 are defined as 'existing plant'. Existing plant can either comply with the LCPD through installing emission abatement (Flue Gas Desulphurisation)equipment or 'opt-out' of the directive. An existing plant that chooses to 'opt-out' is restricted in its operation after 2007 and must close by the end of 2015

LNG
Liquefied Natural Gas. Natural gas that has been subjected to high pressure and very low temperatures and stored in a liquid state. It is returned to a gaseous state by the reverse process and is mainly used as a peaking fuel

LNG Netback Price
A measure of an export parity price that a gas supplier can expect to receive for exporting its gas.

Load balancing
Maintaining system integrity through measures which equalize pipeline (shipper) receipt volumes with delivery volumes during periods of high system usage. Withdrawal and injection operations into underground storage facilities are often used to balance load on a short-term basis

Load factor
Ratio of average daily deliveries to peak-day deliveries over a given time period

LULUCF
Referred to as Forestry and other land use defined as the greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use such as settlements and commercial uses, land-use change, and forestry activities.

Market coupling
Market coupling links together separate markets in a region, whereas market splitting divides a regional market into prices zones. Market coupling minimises prices differences and makes them converging wherever transmission capacity is sufficient. Cross-border market coupling also drives better use of interconnection capacity

Market Liberalization
The process of removing government control and opening up the markets to private companies

Merit order
The merit order is a way of ranking available sources of energy, especially electrical generation, in ascending order of their short-run marginal costs of production, so that those with the lowest marginal costs are the first ones to be brought online to meet demand, and the plants with the highest marginal costs are the last to be brought on line

MESI 2.0
The Malaysian Electricity Supply Industry (MESI) under the MESI 2.0 initiative, has three key aims, which are to increase industry efficiency, future-proof the industry, and empower consumers

Metering
Measurement of the various characteristics of electricity or gas in order to determine the amount of energy produced or consumed

MyPower
MyPower, (which is a part of Malaysian Energy Supply Industry-MESI) stands for Malaysia Programme Office for Power Electricity Reform, will design and drive the implementation of energy reform over the next three years

NAP
National Allocation Plan. List of selected industrial and power installations with their specific emissions allowance (under the ETS system)

Natural Gas
Mixture of gases which are rich in hydrocarbons. Gases such as methane, nitrogen, carbon dioxide etc. are naturally found in atmosphere. Natural gas reserves are deep inside the earth near other solid & liquid hydrocarbons beds like coal and crude oil.

NDC
Stands for the Nationally Determined Contributions, it implies the achievement of long term goals made under the Paris Agreement which embody efforts by each country to reduce national emissions and adapt to the impacts of climate change.

NEEAPs
National Energy Efficient Action Plans, plans providing detailed roadmaps of how each Member State expects to reach its energy efficiency target by 2020

NEG
National Energy Guarantee was an energy policy proposed by the Turnbull government in late 2017 to deal with rising energy prices in Australia and lack of clarity for energy companies to invest in energy infrastructure.

NEM
The National Electricity Market of Australia interconnects five regional market jurisdictions – Queensland, New South Wales (including the Australian Capital Territory), Victoria, South Australia, and Tasmania.

Nomination
A request for a physical quantity of gas under a specific purchase or transportation agreement

Non-Domestic Consumers
Commercial and industrial customers, and others

NREAPs
National Renewable Energy Action Plans, plans providing detailed roadmaps of how each Member State expects to reach its legally binding 2020 target for the share of renewable energy in their final energy consumption

NTC
Net Transfer Capacity. NTC is the expected maximal electrical generation power that can be transported through the tie lines of two systems without any bottlenecks appearing in any system

Off-peak
Off-peak energy is the electric energy supplied during periods of relatively low system demands as specified by the supplier

On-peak
On-peak energy is electric energy supplied during periods of relatively high system demand as specified by the supplier

OPEC
Organization of the Petroleum Exporting Countries

Open season
A period (often 1 month) when a pipeline operator accepts offering bids from shippers and others for potential new transportation capacity. Bidders may or may not have to provide “earnest” money, depending upon the type of open season. If enough interest is shown in the announced new capacity, the pipeline operator will refine the proposal and prepare an application for construction before the appropriate regulatory body for approval

OPEX
Operational Expenditure, expenditures that a business incurs as a result of performing its normal business operations

P/E
Price / Earning ratio. The ratio of the share price to the Earning per share (EPS). P/E ratio is one of the tools most commonly used for valuing a company share

Paris Agreement
The Paris Agreement is an agreement within the United Nations Framework Convention on Climate Change, dealing with greenhouse-gas-emissions mitigation, adaptation, and finance, signed in 2016.

Peak load
The highest electrical level of demand within a particular period of time

Peak shaving
Reduction of peak demand for natural gas or electricity

PPA
Stands for Power Purchase Agreements that freezes a price and a notional energy volume for both the buyer and seller of electricity for a specific period of time. This price agreement acts as the final agreed price for a development project that is either achieving financial close or remaining on the shelf. The agreement also includes reference to cases of failure to meet the contract terms and conditions including, the payment of liquidated damages.

PPU
(Programmations pluriannuelles de l’énergie) Multi-year Energy Programming, a tool for planning and steering national energy policy, which defines the priorities for actions and the specific objectives to be achieved over the period 2016-2023, targeting all energy sources, in order to achieve the national objectives set by the LTE

REBA
Stands for Renewable Energy Buyers Alliance, is a a membership association of large clean energy buyers, energy providers, and service providers that, together with NGO partners, are committed to unlocking the marketplace for all nonresidential energy buyers to lead a rapid transition to a cleaner, prosperous, zero-carbon energy future.

Regulated Market
A regulated electricity market contains utilities that own and operate all electricity

RES
Renewable Energy Sources. Energy (electricity or heat) produced using wind, sun, wood, biomass, hydro and geothermal. Their exploitation generates little or no waste or pollutant emissions

RGGI
Stands for Regional Greenhouse Gas Initiative, which is the first mandatory market based program in the United States to reduce greenhouse gas emissions is a cooperative effort among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont to cap and reduce carbon dioxide (CO_2) emissions from the power sector.

Rhodium Group
Rhodium Group is an independent research provider combining economic data and policy insight to analyze global trends.

SAIDI
Stands for System Average Interruption Duration Index that measures the average outage duration for each customer served in units of time, often minutes or hours.

SGIG
NA

Shippers
The party who contracts with a pipeline operator for transportation service. A shipper has the obligation to confirm that the volume of gas delivered to the transporter is consistent with nominations. The shipper is obligated to confirm that differences between the volume delivered in the pipeline and the volume delivered by the pipeline back to the shipper is brought into balance as quickly as possible

SLCP
Stands for Short-lived Climate Pollutants that identifies black carbon, methane, tropospheric ozone, and fluorinated gases. Currently, fluorinated gases (HFCs, perfluorocarbons (PFCs), SF6, and NF3) account for 3 percent of domestic greenhouse gas emissions in terms of carbon dioxide equivalency (CO_2e)

Smart Grid
An electricity supply network that uses digital communications technology to detect and react to local changes in usage.

Solar Power Europe
European Photovoltaic Industry Association. The association that represents the photovoltaic (PV) industry towards political institutions at European and international level.

Spot contract
Short-term contract, generally a day ahead

State Ownership
State ownership is the ownership of an industry, asset, or enterprise by the state or a public body representing a community as opposed to an individual or private party

Super Pollutants
Methane and black carbon identified as the Super Pollutants being some of the most aggressive contributors to global warming.

System Loss
System losses occur when 100% efficiency isn't achieved in either conversion or transport of energy.System losses are of two types:1. Technical Loss, driven by the characteristics for the equipment and materials 2. Non-technical Loss, driven by theft, meter readings, pilferage etc.

Take-or-pay contract
Contract whereby the agreed consumption has to be paid for, irrespective of whether the consumption has actually taken place

TCI
Stands for Transportation and Climate Initiative, it is a regional collaboration of 12 Northeast and Mid-Atlantic states and the District of Columbia that seeks to improve transportation, develop the clean energy economy and reduce carbon emissions from the transportation sector.

Third Energy Package
Third Energy Package. A legislative package proposed on September 19, 2007 by the EC in order to pursue the liberalisation of the electricity and gas markets

TPA
Third Party Access. Recognised right of each user (eligible customer, distributor, and producer) to access in a non discriminatory and efficient manner transmission or distribution systems in exchange for payment of access rights

UFC
Federal Union of Consumers

Unbundling
Separation of roles according to the value chain segment (generation, transmission, distribution, retail) required by European Directives for enabling fair competition rules

UNEP
United Nations Environment Program

US Climate Alliance
The United States Climate Alliance is a bipartisan coalition of governors committed to reducing greenhouse gas emissions consistent with the goals of the Paris Agreement

US Energy Information Administration
The U.S. Energy Information Administration (EIA) is a principal agency of the U.S. Federal Statistical System responsible for collecting, analyzing, and disseminating energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment.

Utility Death Spiral
In 2013, the Edison Electric Institute (EEI) released a report positing that an eroding revenue stream, declining profits, rising costs, and ever-weakening credit metrics would diminish the ability of electric utilities to survive in an increasingly off-the-grid world.

White Certificate
A certificate stating a volume of engaged energy savings (electricity, gas, fuel, …) at end-users' site, like a home or a business. They are tradable or not

Wholesale Electricity Market
The wholesale market is where electricity is traded (bought and sold) before being delivered to end consumers (individuals, households or businesses) via the grid

List of Acronyms

1. ACCC: Australia Competition and Consumer Commission
2. ACEEE: American Council for an Energy Efficient Economy
3. ACORE: American Council on Renewable Energy
4. ACT: Australian Capital Territory
5. ADIT: Accumulated Deferred Income Tax
6. AEMC: Australian Energy Market Commission
7. AEMO: Australian Energy Market Operator
8. AER: Australian Energy Regulator
9. AGA: Advanced Grid Analytics
10. AMI: Advanced Metering Infrastructure
11. APEC: Asia-Pacific Economic Cooperation
12. APGCC: ASEAN Power Grid Consultative Committee
13. APRA: Australian Prudential Regulation Authority
14. ARENA: Australian Renewable Energy Agency
15. ARFVTP: Alternative and Renewable Fuel and Vehicle Technology Program
16. ARRA: American Recovery and Reinvestment Act
17. ASEP: Access to Sustainable Energy Program
18. ASIC: Australian Securities & Investments Commission
19. ASEAN: Association of Southeast Asian Nations
20. BAU: Business-as-usual
21. Bcm: Billion cubic meters
22. BESS: Battery Energy Storage System
23. Bloomberg NEF: Bloomberg New Energy Finance
24. BNEF: Bloomberg New Energy Finance
25. BoM: Bureau of Meteorology
26. B2C: Business-to-Consumer
27. CAFÉ: Corporate Average Fuel Economy
28. CAGR: Compound Annual Growth Rate
29. CAISO: California Independent System Operator
30. CapEx: Capital Expenditure
31. CARC: Customer Acquisition and Retention Costs
32. CAT: Climate Action Tracker
33. CC: Contestable Consumers
34. CCA: Climate Council Authority
35. CCC: Climate Change Commission
36. CCGT: Combined Cycle Gas Turbine
37. CCS: Carbon Capture and Storage
38. CEFC: Clean Energy Finance Corporation
39. CER: Clean Energy Regulator
40. CEVS: Carbon Emissions-Based Vehicle Scheme
41. CO_2: Carbon dioxide
42. CO_2e: Carbon dioxide Equivalent
43. COAG: Council of Australian Governments
44. CPI: Consumer Price Index
45. COP22: 22nd Conference of the Parties
46. CPP: Clean Power Plan
47. CREZ: Competitive Renewable Energy Zones
48. CRI: Climate Risk Index
49. CRM: Customer relationship management
50. CSI: Customer Satisfaction Index
51. CSI: California Solar Initiative
52. CSIRO: Commonwealth Scientific and Industrial Research Organization
53. CSP: Competitive Selection Process
54. CST: Concentrated Solar Thermal
55. CTS: Costs to Serve
56. DEE: Department of Environment and Energy
57. DER: Distributed Energy Resource
58. DES: Distributed Electricity and Storage
59. DILG: Department of the Interior and Local Government
60. DfE: Design for Efficiency
61. DMIRS: Department of Mines, Industry Regulation and Safety
62. DMO: Distribution Market Operator
63. DMO: Default Market Offer (aka 'standing offers')
64. DoE: Department of Energy
65. DPPA: Direct Power Purchase Agreement
66. DREAMS: Development for Renewable Energy Applications Mainstreaming and Market Sustainability
67. DSO: Distribution System Operator
68. DSL: Distribution System Loss
69. DSM: Demand-side Management
70. DU: Distribution Utilities
71. EASe: Energy Efficiency Improvement Assistance Scheme
72. eceee: European Council for an Energy Efficient Economy
73. EBITA: Earnings before Interest, Taxes, and Amortization
74. EBITDA: Earnings before Interest, Tax, Depreciation and Amortization
75. EBSS: Efficiency Benefit Sharing Scheme
76. EC: Energy Commission
77. ECF: Equity Crowd Funding
78. EE: Energy Efficiency
79. EERS: Energy Efficiency Resource Standards
80. EIA: Energy Information Administration
81. EMA: Electricity Market Authority

82. EMC: Energy Market Company
83. EMS: Energy Management System
84. ENSO: El Niño-Southern Oscillation
85. ENTR: Electricity Network Transformation Roadmap
86. EPA: Environmental Protection Agency
87. EPBC: Environment Protection and Biodiversity Conservation
88. EPIC: Energy Policy Institute at University of Chicago
89. EPS: Earnings per Share
90. ERCOT: The Electric Reliability Council of Texas
91. ERC: Energy Regulatory Commission
92. ERF: Emissions Reduction Fund
93. ESB: Energy Security Board
94. ESCO: Energy Service Company
95. ESOO: Electricity Statement of Opportunities
96. ETI: Energy Transition Index
97. ETS: Emissions Trading Scheme
98. EV: Electric Vehicle
99. EVN: Vietnam Electricity Company
100. FERC: The Federal Energy Regulatory Commission
101. FFO: Funds from Operation
102. FFR: Fast Frequency Response
103. FLNG: Floating liquefied natural gas
104. FPSS: Future Power System Security
105. FPA: Federal Power Act
106. FRC: Full Retail Contestability
107. FUM: Forecast Uncertainty Measure
108. GCF: Green Climate Fund
109. GDP: Gross Domestic Product
110. GEOP: Green Energy Option Program
111. GHG: Greenhouse Gas
112. GIS: Geographic Information System
113. GJ: Gigajoules
114. GMI: Grid Modernization Initiative
115. GMLC: Grid Modernization Lab Consortium
116. GMRG: Gas Market Reform Group
117. GREET: Grant for Energy Efficient Technologies
118. GSSF: Grid Scale Storage Fund
119. GSOO: Gas Statement of Opportunities
120. GTFS: Green Technology Financing Scheme
121. GW: Gigawatt
122. GWh: Gigawatt-hours
123. HDB: Housing and Development Board
124. HEV: Hybrid Electric Vehicle
125. HFCs: Hydrofluorocarbons
126. HK Electric: Hongkong Electric Company
127. HVAC: Heating, Cooling & Ventilation
128. HKSAR: Hong Kong Special Administrative Region
129. IA: Investment Allowance
130. IBR: Incentive Based Regulation
131. ICPT: Imbalance Cost Pass-Through
132. ICT: Information and Communication Technologies
133. IEA: International Energy Agency
134. IEC: International Energy Consultants
135. IEMOP: Independent Electricity Market Operator of the Philippines
136. IEP: International Environmental Partnership
137. IFC: The International Finance Corp
138. INDC: Intended Nationally Determined Contribution
139. IoT: Internet of Things
140. IOUs: Investor-owned Utilities
141. IPCC: Intergovernmental Panel on Climate Change
142. IPP: Independent Power Producer
143. IPv6: Internet Protocol version 6
144. ISEM: Institute for Superconducting and Electronic Materials
145. ISO: International Organization for Standardization
146. ISP: Integrated System Plan
147. ITC: Investment Tax Credits
148. IUS: Integrated Utility Services
149. IVR: Interactive Voice Response
150. kgoe: Kilograms of oil equivalent
151. KV: Kilovolt
152. KW: Kilowatt
153. KWh: Kilowatt-hours
154. LCOE: Levelized Cost of Energy
155. LDC: Least Developed Countries
156. LNG: Liquefied Natural Gas
157. LPG: Liquefied Petroleum Gas
158. LRET: Large-scale Renewable Energy Target
159. LSS: Large Solar Scale
160. LULUCF: Land Use, Land Use Change and Forestry
161. M2M: Machine to Machine
162. M&A: Merger and Acquisition
163. MESI: Malaysian Energy Supply Industry
164. MENA: Middle East and North Africa region
165. MESTECC: Minister of Energy, Science, Technology, Environment and Climate Change
166. MDB: Multilateral development banks
167. MDM: Meter Data Management
168. MIDA: Malaysian Investment Development Authority
169. MIT: Massachusetts Institute of Technology
170. MMBTU: Million Metric British Thermal Units
171. MMT: Million Metric Tonnes
172. MMTPA: Million Metric Tonnes Per Annum
173. MNCAA: The Mayors National Climate Action Agenda

174. MoT: Ministry of Transport
175. MOEA: Ministry of Economic Affairs
176. MOIT: Ministry of Industry and Trade
177. MOU: Memorandum of Understanding
178. MSCI: Morgan Stanley Capital International
179. $MtCO_2$-e: Million Tonnes of Carbon Dioxide Equivalent
180. Mt: Million Tonnes
181. Mtoe: Million Tonnes of Oil Equivalent
182. MW: Megawatt
183. MWe: Mega Watt Electrical
184. MWp: Mega Watt Peak
185. MWh: Megawatt-hours
186. NAFTA: North American Free Trade Agreement
187. NCOS: National Carbon Offset Standard
188. NDC: Nationally Determined Contributions
189. NEA: National Environment Agency
190. NEA: Nuclear Energy Agency
191. NEB: National Energy Board
192. NECF: National Energy Customer Framework
193. NEPA: National Environmental Policy Act
194. NEM: Net Energy Metering
195. NEM: National Electricity Market
196. NEMEMF: National Electricity Market Emergency Management Forum
197. NEMS: National Energy Modeling System
198. NGERAC: National Gas Emergency Response Advisory Committee
199. NGV: Natural Gas Vehicle
200. NIA: National Irrigation Administration
201. NIC: Network Interface Card
202. NOL: Net Operating Loss
203. NREP: National Renewable Energy Program
204. NSP: Network Service Providers
205. NSPS: New Source Performance Standards
206. NSW: New South Wales
207. NT: Northern Territory
208. OCBC: Oversea-Chinese Banking Corporation
209. OECD: Organization for Economic Co-operation and Development
210. OEM: Open Electricity Market
211. PACE: Property Assessed Clean Energy
212. PAG: Providence Asset Group
213. PASA: Projected Assessment of System Adequacy
214. PDP: Power Development Plan
215. PHEV: Plug-in Hybrid Electric Vehicle
216. PHES: Pumped Heat Electrical Storage
217. PBR: Performance-Based Ratemaking
218. PEV: Plug-in Electric Vehicle
219. PJ: Petajoule
220. PNOC: Philippine National Oil Company
221. PPAs: Power Purchasing Agreements
222. PPP: Public Private Partnership
223. PSA: Power Supply Agreements
224. PV: Photovoltaic
225. PVN: PetroVietnam
226. QLD: Queensland
227. RAB: Regulated Asset Base
228. R&D: Research and Development
229. RE: Renewable Energy
230. REBA: Renewable Energy Buyers Alliance
231. REC: Renewable Energy Certificate
232. REDD+: Reduce Emissions from Deforestation and Forest Degradation
233. RGGI: Regional Greenhouse Gas Initiative
234. REJI: Renewable Energy (Jobs and Investment)
235. REP: Retail Electric Provider
236. REPPA: Renewable Energy Power Purchase Agreement
237. REPI: Retail Electricity Pricing Inquiry
238. RERT: Reliability and Emergency Reserve Trader
239. RES: Renewable Energy Sources
240. RETR: Renewable Energy Transition Roadmap
241. RET: Renewable Energy Target
242. RETF: Renewable Energy Trust Fund
243. REZ: Renewable Energy Zones
244. RIT-T: Regulatory Investment Test for Transmission
245. RPS: Renewable Portfolio Standards
246. RRO: Regional Reliability Organizations
247. RTO: Regional Transmission Organization
248. SA: Southern Australia
249. SAIDI: System Average Interruption Duration Index
250. SARE: Supply Agreement for Renewable Energy
251. SCA: Scheme of Control Agreement
252. SCADA: Supervisory Control and Data Acquisition
253. SCC: Social Cost of Carbon
254. SCEM: Singapore Certified Energy Manager
255. SEA: Southeast Asia
256. SGER: Specified Gas Emitters Regulation
257. SGIG: Smart Grid Investment Matching Grant
258. SLCP: Short-lived Climate Pollutants
259. SMOC: Streaming Media Online Charging System
260. SMR: Small Modular Reactors
261. SoC: Scheme of Control
262. SRES: Small-scale Renewable Energy Scheme
263. SSR: Summer Saver Rebate
264. S&P: Standard & Poor's
265. TAITRA: Taiwan External Trade Development Council

266. TAS: Tasmania
267. TCF: Trillion cubic feet
268. TCI: Transportation and Climate Initiative
269. TNB: Tenaga Nasional Berhad
270. TNSP: Transmission Network Service Providers
271. ToU: Time-of-Use
272. TWh: Terawatt-hours
273. T&D: Transmission and Distribution
274. UNCED: United Nations' Conference on Environment and Development
275. UNEP: United Nations Environment Programme
276. UNFCCC: United Nations Framework Convention on Climate Change
277. UOB: United Overseas Bank
278. USAID: United States Agency for International Development
279. US EIA: United States Energy Information Administration
280. USTDA: United States Trade and Development Agency
281. UTP: Uniform Tariff Policy
282. VES: Vehicular Emissions Scheme
283. VIC: Victoria
284. V-LEEP: Vietnam Low Emission Energy Program
285. VPP: Virtual Power Plant
286. VRE: Variable Renewable Electricity
287. VRET: Victorian Renewable Energy Target
288. VWEM: Vietnam Competitive Wholesale Electricity Market
289. WA: Western Australia
290. WESM: Wholesale Electricity Spot Market
291. WSD: Water Supplies Department
292. WTE: Waste-to-Energy
293. WTO: The World Trade Organization
294. WWII: World War II
295. YTD: Year to date
296. ZEV: Zero-Emission Vehicle

Country Abbreviations and Energy Authorities

Countries	Abbreviation	Regulators	Ministries or authorities for energy-related topics
Austria	AT	E-Control	Ministry of Agriculture, Forestry, Environment and Water Management: www.bmlfuw.gv.at/ Environment Agency: www.umweltbundesamt.at/ Competition Authority: http://www.bwb.gv.at/
Belgium	BE	CREG (national) BRUGEL (Brussels) CWAPE (Walloon) VREG (Flanders)	Ministry of Economic Affairs: http://economie.fgov.be/
Bulgaria	BG	DKER	Ministry of Economy and Energy: www.mi.government.bg/
Canada	CA	NEB	National Energy Board: www.neb-one.gc.ca Ministry of Energy: http://www.energy.gov.on.ca
Croatia	HR	HERA	Ministry of Economy, Labour and Entrepreneurship: www.mingo.hr/
Czech Republic	CZ	ERU	Ministry of Industry and Trade: www.mpo.cz/ Competition Office: www.compet.cz/
Denmark	DK	DERA NordREG	Energy Agency: www.ens.dk/ Ministry of Economic and Business Affairs: www.evm.dk/ Ministry of Environment: www.mim.dk/
Estonia	EE	ETI	Ministry of Economic Affairs: www.mkm.ee/ Competition Authority: www.konkurentsiamet.ee/
Finland	FI	EMV NordREG	Ministry of Employment and the Economy: www.tem.fi/ Ministry of Environment: www.ymparisto.fi/ Competition Authority: www.kilpailuvirasto.fi/
France	FR	CRE	Ministry of Ecology, Sustainable Development and Energy: www.developpement-durable.gouv.fr/
Germany	DE	BNetzA UNFCCC	Federal Environment Ministry: www.bmu.de/ Energy Agency: www.dena.de/ United Nations Framework Convention on Climate Change https://unfccc.int/ Competition Authority: www.bundeskartellamt.de/

Countries	Abbreviation	Regulators	Ministries or authorities for energy-related topics
Greece	GR	RAE	Ministry of Development: www.mindev.gov.gr/el/ Ministry of Environment, Energy and Climate Change: www.ypeka.gr/ Competition Commission: www.epant.gr/
Hungary	HU	MEH	Energy Office: www.mekh.hu/
Hong-Kong	HK	EMSD HKSAR	Electrical and Mechanical Services Department: www.emsd.gov.hk Hong Kong Special Administrative Region Environment Bureau: http://www.enb.gov.hk/en/
Ireland	IE	CER (Republic of Ireland)	Department of Communications, Energy & Natural Resources: www.dcenr.gov.ie/Energy/ NIAUR (Northern Ireland)
Italy	IT	AEEG	Ministry of Environment: www.minambiente.it/ Ministry of Economic Development: www.sviluppoeconomico.gov.it/ Competition Authority: www.agcm.it/
Latvia	LV	SRPK	Ministry of Economy: www.em.gov.lv/ Competition Council: www.kp.gov.lv/
Lithuania	LT	REGULA	Ministry of Economy: www.ukmin.lt/
Luxemburg	LU	ILR	Ministry of Economic Affairs: www.eco.public.lu/
Malaysia	MY	ST MESTECC MoT MESI	Energy Commission : www.st.gov.my Minister of Energy, Science, Technology, Environment and Climate Change https://www.mestecc.gov.my/web/en/ Ministry of Transport Malaysian Energy Supply Industry
Mexico	MX	SENER	Secretaría de Energía de México: www.gob.mx Comisión Federal de Electricidad: http://www.cfe.gob.mx
Netherlands	NL	DTe	Ministry of Economic Affairs: www.rijksoverheid.nl/ Energy Council: www.algemene-energieraad.nl/ Competition Authority: www.nmanet.nl/
Norway	NO	NVE NordREG	Oil and Energy Ministry: www.regjeringen.no/ Competition Authority: www.konkurransetilsynet.no/

Countries	Abbreviation	Regulators	Ministries or authorities for energy-related topics
Philippines	PH	ERC DILG ERC IEMOP DOE	Energy Regulatory Commission: www.erc.gov.ph Department of the Interior and Local Government https://www.dilg.gov.ph/ Energy Regulatory Commission https://www.erc.gov.ph/ Independent Electricity Market Operator of the Philippines http://www.iemop.ph/ Department of Energy https://www.doe.gov.ph/
Poland	PL	URE	Ministry of Economy: www.me.gov.pl
Portugal	PT	ERSE	Ministry of Economy: www.min-economia.pt/ Directorate General for Energy and Geology: www.dgeg.pt/
Romania	RO	ANRE	Ministry of Energy and Resources: www.minind.ro/
Singapore	SG	EMA HDB EDB	Energy Market Authority: www.ema.gov.sg Housing and Development Board https://www.hdb.gov.sg/cs/infoweb/homepage The Singapore Economic Development Board https://www.edb.gov.sg/
Slovakia	SK	URSO	Ministry of Economy: www.economy.gov.sk/ Ministry of Environment: www.enviro.sk/
Slovenia	SI	AGEN	Ministry of Infrastructure: www.mzip.gov.si/
Spain	ES	CNMC	Ministry of Industry, Energy and Tourism: www.minetur.gob.es/ Ministry of Agriculture, Fishing & Food: www.mapa.gob.es/ Ministry of Ecologic Transition: www.miteco.gob.es/
Sweden	SE	EI NordREG	Ministry of Energy: www.regeringen.se/ Competition Authority: www.kkv.se/
Switzerland	CH	BFE IPCC	Federal Department of Environment, Transport, Energy and Communications: www.uvek.admin.ch/ Intergovernmental Panel on Climate Change http://www.ipcc.ch/ Competition Authority: www.weko.admin.ch/

Countries	Abbreviation	Regulators	Ministries or authorities for energy-related topics
Taiwan	TW	BOE TAITRA MOEA	Bureau of Energy, Ministry of Economic Affairs: www.moeaboe.gov.tw Taiwan External Trade Development Council https://en.taitra.org.tw/ Ministry of Economic Affairs https://www.moea.gov.tw/Mns/english/home/English.aspx
United Kingdom	UK	OFGEM	Department of Energy and Climate Change: www.decc.gov.uk/ Competition Authority: www.gov.uk/government/organisations/competition-and-markets-authority
United States of America	USA	DoE EIA US Climate Alliance FERC	U.S. Department of Energy: https://www.energy.gov/ US Energy Information Administration: https://www.eia.gov/ https://www.usclimatealliance.org/ Federal Energy Regulatory Commission (FERC): https://www.ferc.gov/
Vietnam	VN	MOIT	Ministry of Industry and Trade: www.moit.gov.vn
Australia	AUS	ACCC AEMO AEMC AER APRA CSIRO COAG ARENA CER DEE	Australian Competition and Consumer Commission https://www.accc.gov.au/ Australian Energy Market Operator https://www.aemo.com.au/ Australian Energy Market Commission https://www.aemc.gov.au/ Australian Energy Regulator https://www.aer.gov.au/ Australian Prudential Regulation Authority https://www.apra.gov.au/ Commonwealth Scientific and Industrial Research Organisation https://www.csiro.au/ Council of Australian Governments Energy Council http://coagenergycouncil.gov.au/ Australian Renewable Energy Agency https://arena.gov.au/ Clean Energy Regulator http://www.cleanenergyregulator.gov.au/ Department of the Environment and Energy http://www.environment.gov.au/

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VaasaETT is a leading retail energy consultancy, specialized in complex market issues in six continents and over 90 jurisdictions around the world. We support a global client base of energy companies, governments, regulators, innovators, investors and enterprise consumers, based on the most extensive insight and advanced market analytics.

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