Capgemini

20th Edition
November 2018

WEMO
World Energy Markets Observatory

In collaboration with: vaasaETT DE PARDIEU BROCAS MAFFEI AVOCATS

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WEMO 2018 Global Editorial

Colette Lewiner

Oil prices have increased

Oil prices rose as high as US$80/barrel for the first time since 2014; this represents an increase of nearly 100% since January 2016.

Four factors in particular came into play:

- ***Supply and demand:*** the booming world economy has led to a demand increase of more than 5Mb/d[1] since 2015 with global oil consumption expected to top 100Mb/d by the end of 2018. World oil demand rose by 1.6% (or 1.5 Mb/d) in 2017, a rate that was higher than the annual average of 1% seen over the last decade. Inventories of crude that had built up during the 2014-2016 glut have decreased because of this strong demand and the supply cuts by OPEC/Russia.
- ***OPEC and Russia:*** in late 2016 an agreement was reached to limit their supplies in order to push up the oil price. This deal has removed at least 1.8 Mb/d since the start of 2017. Despite American pressure to enhance production in order to lower prices, OPEC and Russia agreed in June 2018 to increase production slightly less than 1 Mb/d above current OPEC output. In practice the increase will be less (around 700,000 b/d) because many OPEC members aren't in a position to raise their output. The oil price increased moderately after these decisions were announced.
- ***Geopolitical risks:*** when supplies are tight, as presently, these risks become significant.
  - The U.S. withdrawal from the Iran nuclear deal announced in May 2018 and the probable sanctions on Iran's oil exports are the most tangible risk. Iran is the third largest worldwide oil producer and since the nuclear deal was struck and the oil-related sanctions lifted, Iran's exports had increased.
  - Venezuela's oil output has fallen by at least 500,000 b/d because of the economic and political crisis in the country and there is little sign that the state oil company PDVSA will be able to reverse the trend.
  - The conflict between Saudi Arabia and Houthi rebels in Yemen: the Houthis, who have Iran's support, have stepped up their attacks on Saudi Arabia's oil infrastructure and even Riyadh. There is a chance either of supply disruption or a flare-up of tension between Saudi and Iran.
  - Finally, Libya, where oil output has recovered to 1Mb/d, remains highly unstable even seven years after the civil war started. In conclusion the risk of a supply disruption is significant.
- ***Swelling supplies from the US:*** Shale fields at 10.7Mb/d had been expected to fill global supply gaps but shale oil has faced pipeline constraints and infrastructure bottlenecks limiting how quickly production can reach the market.

For the future, many observers forecast robust oil prices although they don't see a return to pre-downturn levels.

In 2008, the oil barrel price peak at US$150 coincided with the beginning of the economic recession. What was the chicken and what was the egg? Could today's price level trigger a new recession?

1 Mb/d: million barrels per day

Gas is still a regional commodity

Global natural gas demand grew by 3%, thanks in large part to abundant and relatively low-cost supplies. China alone accounted for almost 30% of growth globally.
Gas prices rose in Europe, Asia and North America in 2017, but remained below the 10-year average. Over the past year, European and Asian prices have been supported by increasing oil, coal and carbon prices.[2]

Apart from Liquefied Natural Gas (LNG), natural gas markets are regional as reflected by large discrepancies in spot prices between different regions.
At the end of 2017, when the U.S. Henry Hub spot price was around US$3/MBTU[3], the UK NBP price reached US$6/MBTU and the Japan price was nearly triple that at US$7-8/MBTU.

The LNG global market represents 10% of gas supplies worldwide. It has grown significantly in recent years: in 2017 it reached 294 Mtpa[4] and in 2020 it is likely to represent 360 Mtpa or 150% of its 2015 capacity.
Following its "blue sky policy" to curb Green House Gases (GHG) emissions and limit coal usage, China increased imports by 46% in 2017 overtaking South Korea to become the world's second largest LNG buyer after Japan. It was the third largest destination for U.S. LNG exports after Mexico and South Korea[5].
Thanks to the abundance of low cost gas unlocked by the shale revolution, the U.S. is a competitive supplier compared in particular to Russia, Qatar and Australia.

A first wave of U.S. LNG plants has been under construction along the Gulf of Mexico. The earliest Cheniere Energy's Sabine Pass in Louisiana started exports in February 2016; Dominion Energy's Cove Point in Maryland exported its first cargo in March 2018. There has been no approval for new U.S. LNG plants since 2015 because of expectations of excess supply. These expectations have diminished because of soaring LNG demand. In May 2018, Cheniere announced it was expanding its Corpus Christi plant in Texas. Other U.S. projects are making good progress, signaling a second wave of investment in U.S. LNG plant export capacity.

The biggest threat to these plans is the trade dispute between the U.S. and China. Even if LNG was excluded from China's list of U.S. exports threatened with retaliatory tariffs (almost all U.S. fossil fuels are on this list including oil and coal) the prospect of being shut out of the world's biggest growth market will hang over Final Investment Decisions until hostilities are brought to an end.

Coal demand and prices are up

Despite being the major commodity least loved by analysts, global coal demand rose about 1% in 2017, reversing the trend seen over the last two years. This growth was mainly due to demand in Asia, almost entirely driven by an increase in coal-fired electricity generation.

This growth is reflected in prices: in June 2018 the price of thermal coal (burnt in power plants to produce electricity) rose to US$112 a ton, 130% higher than its 2016 low because of strong Asian demand. Although thermal coal is being phased out of many European countries (except Germany and Poland) it accounts for 40% of energy consumption in emerging markets, especially Asia. Demand from India, Japan and South Korea was robust in H1 2018 while an early summer heatwave boosted imports to China despite the Beijing government's efforts[6].

Economic growth is increasing the threat of climate change

Economic growth is triggering growth in global energy demand, which increased by 2.1% in 2017, (compared with 0.9% the previous year[7]): 72% of the rise was met by fossil fuels, a quarter by renewables, and the remainder by nuclear.

Global energy-related CO_2 emissions grew by 1.4% in 2017, reaching a historic high of 32.5 gigatonnes (Gt), a resumption of growth after three years of global emissions remaining unchanged. The increase in CO_2 emissions, however, was not universal. While most major economies saw a rise, some others experienced declines, including the United States, the United Kingdom, Mexico and Japan.

The Paris 2015 Climate Accord objective to keep the global temperature rise below 2 degrees in 2050 is becoming even more difficult to achieve.
Already the 2015 countries' pledges projections led to warming of 3 degrees, which would have catastrophic consequences for life

2 https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/natural-gas/natural-gas-prices.html
3 MBTU: Million British Thermal Unit
4 Mtpa: Million tons per annum
5 Ed Crooks, "US trade spat threatens new wave of LNG plants", *Financial Times*, June 27, 2018
6 https://in.reuters.com/article/column-russell-coal-china/column-chinas-first-half-coal-imports-surge-indonesia-the-winner-russell-idINL4N1TS213
7 IEA global Energy & CO_2 Status report 2017

on Earth, and the 2017 results were not in the right direction. It is now unclear how governments will be able to announce increased ambitions in line with the goal of holding global warming at 1.5 degrees in 2050.

Following his electoral campaign commitment, President Trump announced in June 2017 that the United States would withdraw from the Paris Accord. Even if other countries don't follow the U.S. decision, it is weakening efforts to combat global warming, since American financing will probably stop in 2019.

Domestically, the U.S. administration has cancelled the Clean Power Act (which was never actually implemented) and there has been a relaxation of car consumption constraints. Also, the Environment Protection Agency (EPA) budget was significantly reduced.

However, ignoring President Trump's proposed cuts to renewable energy and early-stage energy programs, Congress decided to increase energy-related R&D and innovation budgets for 2018:

- the office of Nuclear Energy received a growing R&D budget of US$669 million (US$107 million increase)
- ARPA-E (the Advanced Research Projects Agency-Energy) funding increased to a record high of US$353 million compared to US$306 million in 2017
- the U.S. Department of Energy's (DOE) energy efficiency and renewable energy budgets both increased by around 15%.

Ironically, in 2017 the U.S. was one of the few countries that had decreased its GHG emissions!

Renewables, carbon-free generation and storage are expanding

Renewables

• Intermittent renewables generation has specific characteristics:

Wind and photovoltaic (PV) solar are renewables with no storage, being purely intermittent; hydropower (dams), biomass and, to a certain extent, concentrated solar have storage. They don't have the same generation output characteristics or the same grid impact. The intermittent renewables capacity factor[8] varies according to location and, notably, wind and solar intensity. In the U.S., on average, the 2017 wind capacity factor was 37% and the PV[9] solar 27% while the nuclear plant capacity factor was 92%[10].

These differences need to be taken into account when comparing installed capacity of intermittent renewables with schedulable generation (nuclear, gas or coal fired plants).

• In contrast to previous years, 2017 investment in electric renewables generation

decreased by 7%[11] to US$298 billion, while investment in the oil and gas value chain increased. Solar and offshore wind investment increased while onshore wind and hydropower investment decreased; probably because of the lack of suitable sites and, in the case of onshore wind, local opposition.

Thanks to productivity gains (with the same investment more capacity can be built) solar and wind renewable energy installed capacity continued to grow representing 61% of all net power generation capacity added. However, regional and technological progress varied: in Europe wind power continued to progress while in the U.S. renewables growth was mainly in solar. The real boom is in photovoltaic solar in China with 53 GW installed capacity in 2017 (nearly half of newly installed worldwide solar capacity), a benefit of the "blue sky policy".

At the end of 2017, global renewable generation capacity amounted to 2,179 GW. Hydro accounted for the largest share of the global total, with installed capacity of 1,152 GW. Wind and solar energy accounted for most of the remainder, with capacities of 514 GW and 397 GW respectively. Other renewables included 109 GW of bioenergy, 13 GW of geothermal energy, and 500 MW of marine energy (tide, wave and ocean energy)[12].

During the first half of 2018, global solar energy investment decreased by 19%[13] to US$72 billion notably because of the Chinese government's decision to slow down solar photovoltaic (PV) development. In contrast, wind investment grew by 33% reaching US$57 billion.

2017 saw some spectacular achievements:

In Denmark, wind energy met as much as 43.4% of electricity consumption. The government's goal is for wind

8 The net capacity factor is the ratio of an actual electrical energy output over a given period of time to the maximum possible electrical energy output over that period.

9 PV: photovoltaic solar

10 https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b

11 IEA World Investment Report July 2017

12 https://www.irena.org/publications/2018/Mar/Renewable-Capacity-Statistics-2018

13 Bloomberg New Energy Finance study July 2018

and solar energy to meet at least 50% of its energy needs by 2030, which is likely thanks to the very efficient Nordpool grid interconnections with countries having schedulable electricity sources: hydro in Norway, nuclear and hydro in Sweden, nuclear in Finland.

The first industrial-scale floating wind farm Hywind (30 MW) was commissioned by Equinor (formerly Statoil) in Scotland.

In early December 2017, the largest floating solar power station in the world – 40 GW, 800,000 m² [14] – was launched in China.

In March 2018, SoftBank and Saudi Arabia announced a project to build the world's biggest solar farm. When completed, nominally in 2030, it will have a capacity of 200 GW and cost US$200 billion. This project is consistent with the country's Vision 2030 project that aims to diversify its heavily oil-dependent economy. In addition to that huge solar farm, the government plans to spend US$80 billion on a fleet of nuclear reactors.

- ***Solar and onshore wind continued to gain in competitiveness in 2017***

According to the latest Bloomberg New Energy Finance (BNEF) worldwide study[15], the average LCOE[16] of onshore wind was down 18% year on year at US$55/MWh, and that of photovoltaics dropped to US$70/MWh (down 18%). The decline is less pronounced for offshore wind (- 5%) at US$118/MWh. For onshore wind, the lowest costs are recorded in Australia, Brazil, Sweden and India, while for solar, the countries with the most competitive costs are Chile, India, Australia and Jordan.

Photovoltaic solar LCOE costs are expected to continue to decrease (by 60% from 2016 to 2025). Over the same period, the onshore wind LCOE is expected to decrease by 26% and offshore wind by 35%.

- ***Intermittent renewables have an important impact on grid management as the grid***

operator has to constantly balance supply with variable demand. With intermittent renewables supply, capacity back-up (i.e. operational margin) is needed and the grid design, equipment and management become more complex, hence the need for smarter grids.

In order to compare costs with schedulable generation, one has to add between 15-40% cost to the LCOE renewable costs and this figure increases when renewables generation share increases.

- ***As shown by studies[17], it is not possible today to manage an electricity grid with 100% intermittent renewables generation for several reasons:***
  - Intermittent renewables sources would occupy a significant land space. For example, if wind power generated 100% of French electricity consumption, windmills would occupy 5% of French territory, which is about the area currently occupied by cities, roads and car parks[18]. In France, to produce the electricity equivalent of a 1,000 MW nuclear reactor (France has 58 reactors) a surface equivalent to intramural Paris would have to be covered by solar panels.
  - A grid with 100% intermittent renewables is not manageable[19] as increased operational margins are needed to compensate for intermittency and as the system has to be massively oversized. Operational back-up with electrical batteries is too expensive and not feasible today. For example, in France, if all electricity was generated by intermittent renewables, battery storage of electricity would represent consumption of materials and environmental problems (for batteries manufacturing and their end of life management) out of proportion to the means available. As an illustration, to store one week of French electricity generation (with 1.5 TWh stored by day) each person would need around 500 kg of Li-ion batteries!
  - Operational backup has to be provided by schedulable electricity sources: traditional fossil fuel plants or nuclear. With no such electricity sources, grid dynamic stability would be endangered which would imply renewable power curtailment.
  - Finally, the economics of such a system would be a robust challenge, as the cost of integrating renewables on the grid grows with their share of generation. A recent study on an European Union (EU) electrical

14 Equivalent to 110 football fields

15 March 2018

16 LCOE: Levelized Cost Of Energy

17 Clara Franziska Heuberger, Niall Mac Dowell, "Real-World Challenges with a Rapid Transition to 100% Renewable Power Systems", Joule. [online]. Volume 2, Issue 3. March 21, 2018. https://www.sciencedirect.com/science/article/pii/S2542435118300485

18 https://jancovici.com/transition-energetique/renouvelables/pourrait-on-alimenter-la-france-en-electricite-uniquement-avec-de-leolien/

19 Overcapacity and the challenges of going 100% renewable by Chris Lo

system with 60% renewables (including 40% wind power and solar and 20% hydropower) by 2030 shows[20] that there are already strong implications for system operation and costs. Similar studies show that nuclear electricity is needed as a carbon free and schedulable complement to renewables.

- ***New players are entering the sector:*** Oil companies such as BP or Shell are coming back to solar energy. By the end of 2017, BP had acquired a 43% stake in Lightsource, Europe's biggest solar developer, marking its return to the sector from which it withdrew six years before. In January 2018, Shell ventured back into solar after a 12-year hiatus, buying a 43.86% stake in Silicon Ranch Corporation for US$217 million.

Total entered the solar energy sector in 2011 by acquiring American Sunpower. More recently, in 2017, Total announced the signing of an agreement with the French EREN RE, with an indirect stake of 23% and a takeover of the company after five years.

For many years, Utilities such as EDF, Engie, Enel or Iberdrola have had renewable energy generation plants in their countries and abroad and have multiple projects in their portfolios. EDF, for example, has dynamic renewable worldwide development supported by its subsidiary EDF EN (12 GW wind and solar installed capacity in 22 countries[21]).

In addition, at the end of 2017 EDF announced a plan to develop and build in France 30 GW of PV by 2035, which represents four times the country's current solar production capacity. The dedicated investment is planned to be as much as €25bn.

- ***Strategic considerations:*** As the wind and solar industries are young, concern has to be raised regarding the real lifetime of installations, wind offshore platforms end of life management, and solar panel recycling.

Concerns arise also from China's essential monopoly on the global solar industry, manufacturing over 70% of the world's solar panels[22]. It has flooded American and European markets (and now countries such as India and Japan) with cheap panels and has triggered the bankruptcy of many western solar panel manufacturers notably in Germany and the U.S..

In fact, the EU policy of heavily funding solar and wind renewables generation through feed-in tariffs is costly for European consumers and is benefiting China. It would have been much better from economic and strategic perspectives, to invest more in R&D in order to create a high-tech solar industry in Europe.

In 2012, the U.S. followed by the EU[23] imposed import tariffs against Chinese solar products. However, using a loophole in the final ruling, Chinese manufacturers circumvented these tariffs and continued their development.

Again in January 2018, President Trump announced that solar modules and cells will face a tariff rate of 30% in the first year declining 5% in each of the three subsequent years. These new tariffs apply to all importing countries but are largely a response to cheap Chinese products and companies moving manufacturing operations outside the USA.

This decision has already triggered actions to relocate manufacturing: for example, in April 2018 SunPower, which manufactures its PV panels outside the U.S., announced the acquisition of SolarWorld Americas in order to relocate its cell manufacturing in the United States.

However, in the short term, the Trump administration's tariffs are expected to increase the cost of solar and hinder the pace of U.S. solar installations: in Q1 2018, total corporate funding fell to only US$2 billion, a 65% fall from Q4 2017.

Moreover, China's spectacular photovoltaic solar capacity growth is becoming very onerous for the country. Its solar development fund has a growing deficit that reached more than Yuan 100 billion (€13 billion) by the end of 2017. In addition, many PV installations are not connected to the grid. These factors pressured the Chinese government to announce in early June 2018, dramatic decreases in solar subsidies and a freeze on permits for new installations.

According to a 2018 BNEF study, a pessimistic scenario would have worldwide new installed solar capacity decrease by 3% in 2018 to 95 GW.

20 https://www.power-technology.com/features/featureovercapacity-and-the-challenges-of-going-100-renewable-5872868/

21 Alain Burtin, Vera Silva, "Technical and Economic Analysis of the European Electricity System with 60% RES". [online]. June 17, 2015. http://www.energypost.eu/wp-content/uploads/2015/06/EDF-study-for-download-on-EP.pdf

22 by end 2017

23 https://thediplomat.com/2018/02/chinas-solar-power-dominance-and-trumps-trade-tariffs/

Electricity storage

- ***There are different ways of accommodating an increasing share of renewables in the electricity system:***
  - Develop more interconnections in order to increase the overall electricity exchange zone and to average the different energy sources variabilities (wind, solar, for example)
  - Implement "time of use tariffs" to trigger increased customer demand response when cheap renewable electricity is available
  - Use hydroelectric dams that can generate less electricity during off-peak periods and quickly respond to high load demands
  - Dispatch "peakers" that are typically simple-cycle gas turbines able to start up and reach full load in as little as five minutes. However, they emit GHG
  - Use nuclear plants load following potential
- There are various storage technologies depending on the required storage time:
  - for very short periods (seconds, minutes) flywheels can be adapted
  - for short periods (minutes, hours) batteries are the best technology
  - for hours to days storage: compressed air is being studied
  - for days to months, pumped hydro storage is a very good solution.

  Unfortunately, in Europe there are few suitable sites left and these projects are not presently profitable[24]
  - Inter-seasonal, mega batteries such as in South Australia, with the largest worldwidebattery (worth US$50 million) or the California mega project[25]
- ***Triggered by electric vehicle development, battery technologies are progressing quickly.***
  This progress is also benefiting the large stationary batteries used for grids or small individual batteries used for self-consumption.
  - *Key criteria of battery choice*: performance (number of cycles, capacity, energy, yield), security, environmental impact, and system costs (battery plus electric inverter)
  - *Technologies:* lithium-ion is today the reference technology used in cell phones and e-vehicles. It is increasingly penetrating the stationary market for electrical systems. These batteries have high energy density, high yield and can accommodate a large number of cycles; however, they are inflammable.
    Solid state batteries that are safer (no fire risks) and have a much higher energy density[26] than lithium-ion batteries, have emerged as potential game changers for future battery chemistries. Leading car manufacturers are already adopting them for some of their models.
    Other new technologies such as Zn-Air, metal-Air, sodium-ion, new Red-ox systems, and nano-technologies are at different industrial development stages.
  - *Battery costs* have decreased quickly with an acceleration since 2016. These costs were divided by 5 in 10 years, decreasing nearly as quickly as PV cells. They should continue to decrease from around US$200/kWh in 2017 to below US$100/kWh in 2025-2035.
  - *Future battery* challenges are related to recycling, safety (even in extreme conditions), energy density increase and weight decrease (for mobility), increased number of possible cycles, quick charging (especially for e-vehicles), low CO_2 emissions during battery manufacturing, and further cost decreases (to US$80/kWh).
  - *Batteries' end of life:* three areas are being investigated: repurposing used electric vehicle batteries in grid-scale storage applications; remanufacturing individual modules or packs for reuse in new vehicles; and recycling materials in used cells and packs into new battery grade materials[27].
- ***Hydrogen produced by electrolysis is a mobility and storage long-term option but it is still expensive.***
  Hydrogen-fueled vehicles represent high investment but while the cost of fuel is higher than for Electric Vehicles (EVs) it is comparable to gas-fueled cars. Currently, power-to-gas[28] is not competitive as it produces gas at a cost of €50-100/MBTU, much higher than natural gas market prices (€6/MBTU in Europe and much less in the U.S.) and even higher than subsidized biogas (€30/MBTU in France).

24 As a consequence of the increased renewables share on the grids, the difference between peak and off-peak electricity prices has decreased
25 By mid 2018, Pacific Gas & Electric Co detailed plans for four storage projects totaling nearly 570 megawatts
26 Their energy density is twice lithium-ion batteries
27 https://www.nrc-cnrc.gc.ca/eng/publications/nrc_pubs/energy_storage/2016/summer_main_article2016.html
28 Power-to-gas is a technology that converts electrical power to a gas fuel.

- ***Critical metal resources: Lithium and cobalt are fundamental components of current lithium-ion batteries.***

  With the rapid growth in battery demand, their availability could become seriously critical[29]. In addition, both elements suffer from strong geographical concentration (65% of the world's cobalt comes from the Democratic Republic of Congo).

  Chinese battery suppliers are securing lithium and cobalt resources: in early 2018, Glencore Plc, the world's biggest producer of cobalt, agreed to sell around a third of its cobalt production over the next three years to Chinese battery recycler GEM. CATL, which specializes in batteries for electric vehicles, has acquired a majority interest in the North American Lithium mine at Quebec.

- ***Utilities' roles in the battery space could be:***
  - System designer and energy system manager. For example, EDF has installed at West Burton (a large coal-fired plant in the UK) a 49 MW battery providing enhanced frequency response to the National Grid[30].
  - Grid services providers as illustrated by AEP in the U.S.[31]
  - Investment in batteries: EDF decided to invest in 50GW of batteries by 2035.
    These batteries would increase security of supply and smooth the generation load curve

- ***Electric vehicles***
  - In 2017, EVs (battery-electric vehicles and plug-in hybrids) accounted for 1.1 million vehicles, representing 1.7% of new worldwide car sales, up from 1.1% in 2016[32]. EV sales[33] are forecast to climb to 1.6 million in 2018 and further upwards to an estimated 2 million in 2019[34].
    Many car manufacturers[35] have announced EV milestones and targets. If all these announcements were to come true, there will be about 25 million EVs sold by 2025 or 20% of all cars! As in other parts of the energy sector, China is a dominant player: in 2017 Chinese auto manufacturers produced 680,000 all-electric cars, buses and trucks – more than the rest of the world combined – and China's output is growing faster than the rest of the world (twice as fast as the U.S.)[36]. Despite rapid progress, the EV industry still needs to overcome major challenges related to battery technology (energy density and cost) and charging infrastructure.
  - Utilities and Oil and Gas companies have started investing heavily in establishing electric vehicle charging stations. In 2017, the French Utility Engie acquired the Dutch company EVBox, one

29 Analysis by researchers at the Helmholtz Institute Ulm (HIU) of the Karlsruhe Institute of Technology (KIT) https://www.kit.edu/kit/english/pi_2018_027_scenario-2050-lithium-and-cobalt-might-not-suffice.php

30 https://www.energy-storage.news/news/edfs-completed-49mw-battery-system-brings-nearly-all-efr-projects-over-the

31 https://www.elp.com/articles/2016/09/aep-texas-sees-battery-energy-storage-as-alternative-to-grid-upgrades.html

32 https://www.businessinsider.com.au/the-rapid-growth-in-global-electric-vehicle-sales-in-4-charts-2018-1

33 Frost & Sullivan's, Global Electric Vehicle Market Outlook 2018

34 https://www.forbes.com/sites/sarwantsingh/2018/04/03/global-electric-vehicle-market-looks-to-fire-on-all-motors-in-2018/#71e77ab02927

35 https://www.reportbuyer.com/product/4833514/global-electric-vehicle-market-outlook-2018.html

36 https://www.scmp.com/business/companies/article/2143646/chinas-ev-market-growing-twice-fast-us-heres-why

of the world's largest providers of charging solutions for electric vehicles with more than 40,000 charging stations in service. In 2017 Shell acquired The New Motion in the Netherlands, which owns a network of 30,000 charging stations; and in June 2018, BP announced the acquisition of Chargemaster, the UK's largest network of charging stations (6,500). Interaction between EVs and electricity operators is a major issue. On the one hand, their development will push electricity consumption up which is good news for Utilities, and idle EV batteries could improve electricity grid stability especially when the share of intermittent renewables is increasing. On the other hand, if EV charging is not mastered, specifically to avoid quick charging at certain times of day, their development would pose a big challenge for the DSOs[37], pushing them to significantly reinforce their grid for peak hours' consumption[38] which is very costly.

Nuclear is a carbon-free schedulable generation technology

- ***Large reactors between 1,000 and 1,600 MW are the present widespread technology.***
  - After significant delays, the first French-designed EPR[39] became operational in China in 2018; a very important milestone for this new third generation reactor. Years later than scheduled and with huge budget overruns, the Finnish EPR at Olkiluoto and the French one at Flamanville are due to come in service in 2019-2020. A further project involving two EPRs at Hinkley Point C (South-West England) is due for completion at the end of 2025. The Taishan reactor coming online answers many technical concerns, notably regarding safety. These technical assessments should be reinforced after the completion of Flamanville and Olkiluoto. This first EPR start-up marks a turning point for the French nuclear industry, which streamlined its organization at the end of 2017 following EDF's acquisition of Framatome (ex Areva NP), making EDF the clear leader in France's nuclear industry. The commissioning of Taishan is reassuring for the Hinkley Point C decision and could push India to finalize the acquisition of 6 EPRs for the Jaitapur site[40]. However, the commercial battle for French technology is not won.
  - Several years later than planned and with a large cost overrun, the first AP1000 reactor at the Sanmen plant, developed by *Westinghouse*, also began loading fuel during spring 2018. However, Westinghouse has been in chapter 11 bankruptcy protection since 2017 and plunged its owner Toshiba into a financial crisis. Westinghouse is in the process of being sold to Brookfield, a Canadian asset manager, after a US$4.6 billion deal with Toshiba in January 2018.
  - *China* is chasing an aggressive target to increase its nuclear capacity to 58 GW by 2020 from 35.8 GW at the end of 2017 or 4% of this big nation's power generation. China has become largely self-sufficient in reactor design and construction but is making full use of western technology while adapting and improving it. China's policy is to "go global" with exporting nuclear technology. Under a Strategic Investment Agreement signed by EDF and CGN[41] in October 2015, CGN agreed to take a 33.5% stake in the Hinkley Point C project, and to participate in the joint development of new UK nuclear power plants at Sizewell and Bradwell. The Hinkley Point C and Sizewell C plants will be based on France's EPR reactor technology, while the new plant at Bradwell will feature CGN's third generation Hualong One design. Thanks to its experience in operating nuclear reactors and its cheap nuclear supply chain, China is likely to become a big player in the international nuclear sector.
  - Rosatom from *Russia* is today probably the most successful company building new reactors. In addition to operating 35 reactors in Russia, Rosatom is leading the new nuclear construction market with the highest number of simultaneously implemented nuclear reactor construction projects (6 in Russia and 35 abroad). Nuclear experts recognize the enhanced safety features of its generation 3 VVER-1200 currently being constructed worldwide. In addition, Rosatom is able to offer a full range of services from operations support and

37 DSO: Distribution System Operators
38 WEMO 2017 edition (editorial)
39 EPR: Evolutionary Power Reactor
40 March 2018 agreement between EDF and NPCIL (Nuclear Power Corporation of India Limited)
41 CGN: China General Nuclear Power Corporation

maintenance to financing new projects.

- ***Small reactors:*** Compared to large reactors, small reactors are easier to finance, more modular, and more adapted to grids in developing countries and to multipurpose use.
  - *Floating reactors:* capitalizing on its experience with nuclear-powered icebreakers, in May 2018 Russia shipped its first two 35 MW floating reactors to a Far East destination (Pevek) where they will be connected to the grid in 2019. These reactors will generate heat and electricity. On the one hand, they can deliver electricity anywhere along a coast and connect to the local grid. On the other hand, there are specific safety concerns such as cyclones and tsunamis. If operations go well, this type of reactor could be developed for specific usages such as supplying electricity for oil platforms or seawater desalination plants.
  - *Small Modular Reactors (SMRs):* For many years, companies in the nuclear industry have been testing the SMR concept. Probably the most advanced project in the West is the NuScale Power Module (NPM) developed by NuScale from the U.S.. The NPM builds on nuclear technology with a focus on integration and simplification. Each module can produce 50 MW of electricity. A power plant can house up to 12 of these modules for a total output of 600 MW. The NPM design is making steady progress and NRC[42] approval is scheduled for mid-2020. Russia, China, South Korea, France, the UK and other European countries also have SMR projects.
  As already pointed out, these small reactors have many benefits; the main concern is the lack of scale that leads to relatively larger investment and higher electricity costs. This is why SMR manufacturers are developing integrated simplified designs and maximizing the equipment that can be manufactured in plants in order to lower costs.
  The success of this industry policy will be tested a few years from now.

China's growing importance in energy

In the global energy market, China is positioned in a large number of areas and geographies. China is a:

- ***Large consumer*** with growing needs and the biggest emitter of GHG, well above the USA. These emissions together with other industrial pollution problems have created huge health issues for the population and the Chinese government has launched a long-term program to develop carbon-free sources of electricity (nuclear, solar PV and wind power) in addition to building hydropower mega projects such as the Three Gorges Dam.
- ***Significant energy equipment provider:*** China has a long-term policy of developing equipment first for its own use and then selling it on the international market China is by far the biggest worldwide consumer of coal and the biggest developer of coal-fired power plants. Chinese companies are building more than 700 new coal plants at home and worldwide, with around half of the new coal generation expected to go on line in the next decade[43].
  Having adapted Western technologies such as French EPR in nuclear, solar panels or wind turbines to its own market and capabilities, China is now exporting related equipment.
  In addition to the partnership agreement signed with EDF in 2015, in July 2018 CGN expressed its interest in buying a stake in the UK's EDF Energy nuclear plants.
  Cheap solar panels are flooding all markets provoking protectionism reactions from the EU and the U.S. administration. Moreover, in June 2018, the Chinese government decided to slow down domestic solar capacity growth, pushing more Chinese equipment onto international markets.
  China is also exporting wind turbines and investing massively in electricity storage development with the aim of becoming a dominant player, as it already is in EV manufacturing.
- ***Dominant player in critical resources:*** China also has a dominant share (95%) in worldwide production of rare earths[44] and reserves (30%), as well as a big market share in rare metals production[45]. These mineral resources are crucial for successful energy transition and digital revolutions as they are key elements for magnets, EVs, electric batteries, wind turbines, nuclear reactors, smartphones, computers, consumer electronics, and so on. China is thus in a strategic position regarding energy transition and is influencing the price of those commodities. Additionally, it is implementing an acquisition policy outside China. For example, in 2017 HP Mine Operations LLC (a Chinese-led consortium) acquired Mountain Pass, the sole U.S. rare earth mine in California. This is still being fought over by

42 NRC: Nuclear Regulatory Commission
43 According to Urgewald a Berlin based environmental group.
44 Rare earth are 17 elements used in sectors like renewable energy, telecommunication and defense
45 Guillaume Pitron, La guerre des Métaix, 2018

politicians and Non-Governmental Organization (NGOs.)
The extraction and refining of these minerals is very polluting and recycling them is difficult. Thus, Western countries have left these operations to Chinese companies, reinforcing the country's strategic position.
Having acknowledged China's dominant position, the West, and in particular the U.S., Japan and the EU, could implement long-term security of supply policies by looking for new types of reserves (in the oceans for example) and by encouraging innovation to replace rare minerals in critical equipment with more common resources.

- ***Big investor in energy companies:*** For more than a decade China has deployed an aggressive acquisition policy (notably in oil reserves) first in Africa, then in South America and Asia. In Europe it is now acquiring or taking a stake in energy-related companies: on a €4.75 billion acquisition spree, the State Grid of China Corporation (SGCC, the second largest grid company in China) bought stakes in the grids of Greece, Italy, Portugal and Spain. From southern Europe SGCC is moving to Germany where, in February 2018, it offered to buy a 20% stake in the regional grid company 50 Hertz.
In Portugal, CTG (China Three Gorges) which already has a 23% stake in EDP (Energias de Portugal) offered to increase its share to more than 50%.
The huge Silk Road US$900 billion Chinese investment project is not only targeting road and rail infrastructures but also electricity and gas ones. It is also a commercial tool for China to establish a leading position in the European energy market.

The digital revolution is accelerating

General considerations

In looking to the future, one needs to be humble in regard to earlier, unanticipated rapid technology evolution and remember that the Web was launched in 1990, Google was created in 1998, and the iPhone came on the market in 2007. The digital revolution is accelerating thanks to technology progress and consequent economic gains. On the one hand, individuals are quickly adopting these new digital enabled services but on the other hand, their fears relating to job losses or transformation are slowing down digital deployment. Cybersecurity is and will remain a big concern.

- ***Technology:***
  - Web access will become a commodity for all individuals (in 2016 around 50% of the world population had internet access) and corporations worldwide.
  - The Internet of Things (IoT) will continue to evolve. There were 500 million connected objects in 2005, more than 8 billion in 2017 and it's likely there will be 100 times more in 2030[46]. The two limitations are probably cybersecurity constraints and finite resources (such as human attention).
  - Visual interaction with a screen will be progressively replaced by smart interaction using voice. For example, Amazon's Alexa has sold more than 5 billion units since its 2014 launch.
  - Artificial Idiot, or weak Artificial Intelligence, able to reproduce learned human strategies and to converse on simple things in natural language, will be implemented in an increasing number of processes.
  - Auto-certified transactions such as block chain will be progressively adopted. As an example, E.ON and Enel exchanged the first electricity capacities via block chain in October 2017. In the gas market, a transaction was carried out using the same system between Wien Energie and Neas for a "day-ahead" contract in Germany.
- ***Economic gains:***
Digital adoption has huge potential to decrease costs in the industry and service sectors. These productivity gains are limited by slow adoption in organizations changes, in streamlining internal processes and in recruiting or developing the required skills. However, digital-related usage is increasing quickly, creating new revenue that could progressively become a company's main revenue streams.
- ***Human factor:***
Individuals act differently in their private life and at work:
  - Private life: all over the world, numerous start-ups are developing thousands of new digitally enabled appliances and services from simple things such as connected keys to collaborative services such as houses, offices or car-sharing.
  - In the working space, digital transformation will impact on nearly all jobs in all sectors; it's estimated that around 400 million jobs will be affected worldwide. While it is unclear whether there will be net job losses, some jobs will disappear or be fundamentally transformed, notably those associated with manual and repetitive tasks. Will organizations be able to reskill

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those employees, whose jobs are fated to be replaced by robots or chat bots, to other functions?

- ***Regulations:*** protecting personal privacy is a key request from digital players, hence the new European regulation on personal data protection (GDPR[47]). In 2018, nearly all firms had implemented internal work streams (on processes and IT systems) in order to meet the May 2018 GDPR implementation deadline.

Utilities' digital transformation

All segments of the value chain are impacted by digital transformation:

- ***Client relationships:*** utilities as telecom operators or financial services providers have numerous clients. Digital operations will enable significant and quick savings. A lot of progress has already been made thanks to digitally enabled interaction to improve the customer experience. However, this transformation is slowed down by human factors. For example, replacing certain call center staff with chat bots will threaten low-skilled jobs. This means that Utilities have in parallel to launch training programs to enable these workers to do more qualified roles: for example, from handling inbound client calls to outbound calls that are more complex.
- ***Operations/Generation:*** many operational processes in maintenance, inspections or quality control can be digitized using, for example, camera images and applying artificial intelligence (AI) to the collected data. In nuclear generation, also, digital technology usage is growing: in June 2018, EDF, Dassault Systèmes and Capgemini signed a long-term partnership agreement for the digital transformation of EDF's nuclear engineering and its ecosystem. It aims to support EDF in the digitalization of its plant engineering projects with a view to strengthening plant performance and overall competitiveness of nuclear power.
- ***Operations/Networks and Smart grids:*** grids are strongly impacted by the increased share of intermittent renewables. Their irregularity can be mitigated by applying AI to historical meteorological data enabling, for example, more accurate forecasting of wind power. Grid operators also benefit from digitization, for example in predictive maintenance or field services.
- ***Services:*** in Western countries, the home monitoring service market is expanding with a growing share of interactive services (in the U.S. it reached 44% in 2017[48]). Utilities are trying to capture parts of this market, but Amazon and Google are also increasing their presence by investing billions of dollars in acquisitions: for example, Google has acquired Nest, and Amazon has acquired the video doorbell company Ring. It is in these new digital related service markets that GAFAM are becoming Utilities' competitors.
- ***Business model transformation:*** in the Utilities sector as in many others, this area is less mature, except for medium size Utilities such as Eneco (in the Netherlands), which has transformed its business model to become a service provider. Historical players, like Centrica, Enel, Engie, E.ON or EDF are also focusing on new service-based business models[49].
- ***Digitization progression*** started with the customer experience and is now focusing on digital operations and new business models.
  The slow pace of change, lack of specific capabilities, leadership weakness, and scale-up challenges are the main obstacles Utilities have to overcome in order to reap all the benefits of digital.

Cybersecurity

According to Capgemini's March 18 The Automation Advantage report, 46% of firms are refraining from innovation (such as moving to the cloud and automating IT infrastructure) due to concern about cybersecurity.

While cyberattacks impact on all sectors, certain strategic sectors such as energy are particularly targeted.

These risks are increased by:

- SCADA[50] systems, which have a complex architecture and are difficult to secure. They are notably used in grid management to facilitate renewables intermittency and generation decentralization
- IoT, which enables smart homes connectivity, energy efficiency increases, and data capture, is not yet secure
- Cloud services increase usage, and open data could make the services that they support vulnerable
- Cyberattacks have already impacted on all segments of the Utilities value chain: generation with the cyber control of a dam near New York in 2013; transmission with the Ukrainian grid attacks in 2015 and 2016; and customer relations with smart

47 GDPR: General Data Protection Regulation
48 Paks Associates
49 Utilities' New Business Models: As-a-Service Breaking Through. IDC white paper, July 2018
50 SCADA: Supervisory Control and Data Acquisition

meter data hacking in 2014.
New regulations in some countries, such as France, have been adopted in order to protect assets in sectors of vital importance. For example, electricity operators have to implement total segregation between Advanced Metering Infrastructure and the SCADA grid management system.

This regulation does not prevent Utilities deploying their digital transformation but it increases the projects' duration and costs.

Conclusion

In the last few years, the worldwide economy has been growing steadily pushing up energy consumption. This growth in demand combined with geopolitical considerations has pushed oil prices up to US$70-80/bl.

Although oil prices are not forecast to reach 2008 heights (US$150/bl), their present level could slow down the global economy.
Despite progress towards greener energy sources, growth in energy demand is threatening the fragile Paris 2015 Climate Accord. Thus, limiting the global temperature increase to no more than 2% by 2050 now seems extremely ambitious.

Progress in energy transition and the digital revolution is facing many different challenges such as cybercrime or the concentration of rare earth and metals production in China.

Moreover, the present commercial war between the U.S. and China is having a strong influence on the energy sector and could endanger current progress in energy transition.

I hope you enjoy reading this second edition of the World Energy Markets Observatory.

Colette Lewiner

Senior Energy Adviser to Capgemini Chairman
Paris, September, 14, 2018

North America

WEMO 2018 North America Editorial

Perry Stoneman & Randall Cozzens

Uncertainty has led to mixed outcomes in action on climate change despite multifaceted initiatives by states, along with declining electricity demand and a generation shift towards clean energy.

At the federal level, 2017 marked yet another year of uncertainty, due to the withdrawal from climate change action, especially the US Clean Power Plan. However, state-level initiatives continued to witness an acceleration, aimed at driving future investment in clean energy, energy efficiency, and clean transportation.

In 2017 US$57 billion was invested in clean energy predominantly in wind and solar. In addition to utility investments many corporations, such as Apple and Google who have been vocal in their support for the Clean Power Plan, have declared action on climate control to be a sound business move as well as the moral and environmental imperative, and continue to pursue economic benefits in clean energy. Overall, if the US is on track to meet the Copenhagen accord target, it looks likely to fall significantly short of the Paris accord targets, given the current pace of decarbonization.

While emissions in the US continued to fall, the pace of decline slowed from an annual average of 1.3% between 2005 and 2016 to under 1% in 2017. The transition in consumption trends towards less carbon-intensive fuels, along with declining electricity demand, has helped to lower the emissions level since 2005. However, the rise in energy-related CO_2 emissions in other sectors, like transport, buildings and industrial, offset half of these electricity gains, primarily due to the absence of abatement opportunities.

Likewise, a report from the Auditor General of Canada indicates that most provinces are not on track to meet emission-reduction targets, despite wide-ranging initiatives. Only five of 12 provinces and territories have targets for reducing GHG emissions by 2020, and only two are on track to hit those goals with domestic reductions. Meeting Canada's 2030 target will require substantial effort and actions beyond those currently planned or in place.

Energy productivity improved by 2.5% in 2017 contributing to the trend that energy growth is no longer linked to GDP growth. Energy efficiency, and investments to boost the efficiency of natural gas usage, have clearly contributed to this trend. Additionally, alternative energy technologies, which became cost-competitive with conventional generation several years ago, are in some instances approaching a levelized cost of electricity (LCOE) that is at or below the marginal cost of certain conventional generation technologies. Wind LCOE in the US$30-60 range continues the trend of cost competitiveness, followed by solar PV at US$43-53; combined-cycle gas, with a LCOE of US$42-78, is in close competition. This trend is primarily due to falling costs in system components (e.g. panels, inverters, racking, turbines, etc.) and dramatic improvements in efficiency, among other factors. Costs continued to fall in the energy storage market and revenue streams continued to evolve. Cost improvements for lithium-ion modules (particularly lithium-ion deliveries scheduled for post-2019 period) continue to be driven by cost-effective batteries, better integration and longer life products. Additionally, with this evolution, several forms of potential revenue streams have emerged in selected US markets, driven by state/ISO subsidies and storage-related product design development. Tesla executives have predicted unparalleled growth levels in 2019 of 300-400% for energy storage businesses.

Renewable generation soared an estimated 14.1% year-over-year in 2017, the highest ever one-year surge, with output increasing by approximately 90 TWh. Renewables and natural gas will comprise most of the capacity additions through 2050, and 2018 is expected to be a near-record year with an estimated 12.5 GW of coal power decommissioning, second only to 2015's high of 15 GW. The projected mix of electricity generation is likely to be most impacted by differences in fuel prices resulting in significant substitution by 2050. Despite sustained and growing cost-competitiveness in certain alternative energy technologies, diverse generation fleets are required to meet baseload generation needs for the foreseeable future, driven primarily by policy uncertainty for the renewables industry, with tax reform, solar tariffs, and concerns relating to grid reliability and resilience. Asset finance for solar witnessed a slump for a consecutive year while remaining strong for wind.

Average retail electricity prices witnessed a modest rise in 2017, offset by lower average usage of electricity and driven by milder weather.

US retail electricity sales fell by 80 billion kWh in 2017, the largest drop since the recession in 2009. Aside from factors such as electricity prices, energy efficiency, and macroeconomic cycles playing a role in the use of electricity in each sector, most of the year-over-year changes in sales were due weather. Consumer spending on electricity fell to of 1.3% of total consumption spending, down from 1.4% in 2016. The share of household expenses on energy costs also drifted near an all-time low, driven primarily by sustained improvements in energy efficiency and the availability of cheaper energy sources.

On average, electricity prices are trending upwards, with notable variations across states. The Pacific states of Alaska and Hawaii continue to have the highest residential electricity prices primarily due to higher fuel cost. According to the Energy Information Administration (EIA), natural gas prices are likely to have the highest impact on electricity price through 2050.

According to the Edison Electric Institute, investor-owned utilities and independent transmission developers spent an estimated US$22.9 billion on electricity transmission in 2017, a 10% rise year-over-year. Driving factors included the need to replace and upgrade aging power lines, resiliency planning in response to potential threats (both natural and those caused by people), integration of renewable resources, and congestion reduction.

Revenue across all four of the industry's primary business segments, i.e., regulated electric, competitive energy, natural gas distribution and natural gas pipeline, were driven primarily by cost control, new electricity rates, and focus on customer base growth.

The natural gas distribution segment experienced the largest revenue growth in both dollar and percentage terms as several natural gas-related acquisitions that closed during 2016 contributed a full year of revenue to 2017.

Electricity suppliers have seen limited growth due to flat electricity demand driven by efficiency initiatives. Replacing old equipment to meet efficiency standards had a drag on earnings, offset by new offerings such as battery storage and smartphone-based thermostat apps.

Customer-centricity and innovative offerings have been among the key drivers for Canadian utilities, which have focused on seizing growth opportunities while stepping up wholesale operations in export markets.

- Hydro-Québec intends to double its revenue by 2030, with a view to increasing its net income, focusing on three main growth avenues: export markets, investing outside Québec, and commercializing innovations
- BC Hydro focused on its demand-side management portfolio in 2017 and achieved 733 GWh of new incremental electricity savings.

Industry consolidation activity slowed in 2017 from 2016's fast pace, which was to be expected as utilities navigated and consolidated the 21 deals announced from 2013 through 2016. Deal action in 2017 among regulated utilities included Sempra's announced acquisition of Oncor, Canadian utility Hydro One's bid for Avista, and Dominion's offer to buy SCANA.

After a gap of almost 30 years, the corporate income tax rate in the US has been reduced to 21% from 35%. The comprehensive legislation contains significant changes in both individual and business taxation but exempts regulated utilities from key provisions limiting interest deductibility and allowing immediate tax breaks for capital expenditure.

2017 was a year of significant transformation and accelerated disruption, with utilities reacting more aggressively to technological advances. While uncertainty remains, energy and utilities companies must address two seemingly contradictory requirements: the need to innovate and the need to economize.

The growth of renewable energy, innovations in battery storage, growth of electric vehicles, and interactive consumers continue to drive utility transformation. Sustained transformation in electricity generation is being driven by environmental considerations, technological advancements and cost, leading utilities to change their fuel mix and improve efficiency. Grid transformation is becoming an imperative. Although distributed generation currently represents only about 1% of total generation, it is expected that over the next decade distributed generation will account for a much greater market share.

Traditional business models in the utilities sector have been coming under pressure, primarily due to a convergence of factors including technological changes, falling costs of distributed generation and increased competition both within the sector and from new entrants. Market developments behind the meter, including renewable energy technology consumerization, the entry of the big five (Google, Apple, Facebook, Amazon, Microsoft) into in the smart home are tempting retail customers to choose new alternative energy solutions. Although an argument can be made as to whether the risk to utilities has been exaggerated, US utilities have been actively exploring ways to retain customers based on value creation in order to avoid the ever-increasing risks.

The rise of prosumers, coupled with ever-present risks from disruptive entrants, has triggered the adoption of a new energy-as-a-service model. Almost four out of 10 utilities believe that within the next three to four years, new products and services will represent 5-9% of total revenue. The most significant impact on revenue is expected to come from electric vehicle (EV) services, generation and storage by householders, and microgrid-as-a-service. However, energy-as-a-service and comfort-as-a-service will likely be the top margin contributors. New technologies for energy storage, like Alevo, Acquion Energy, and Tesla, are changing expectations for residential and utility-scale storage. When tied renewable power generation (e.g. wind and solar), battery at scale could impact the revenue of existing utilities by between US$60-100 billion by 2025. The opposite holds true that utilities can also capitalize on the revenue opportunity associated with microgrid-as-a-service and generation and storage by householders.

North America's installed base of smart home systems reached 31.2 million by the end of 2016, a surge of 58%, with an estimated 5.4 million multifunction or whole-home systems and 25.8 million point solutions, designed for one specific function. An emerging business model at the forefront of this paradigm shift, expected to grow over the next two years, is generation and storage at home (Beroe Inc. 2018).

The fusion of smart mobility and the digital edge are helping utilities remain relevant in today's connected energy economy. Monetization of customer-generated power and excess battery capacity, along with data valorization and monetization, creates a path to avoiding disintermediation. According to an IDC study, the emerging business models of EV services/infrastructure and microgrid-as-a-service currently rank first and second respectively in terms of potential for revenue growth potential.

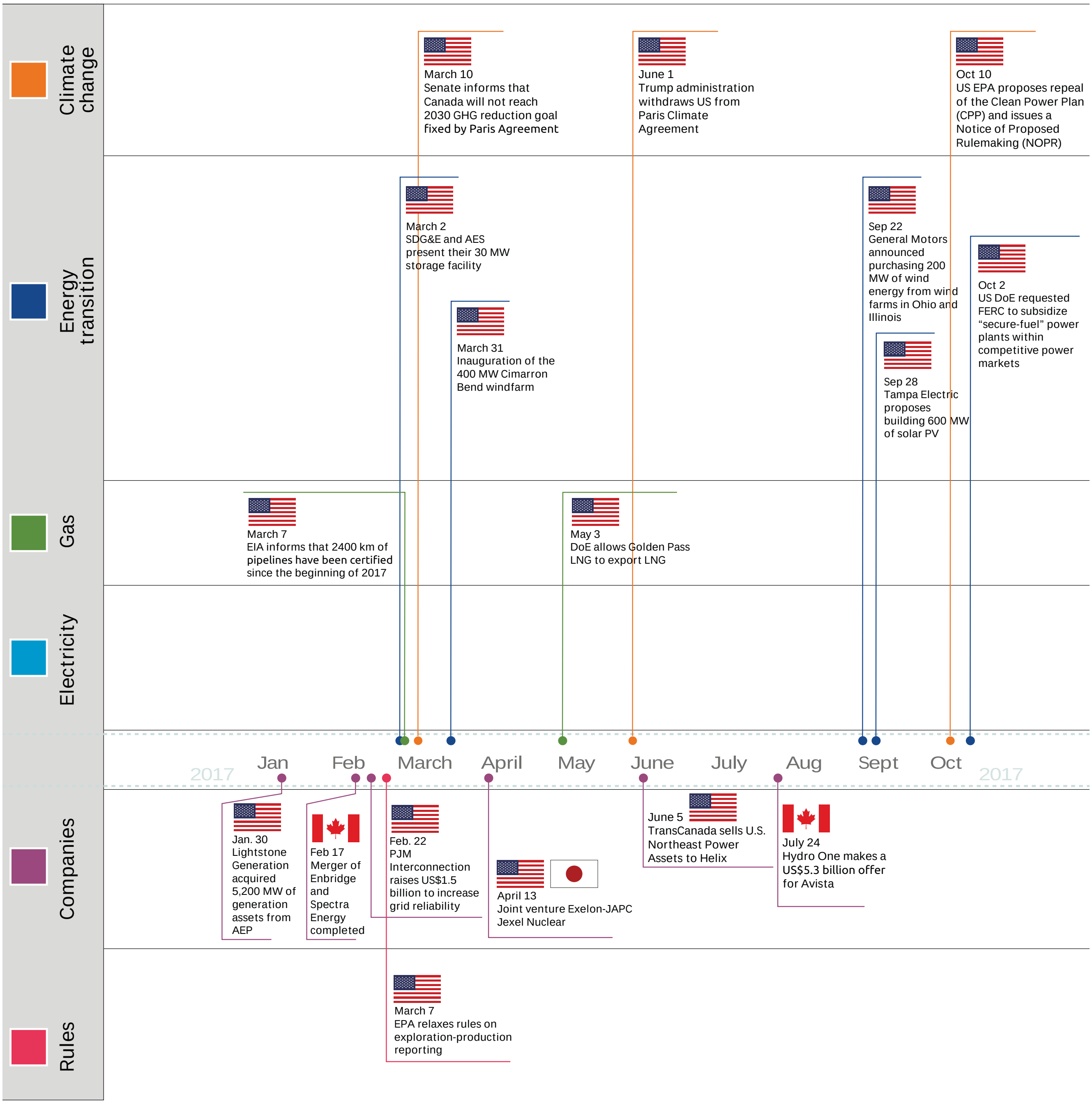
Perry Stoneman

EVP, Global Head of Energy & Utilities

Randall Cozzens

EVP, NA Sector Head of Energy & Utilities

Major energy events (2017 and H1 2018)



2017 Nov Dec Jan 2018 Feb March April May June July 2018

Dec 18
EPA solicits comments on possible successor to CPP (ANOPR)

Dec 22
Congress enacted the Tax Cuts and Jobs Act

Jan 24
President Donald Trump instituted a 30% tariff on imported crystalline silicon solar modules and cells

Jan 31
Formation of the Carbon Costs Coalition announced by 9 states

Feb
Congress' Bipartisan Budget Act, impacted a range of energy incentives

Mar 13
Sempra completes Oncor takeover for US$18.8 billion

Mar 27
Canadian Auditors-General indicates most provinces not on track to meet emission-reduction targets

Apr 26
Deadline for comments on CPP repeal NOPR

May 7
British Columbia unveiled Bill 34, the Greenhouse Gas Reduction Targets Amendment Act, 2018

May 31
The New York ISO projects a 0.14%-per-year fall in electricity demand from the grid of over the next decade

Jul 31
SCANA shareholders approve sale to Dominion Energy

1-Climate Challenges & Regulatory Policies

The US is on track to meet the Copenhagen goals but is significantly behind the Paris targets

- Electricity demand fell in absolute terms, and coal continued to lose ground to alternative energy.
- As a result of declining electricity demand and the generation shift towards less carbon-intensive fuels, power sector emissions fell by roughly the same amount in 2017 as the 2005-2016 annual average, though less than in 2016 and 2015 specifically.
- However, the rise in energy-related CO_2 emissions in other sectors offset half the gains by electric power, primarily due to the absence of abatement opportunities.

2017 witnessed continued progress on carbon pricing initiatives at the regional level, and 2018 will be a critical year for implementation

- Many jurisdictions are incorporating phased approaches to plan for changes to the system design.
- The multi-state US Carbon Costs Coalition is focused on reducing carbon emissions, ensuring equity in policy proposals, developing market-based solutions, creating a resilient local economy and improving public health.
- Canada's Pan-Canadian Framework on Clean Growth and Climate Change sets national standards for carbon pricing but gives individual provinces considerable latitude in program design and revenue allocation.

As the US federal government retreats on climate change, US cities continue to accelerate climate action, aimed at fulfilling the Paris Accord targets

- The EPA has proposed repealing the Clean Power Plan on the grounds that ... it could only work with generation shifting, which would not be sufficient to enable compliance.
- Without an alternative to the Obama administration's climate policy, the EPA is more vulnerable to legal challenges, hence, the uncertainty that looms the climate stance is only slated to aggravate.

A report from the Auditor General of Canada indicates that most provinces are not on track to meet emission-reduction targets

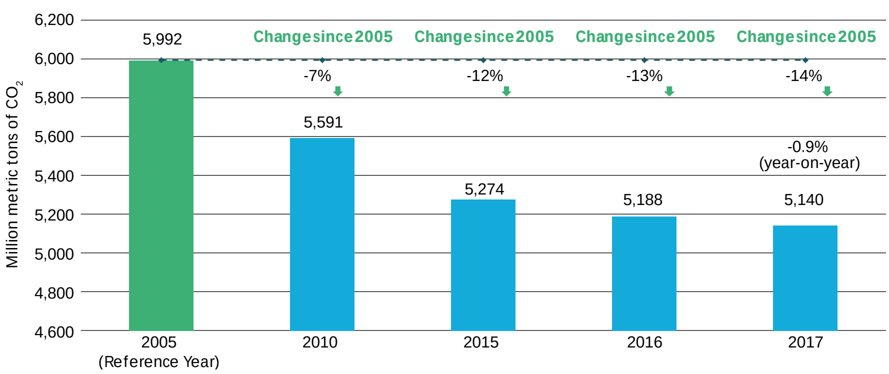
- Only five of 12 Canadian provinces and territories have targets for reducing GHG emissions by 2020, and only two are on track to hit those goals with domestic reductions.
- Meeting Canada's 2030 target will require substantial effort and actions beyond those currently planned or in place.

Energy-related emissions: While emissions in the US continued to fall, the pace of decline slowed from an annual average of 1.3% between 2005 and 2016 to under 1% in 2017

US energy-related CO_2 emissions declined by 14% from 2005 to 2017, driven primarily by growth in less carbon-intensive natural gas consumption

- From 2005 to 2017, coal and petroleum-related CO_2 emissions declined by 39% and 11% respectively; natural gas emissions, however, increased by 24%.
- The transition in consumption trends towards less carbon-intensive fuels has helped to lower emissions levels since 2005.

Figure 1.1. US - Energy-related CO_2 Emissions - Evolution since 2005 (million metric tons)



Source: US EIA, Monthly Energy Review (May 2018)

Despite this trend, the pace of decline has slowed

- Between 2005 and 2016, energy-related CO_2 emissions in the US fell by 13.4%, an average annual decline of 1.3% due to a combination of slower energy demand growth and fuel switching from coal to natural gas and renewables.
- Almost 80% of the reduction in energy-related CO_2 emissions in the US came from the electric power sector.
- Improved efficiency of buildings and appliances has helped flatten electricity demand, and coal has lost market share to lower-carbon natural gas and zero-carbon renewables.

The growth in decline was reportedly half the 2005-2016 average rate.

- Power sector emissions continued to decline, but emissions from the transport, buildings and industrial sectors all grew, offsetting half the decline in the power sector.

- For two years running, transportation emissions exceeded power generation emissions, amid a surge in vehicle usage in the US post recession, coupled with minimal progress on fuel economy.
- Growth in aviation emissions alone offset more than one third of the emissions decline from falling coal use in the electric power sector.
- A notable dissimilarity relative to previous years has been that both natural gas and coal generation declined year-on-year, displaced by growth in hydro, wind and solar generation.

The US still short of Paris Accord

- Assuming no significant changes in non-energy CO_2 or other GHG emissions, sustaining the recent decline in energy-related CO_2 emissions for the next three years should be sufficient to achieve the US Copenhagen Accord target of a 17% reduction below 2005 levels by 2020.
- However, the current pace of decarbonization will still leave the US considerably short of its Paris Agreement pledge of a 26-28% reduction from 2005 levels by 2025.
- A 1.7-2.0% average annual reduction in energy-related CO_2 emissions is required over the next eight years to meet that target, assuming no changes in other gasses.

With the continued relaxation of federal-level policies, especially the Clean Power Plan, state and city-level climate and clean energy policy developments become more critical

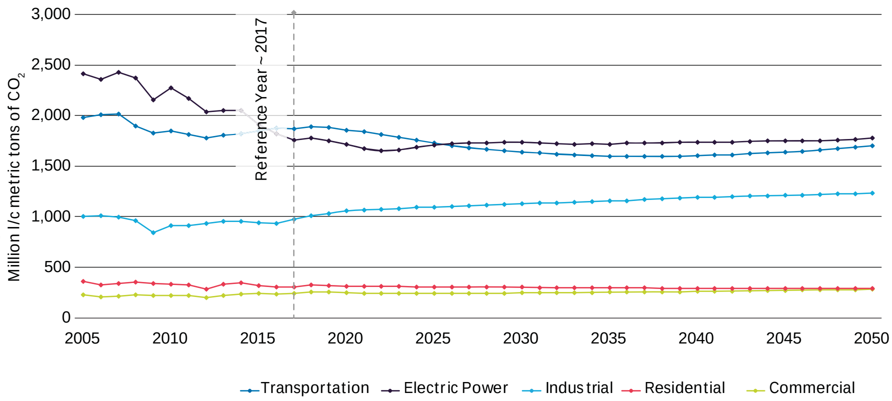
Energy-related Emissions - Projected US emissions mirror the trends in energy consumption, with natural gas and renewables driving the greatest impact

Over the forecast period till 2050, energy-related CO_2 emissions from the industrial sector exhibit the highest growth

Industrial sector

- Natural gas has the largest share of both energy and CO_2 emissions in the industrial sector throughout the projection period, driving a 0.6% annual emissions growth from 2017-2050, on both an absolute and a relative basis.
- The relatively low cost of natural gas leads to further increases in usage and emissions.

Figure 1.2. US - Energy-related CO_2 Emissions by Sector, 2005-2050 (million metric tons)



Source: US EIA Annual Energy Outlook, 2018

Electric power sector

- The projected CO_2 emissions to remain flat through 2050, resulting from favorable market conditions for natural gas and supportive policies for renewables compared with coal.

Commercial sector

- Projected emissions growth rate of 0.1% annually over 2017-2050 is likely to be driven by higher energy use in the sector, partially offset by efficiency gains.

Residential sector

- Efficiency drives, especially the focused approach towards energy storage, are likely to result in a 0.2% annual decline in emissions over the projection period.

Transportation sector

- Along with the residential sector, the transportation sector is also projected to witness a 0.2% annual decline in emissions over the projection period, driven primarily by a surge in fuel economy standards, tempering growth in motor gasoline consumption.

By 2046-2050, the annual domain-average transportation emissions of other GHGs are projected to decrease in continental US

- Decreases in gaseous emissions are mainly due to reduced emissions from on-road vehicles and non-road engines, which exhibit geographical and seasonal variations across the US.
- The on-road vehicle emissions dominate the emission changes.

Emissions from the electricity sector plummeted, allowing transportation to retain its place as the largest-emitting sector for the second year in a row.

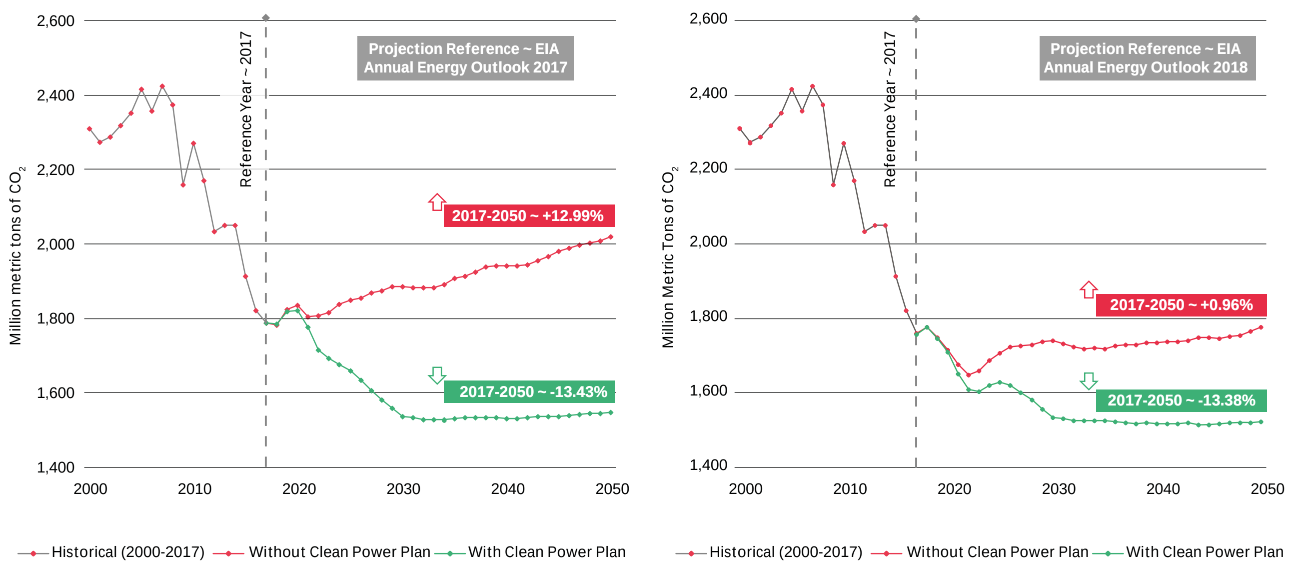
The power sector continued to drive the economy's decarbonization, on the back of declining load and greater renewable generation, rather than coal-to-gas switching, a primary driver of 2016's 5.8% downturn.

Energy-related Emissions - The US federal government continues to relax environmental policies; uncertainty looms around the Clean Power Plan (CPP)

According to the US Energy Information Administration (EIA)'s Annual Energy Outlook 2018, the projected effect of the CPP on CO_2 emissions is now less compared to the 2017 outlook, driven by lower projected levels for coal-fired generation even without the CPP

- The cumulative effect of increased coal plant retirements, lower natural gas prices, and lower electricity demand has caused a reduction in the projected CO_2 emissions from electric generators.
- In 2020, the projected electric power sector CO_2 emissions are 1.72 billion metric tons, which is 120 million metric tons (7%) lower than the projected level of CO_2 emissions in the 2017 outlook without the CPP.
- By 2030, most of the additional planned coal unit retirements are expected to have occurred, and in the absence of the CPP, projected CO_2 emissions are likely to stabilize at about 1.71 billion metric tons, which is 143 million metric tons (8%) below the 2017 outlook without the CPP for that year.
- Over the long term, higher renewables growth would result in electric power sector emissions growing at a slower rate, reaching 1.78 billion metric tons in 2050, which is 242 million metric tons (12%) below the level for that year without the CPP.

Figure 1.3. US - Electricity-related CO_2 Emissions - with or without Clean Power Plan (CPP), 2000-2050 (million metric tons)



Source: US EIA, Annual Energy Outlook 2018

On October 10, 2017, following a review as directed by President Trump's Energy Independence Executive Order, the US Environmental Protection Agency (EPA) proposed repealing the CPP, estimating up to US$33 billion dollars in avoided compliance costs by 2030

- The EPA has deemed the repeal necessary, since the CPP could only work with generation shifting, which would not be sufficient to permit compliance.
- The CPP had been embroiled in litigation (e.g. West Virginia vs. EPA) and the federal government has been facing a backlash from environmental groups, corporations and pro climate change state-level administrations, coupled with ethics controversies.
- Mirroring national opinion, state-level views on climate change and environmental policy are sharply divided.

As the US federal government retreats on climate change, US cities continue to accelerate climate action, aimed at fulfilling the Paris Accord targets

- Despite almost universal scientific consensus that climate change poses a growing threat, President Donald Trump's infrastructure plan makes no mention of the need to build in resilience to rising global temperatures.
- Instead, it actually seeks to weaken environmental reviews as a way of speeding up the infrastructure permit process, contradicting the priorities of many local leaders who view climate change as a growing concern.
- According to Boston University's 'Menino Survey of Mayors', conducted in the summer of 2017 on a representative sample of 115 US mayors, two-thirds agreed that cities should play a role in reducing the effects of climate change, even if it means making fiscal sacrifices.

Debate over the appropriacy of the repeal continues, as environmental organizations and some states challenge the sufficiency of analysis behind the repeal, while others await the outcome of both repeal and replacement activity

CPP repeal: Will the benefits outweigh the cost?

- The EPA's regulatory impact analysis indicates a divergence from the Obama administration's cost-benefit analyses supporting the CPP:
  - Narrowing social cost of carbon, limiting domestic benefits vs. the global benefits used by the Obama administration
  - Eliminating reliance on co-benefits (meaning benefits from deduction in non-carbon emissions, i.e. particulate matter and ozone) because of data gaps and uncertainty in benefits
  - Changing from a reduction in CPP cost to a "benefit".
- The EPA estimates that the adjustments add up to US$33 billion in costs to be avoided vs. the Obama administration's EPA calculations of US$8.4 billion.

Proposed CPP replacement - Will it suffice?

- The Trump administration has drafted a new proposal to regulate CO_2 emissions from coal-fired power plants, one that is far less stringent than the climate plan finalized in 2015 by the Obama administration:
  - The federal government has essentially accepted, for now, that it is legally obligated to address GHGs that cause global warming, even though President Trump has dismissed established climate science
  - However, the new proposal is likely to result in only small tweaks to the nation's energy system
  - The new proposal, according to industry attorneys familiar with the plan, would recommend regulating the emissions of individual coal plants, which would call for modest upgrades, such as improving efficiency or substituting fuel.
- Any successor rule that gives states too much discretion under a federal standard, is likely to face a backlash from CPP supporters.
- Industry observers believe that the EPA hopes to complete the 'repeal and replace' by the end of 2018, so that the current administration can fully litigate and defend them during this term of office.

The Obama-administration's CPP aimed to cut emissions from the nation's power plants to roughly 32% below 2005 levels by 2030. But as market forces have pushed hundreds of coal plants into retirement, and as wind and solar power have become cheaper, many states are now on track to exceed those initial targets even in the absence of federal regulation. As a result, many environmentalists contend that the original rules were too weak, not too aggressive.

Topic Box 1.1: Corporations outweigh CPP benefits over repeal, citing 'climate stance an upright business move along with a moral and environmental imperative

In April 2018, Apple Inc. pushed back against the EPA's proposal to repeal the CPP, arguing that scrapping the policy, which calls for cutting power plant pollution, would dull the US' competitive edge in the clean energy economy

In 2013, Apple hired former EPA administrator Lisa Jackson as VP of environment, policy, and social initiatives, indicating the significance it places on green initiatives. Since 2018, Apple has run on 100% green energy, all produced by the company itself. In addition, Apple has convinced 23 companies in its supply chain to sign a pledge to get to 100% renewable energy for the portion of their business relating to Apple products. Over the last six years, that has involved financing, building, or locating new renewable energy sources, such as solar and wind farms, near the company's facilities. Apple now has 25 operational renewable energy projects, with 15 more now in construction in 11 countries. Just eight years ago, only 16% of its facilities were powered by renewable energy. By 2015 that number had increased to 93%, then to 96% in 2016. The company has reduced GHG emissions (CO_2e) by 58% since 2011, preventing 2.2 million metric tons of CO_2e. Additionally, Apple has been consistent about keeping Renewable Energy Certificates (RECs) closely associated with actual energy. With over US$285 billion in cash reserves, the company continues to target even the smallest facilities, and the monumental achievement indicates its seriousness.

EPA's proposal to repeal the CPP

Opponents argued that the plan was an example of federal overreach:

- Apple's response cites the economic advantages of supporting clean energy, including that it provides corporate electricity buyers with a hedge against fuel price fluctuation, as the price of solar and wind does not change like the price of oil.
- It also notes that China is currently beating the US in clean energy investments.

Proposed alternative insufficient?

- According to Apple, regulating the grid's carbon emissions 'power plant by power plant' would not suffice.
- Apple cites its own experiences operating with 100% renewable energy in the US and the work of its subsidiary, Apple Energy LLC, which sells the excess electricity the company generates back to the grid.
  - "The electricity system is far too interconnected, so regulation should consider the dynamic and interconnected nature of how power is generated, sold and consumed." – Apple.

Google joined Apple in a growing chorus of corporations coming out in support of the CPP

- Google cites both environmental and economic fallout, should the policy be repealed.
  - "Wind and solar deployment, as well as the associated supply chains, have been among the fastest-growing sectors of the US economy in recent years, with job growth rates significantly exceeding the growth rate of the overall labor force." – Google.
- The company also notes its own personal interest in supporting the policy, citing its work to shift toward renewable energy, along with the CPP's potential to drive job growth.
  - "The Clean Power Plan can continue to drive innovation and job growth, while spurring the modernization of the American electricity system and reducing carbon dioxide emissions and helping to mitigate the threat of global climate change." – Google.

Apple and Google support the CPP, which provides a nationwide framework for regulating electricity generation!

Energy-related emissions: Disagreeing with the federal stance on climate action, US Climate Alliance state-level initiatives continue to drive a multifaceted approach to address GHG emissions

Independent analysis highlighted in the Alliance's 2017 Annual Report shows that Alliance states are not only outpacing non-Alliance states in reducing their emissions, they are also growing their economies at a faster pace

- Besides capping pollution from cars, trucks and power plants, states intend to change the way power is bought and sold, find new ways to pay for clean energy projects, eradicate the most dangerous GHGs, and soak up carbon already lingering in the atmosphere.

The Alliance's 2018 Strategy lays out four key focus areas:

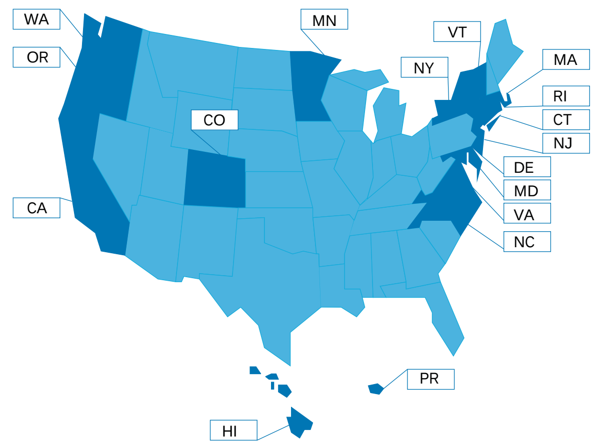
1. Accelerate the implementation of Alliance State climate priorities and ambitions
2. Strengthen business opportunities and job creation in the low-carbon economy
3. Scale up climate action domestically and internationally
4. Communicate climate action by the Alliance and others, both domestically and abroad, to demonstrate and inspire continued leadership.

Slate of new cross-cutting initiatives

- GHG Inventories And Projections
  - Cooperation to improve GHG inventories and projections in order to strengthen policymaking and track and report progress towards climate targets.
- Climate clearinghouse
  - Facilitating data-driven coordination, building a climate clearinghouse – an online platform that aggregates state-specific climate tools, maps, data, and information for use by policymakers and the public.
- International engagement
  - Working across borders to share best practices and further drive down emissions, including regional initiatives such as the North America Climate Leadership Dialogue.

Figure 1.4. US - Climate Stance Update - 2017 (US Climate Alliance)

US Climate Alliance: Subnational Coalition (not legally binding)
A bipartisan coalition of 17 governors committed to reducing GHG emissions consistent with the goals of the Paris Agreement and meeting or exceeding the targets of the federal Clean Power Plan



Target
~26-28% reduction in GHG emissions below 2005 levels by 2025
To accelerate climate action in 2018

Members	Joined
California	01/06/17
New York	01/06/17
Washington	01/06/17
Connecticut	02/06/17
Rhode Island	02/06/17
Massachusetts	02/06/17
Vermont	02/06/17
Oregon	02/06/17
Hawaii	02/06/17
Virginia	05/06/17
Minnesota	05/06/17
Delaware	05/06/17
Puerto Rico	05/06/17
Colorado	11/06/17
North Carolina	02/09/17
Maryland	10/01/18
New Jersey	21/02/18

Represents

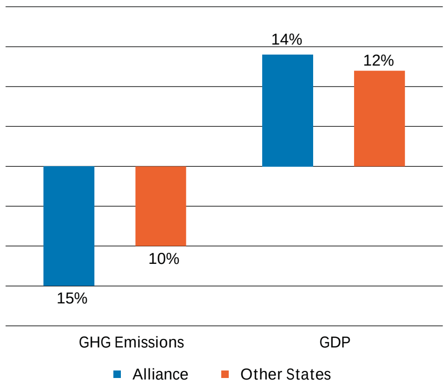
$9.0 trillion in GDP

~40% of US Population

1.3 million Clean Energy Jobs

Alliance states reduced emissions by 15% between 2005 and 2015, compared to 10% for other states, while the economies grew faster than the rest of the country

Change in net GHG Emissions and Economic Output, 2005 to 2015



Source: US Climate Alliance

The Alliance is demonstrating that climate leadership and economic growth go hand-in-hand

- Climate and clean energy policies in Alliance states have attracted billions of dollars of new investment and helped create more than 1.3 million clean energy jobs, nearly half the US total.
- Not only are states taking climate change seriously, they understand that it is a complex issue that requires a multifaceted response.

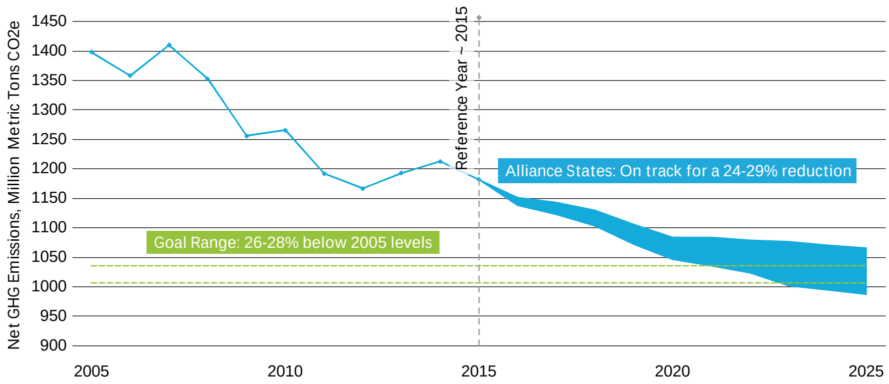
Energy-related emissions: US Alliance states continue to strengthen stance with holistic initiatives

The policies adopted, coupled with the initiatives planned, will continue to attract new jobs and investment in the years ahead in clean energy, energy efficiency and clean transportation while simultaneously driving down GHG emissions

Target the most potent of GHGs

- Plan to draw down the use of hydro fluorocarbons as well as other highly potent GHGs, like methane, which is known to leak from natural gas drilling sites, as well as farms and landfills.
  - California is already leading on hydro fluorocarbons and Colorado on methane, providing a model for other states.

Figure 1.5. US - US Climate Alliance Forecast - Net GHG Emissions, 2005-2025 (million metric tons)



Source: US Climate Alliance 2017

Implement appliance efficiency standards

- Build on the momentum of energy efficiency by issuing new efficiency standards for consumer products not already covered by federal regulations.
  - States are aiming to issue a uniform set of standards to make it easier for businesses to comply.

Develop green banks for clean energy financing

- In order to ramp up production of clean energy, and finance new wind and solar plants, develop a green bank that might fund a small, risky project that will later attract the attention of a commercial investor.
  - Alliance is working to develop new green banks linked to the New York Green Bank, raising more than US$1 billion to be invested in projects in other states.

Modernize power grids

- Develop a playbook to guide regulators and utilities on how to integrate renewables into the power grid.

Make solar power cheaper

- Simplify the permit process, countering the Trump administration's recently imposed tariffs on imported solar cells.

Clean up the transportation sector

- New or expanded tax credits for low-emissions vehicles and more charging stations.

Build resilient infrastructure

- Plan infrastructure projects, taking into account future risks from climate change, and use low-carbon materials.

Will the policies and initiatives be sufficient to achieve the goal of meeting the share of the US emission reduction targets under the Paris Agreement?

- According to Rhodium Group's multifaceted energy-economic model, the Alliance states will continue to lead the nation in reducing GHG emissions and are set to meet their share of the US emissions reduction target.
- Under current policies, Alliance states are projected to achieve a combined 24-29% reduction below 2005 levels by 2025.
- The Alliance is squarely on track, irrespective of federal inaction, while continuing to grow the economies and drive job creation.

Energy-related Emissions - Despite wide-ranging initiatives, Canada is likely to miss its Paris Agreement (NDC) target

A report from the Auditor General of Canada indicates that most provinces are not on track to meet emissions-reduction targets

Only five of 12 provinces and territories have targets for reducing GHG emissions by 2020, and only two are on track to hit those goals with domestic reductions

- New Brunswick and Nova Scotia have climate targets for 2020 that they are likely to achieve through domestic action, while Ontario is relying on a cap-and-trade system that includes emissions reductions from outside the province.
- Besides imposing a federal carbon tax, the federal and provincial governments are also pursuing a host of other policies, including the phase-out of coal-fired electricity; efforts to encourage energy efficiency and fuel switching in buildings, and policies aimed at reducing reliance on gasoline and diesel in transportation.

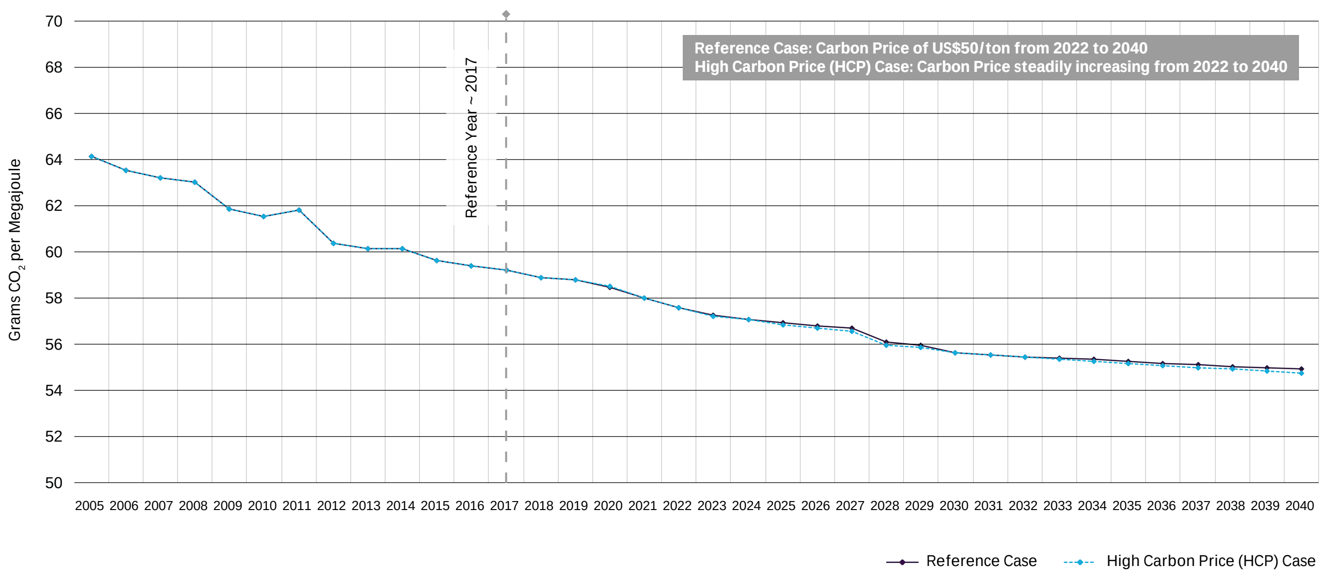
Correlating emissions with fossil fuel consumption, Canada's National Energy Board (NEB) has presented a declining trend in the estimated weighted-average GHG emissions intensity of fossil fuel consumption

- While total fossil fuel consumption is expected to grow, a changing fuel mix leads to declining GHGs per unit of fossil fuel energy used.
- Growth in natural gas, coupled with a steep drop in coal, results in GHG intensity declining by 7.5% from 2016 to 2040, or 14% from 2005 to 2040.
- Capturing carbon from facilities that employ CCS technology also reduces the GHG intensity of fossil fuel use.
- Accounting for reductions in non-combustion emissions, such as reducing methane leaks, as well as including emission credits purchased through international trading mechanisms (such as Ontario and Quebec's emission trading with California, could further decrease emissions intensity.
- However, uncertainty around future climate policies and technology development could impact on fossil fuel combustion-related GHG emission results.

On the basis of current federal, provincial, and territorial policies and actions, Canada is not expected to meet its 2030 target for reducing GHG emissions

- Meeting Canada's 2030 target will require substantial effort and actions beyond those currently planned or in place.
- Despite the presence of a federal goal that relies in part on provincial action, nine of 13 provinces and territories have no GHG targets for 2030, including Alberta, British Columbia, and Newfoundland and Labrador.
- The federal government is expected to introduce legislation to establish a federal "backstop" that would impose a carbon tax in provinces that refuse to establish their own levy or cap-and-trade policy, or that fail to meet federal standards for their system.
- However, the federal carbon tax plan is vigorously opposed by the Saskatchewan government and conservative opposition parties in Ontario and Alberta, where elections loom.

Figure 1.6. Canada - Estimated Weighted-Average GHG Emission Intensity of Fossil Fuel Consumption (Grams CO_2 per Megajoule)



Source: NEB (October 2017)

Topic Box 1.2: Canada's British Columbia unveils legislation to update GHG reduction targets

On May 7, 2018, British Columbia unveiled Bill 34, the Greenhouse Gas Reduction Targets Amendment Act, 2018, which updates the province's GHG emissions reduction targets. The bill repeals the Greenhouse Gas Reduction Targets Act (GGRTA), passed by the former Liberal government in 2007, and replaces it with the Climate Change Accountability Act, which contains an updated set of GHG reduction targets and introduces other new features, including ministerial power to establish GHG emissions targets for individual industry sectors and government reporting requirements

- British Columbia's GHG emissions in 2007 were 64.7 Mt CO_2e.
- The most recent statistics available from British Columbia's GHG inventory show that provincial GHG emissions in 2015 were 61.6 Mt CO_2e, representing a 4.7% reduction.
- In order to meet the new targets, provincial GHG emissions would have to fall below 38.8 Mt CO_2e by 2030, 25.9 Mt CO_2e by 2040, and 12.9 Mt CO_2e by 2050.
- The government's decision to drop the 2020 target comes after the province's Climate Leadership Team (CLT) issued a 2015 report stating that the 2020 target would be 'extremely difficult' to meet, and that GHG emissions in 2020 would actually exceed 2007 levels.

New GHG reduction targets

- The Act replaces the 2020 target with two new targets, oriented towards 2030 and 2040 instead, and keeps the 2050 target in place, with each of the three reduction targets being 20% higher than the one before it.
  - by 2030, emissions will be at least 40% below 2007 levels
  - by 2040, emissions will be at least 60% below 2007 levels
  - by 2050, emissions will be at least 80% below 2007 levels.
- Sectoral initiatives will include plans for buildings and communities, industry, and transportation.

The government has emphasized its intention to remove barriers, and make it attractive and affordable for people, communities and industry to move to lower-carbon alternatives, while at the same time growing an economy that is stronger, cleaner, more diverse and more resilient. With its most recent announcement, the government is looking to foster increased investment and innovation in the low-carbon energy sector over the coming years.

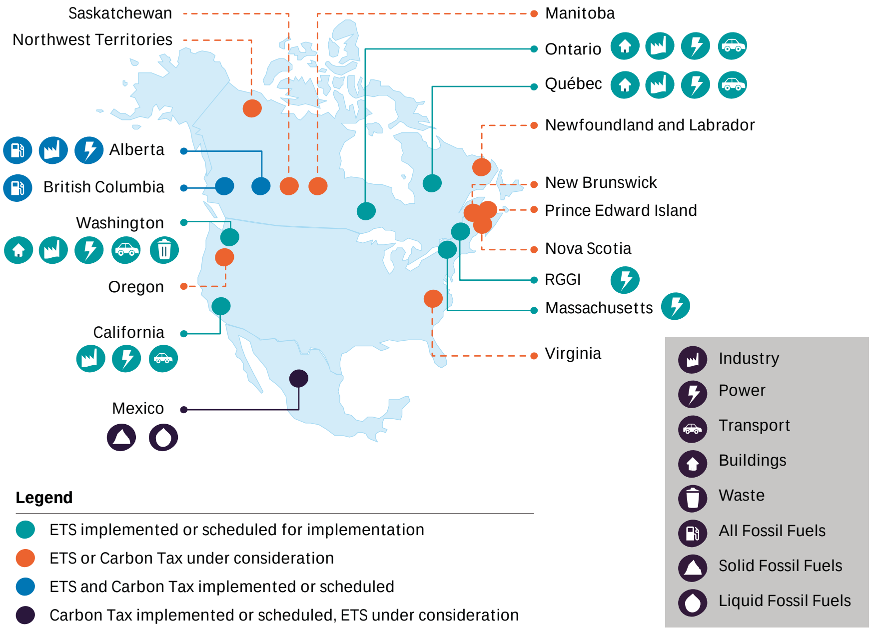
However, questions remain as to what concrete measures the government will put in place through its renewed climate action strategy to ensure the GHG reduction targets are met, and how these measures will interact not only with GHG reduction initiatives across industry sectors, but also with federal climate change policy.

Carbon pricing: The recent developments in carbon pricing initiatives were seen across North America, with newly implemented carbon pricing initiatives in 2017-2018

Summary of selected changes in regional, national and subnational carbon pricing initiatives in 2017-2018

- Initiatives implemented in 2017: Alberta (carbon tax), Ontario (ETS) and Washington (CAR)
- Initiatives implemented in 2018: Massachusetts (ETS)
- New initiatives under consideration: Côte d'Ivoire, Manitoba (Canada), Saskatchewan (Canada)
- Initiatives under consideration with new developments: New Brunswick (Canada), Nova Scotia (Canada).

Figure 1.7. Summary Regional Carbon Pricing Initiatives (ETS and Carbon Tax) - (implemented, scheduled for implementation and under consideration) and Sectoral Coverage



Source: State and Trends of Carbon Pricing, 2018, World Bank (May 2018)

2017 witnessed continued progress on carbon pricing initiatives at the regional level, and 2018 will be a critical year for implementing international carbon pricing mechanisms

Highlights for 2017-2018

- A carbon tax in Alberta, covering all GHG emissions from combustion that are not covered by its baseline-and-credit ETS for large emitters.
- An ETS in Ontario, covering GHG emissions from industry, electricity generators and importers, natural gas distributors and fuel suppliers.
- The Clean Air Rule in Washington State, establishing a baseline-and-credit system which initially covers fuel distributors and industrial companies that are not considered to be energy intensive nor trade exposed.
- An ETS in Massachusetts for power plants; power plants in the state will also continue to be subject to the Regional Greenhouse Gas Initiative.

Many jurisdictions are incorporating phased approaches to plan for changes to the system design

The implementation of carbon pricing initiatives often brings challenges, including capacity and infrastructure concerns.

To address these challenges, many initiatives include phased approaches to plan for adjustments to the system design.

California is proposing to modify components of its ETS design for the post-2020 phases, including the allocation approach and the establishment of a price ceiling.

Carbon pricing continues to gain traction

- Technological evolution is taking place, with innovative tools presenting a new frontier for carbon pricing.
- Emerging digital innovations in data gathering (satellite and sensors) and processing allow for applications in areas such as air pollution and GHG monitoring.
- New systems that enable more efficient development of monitoring, reporting and verification standards with compatible and extensible methods and rules, big data, blockchain, the internet of things (e.g. smart meters), smart contracts[1] and other disruptive technologies hold out the promise of addressing the needs of a new generation of carbon markets post-2020.

1 A "smart contract" refers to transactional terms and conditions embedded in computer code which allow automatic execution of the relevant transaction once precise conformity with those terms and conditions has been established

Carbon pricing: The multi-state Carbon Costs Coalition is focused on reducing carbon emissions, ensuring equity in policy proposals, developing market-based solutions, creating a resilient local economy, and improving public health

On January 31, 2018, nine states announced the formation of the Carbon Costs Coalition, which brings together lawmakers from states to share best practices for strengthening regional momentum and advancing progress on carbon pricing, while accurately accounting for the cost of carbon pollution

Coalition principles

1. Reducing carbon emissions
2. Developing market-based solutions to climate change
3. Ensuring equity in policy proposals
4. Creating a resilient economy
5. Improving public health.

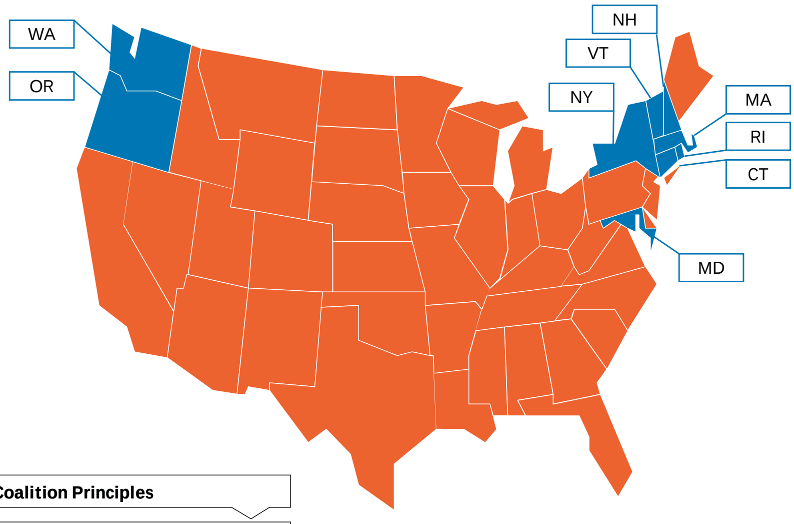
Policy model overview

- Action to mitigate climate change by charging emitters for CO_2 and GHG emissions.
- Multiple policy models to both curb emissions and strengthen energy economies.
  - **Revenue positive** pricing schemes accrue new revenue for the state, which can be reinvested in renewable energy deployment or distributed in other state programs and funds
    - Maryland, Massachusetts, New York, Rhode Island.
  - **Revenue neutral** pricing schemes do not accrue new revenue, instead they offer rebates to consumers directly or replace other taxes whose revenue can be covered by a carbon price
    - Connecticut, Massachusetts, Vermont.
  - **Cap-and-trade** systems set a cap on allowable GHG emissions and distribute limited emission permits that can be purchased and traded among emitters. This system uses market forces to set a price on GHG
    - California, Regional Greenhouse Gas Initiative (RGGI)
  - **Cap-and-invest** systems allocate the funds generated by the sale of permits to specific programs and other efforts to reduce GHG emissions
    - Oregon
  - **Study commissions** are created to better understand the policy impacts of a carbon price within a state. Commissions carry out research and provide recommendations on policy paths for pricing carbon
    - New Hampshire, New York, Vermont.

Figure 1.8. US - Carbon Costs Coalition Initiative

US Carbon Costs Coalition (January 31, 2018)

State legislators from nine states have agreed to form an official coalition focused on accurately accounting for the cost of carbon pollution
Brings together lawmakers from states to share best practices for strengthening regional momentum and advancing progress on carbon pricing



Coalition Principles

Reducing carbon emissions
Ensuring equity in policy proposals
Developing market-based solutions
Creating a resilient economy
Improving public health

Source: State and Trends of Carbon Pricing, 2018, World Bank (May 2018), NCEL

Underlying viewpoint

- Putting a price on carbon shifts the costs accruing from negative impacts to health, environment, and climate from fossil fuel emissions back onto industry emitters from public.
- Businesses agree that putting a price on carbon would bring predictability to energy prices, provide long term savings, and reduce the economic costs of climate change.
- Renewable energy is now more cost competitive with conventional fossil fuels, and in some regions is the lowest-cost option, making a shift to a clean energy economy more feasible.
- Setting a price on carbon aids the transition to clean energy without burdening consumers.
- States can utilize a carbon price as a new revenue source to invest in infrastructure modernization, support clean energy deployment to underserved communities, and spur economic growth by offsetting other taxes levied on the public.

Current legislation in each state under the Carbon Costs Coalition

State	Current Legislation
Connecticut	A revenue neutral bill with carbon priced at US$15 per ton increasing by US$5 per ton annually
Maryland	A revenue positive bill with carbon priced at US$15 per ton increasing by US$5 per ton annually until 2025 where it would remain at US$45
Massachusetts	A revenue neutral bill with carbon priced at US$10 per ton A revenue positive bill with carbon priced at US$20 per ton with a rate increase of US$5 per year until it reaches US$40 per ton A revenue positive bill with carbon priced at US$15 per ton with a rate increase of US$10 per year
New Hampshire	Establishes a study commission on creating a price on carbon
New York	A revenue positive bill with carbon priced at US$35 per ton with a rate increase of US$15 per year until it reaches US$185 per ton Establishes a study commission on creating a price on carbon
Oregon	A cap and invest bill requiring reducing in greenhouse gas emissions of 20% of 1990 levels by 2025, 45% by 2035 and 80% by 2050
Rhode Island	A revenue positive bill with carbon priced at US$15 per ton with a rate increase of US$5 per year
Vermont	The ESSEX Plan
Washington	A revenue positive bill with carbon priced at US$20 with an increase equal to inflation A revenue positive bill with carbon priced at US$15 per ton with a rate increase of US$2.50 until it reaches US$30 per ton A revenue positive bill with carbon priced at US$15 per ton with a rate increase of US$2.50 until it reaches US$30 per ton A revenue positive bill with carbon priced at US$15 per ton of CO_2 with an increase equal to inflation A revenue positive bill with carbon priced at US$15 per ton until 2024 when it will rise to US$20 per ton

Do the benefits of carbon pricing outweigh the costs?

In May 2018, Maryland Delegates David Fraser-Hidalgo and Ben Kramer highlighted the key benefits of carbon pricing:

- Helps spur the growth of renewable energy
- Investments in renewable energy entail more local jobs and increase the money staying within the state
- Helps spur innovation, allowing renewable energy to compete fairly, and provide businesses with longer-term certainty for energy fuel costs
- Helps improve air quality, reducing the impact of emissions linked to worsening public health.

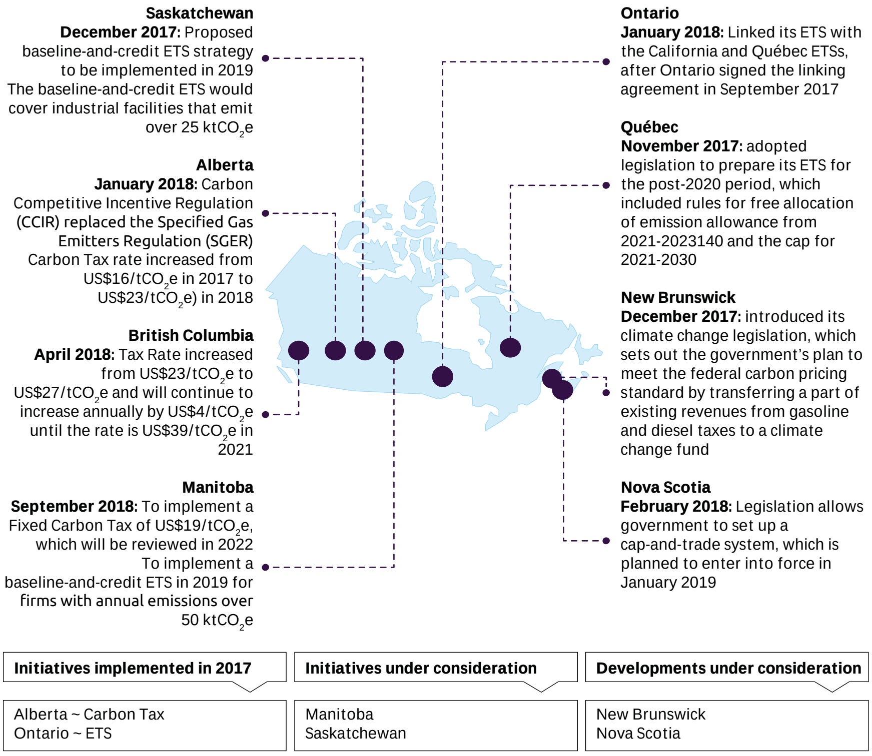
Carbon pricing: Canada's proposed Pan-Canadian Framework for carbon pricing would set national standards but give individual provinces considerable latitude in program design and revenue allocation

While interest around a national carbon price in the US has faded substantially since the collapse of Waxman Markey in 2009, the Canadian government under Prime Minister Justin Trudeau has since developed a national carbon price framework as a key pillar in its plan to meet its Paris Agreement commitments

- Recognizing the fact that several of the largest Canadian provinces (Ontario, Quebec, British Columbia, and Alberta) already have carbon pricing mechanisms in place, the federal government has opted for a national carbon price benchmark which provides individual jurisdictions the flexibility of deciding how to meet the federal standard.
- For jurisdictions that opt for an explicit price-based system (i.e., a carbon tax), the benchmark requires a minimum price of CDN$10/ton CO_2e by 2018, rising to CDN$50/ton of CO_2e by 2022.

Carbon price rises are planned in jurisdictions with comparatively higher prices, which includes :

Figure 1.9. Canada - Key Carbon Pricing developments across Provinces and Territories - 2017 and beyond



Source: State and Trends of Carbon Pricing, 2018, World Bank (May 2018)

- The British Columbia carbon tax, which will increase from US$27/ton CO_2e in 2018 to US$39/ton CO_2e in 2021.
- The proposed carbon tax rate for the Canada federal backstop, which will begin at US$16/ton CO_2e in 2019 and scale up to US$39/ton CO_2e in 2022 (expected to take effect on January 1, 2019).
  - The proposed backstop system consists of two elements: a carbon tax that is generally payable by fuel producers or distributors, and a baseline-and-credit ETS for emissions-intensive, trade-exposed industrial facilities.

Canadian federal carbon pricing plan has met some controversy, including from some citizens concerned about impacts on the cost of living, and from a few recalcitrant provinces

- While support for a carbon price is substantially higher in Canada, opinions across the US are somewhat less influenced by the price effect, indicating Canada's continued reliance on gasoline.

The federal standard aims to ensure that carbon pricing will apply to a broad set of emission sources throughout Canada, with increasing stringency over time

- The Pan-Canadian approach to carbon pricing requires all Canadian provinces and territories to have a carbon pricing initiative in place in 2018 that aligns with the federal standard.
- The federal standard gives provinces and territories the flexibility to implement their own carbon pricing initiative according to their circumstances, either a fixed price or cap-and-trade system, and sets common criteria that all systems must meet, in order to ensure they are fair and effective.

On the subnational level, provinces and territories are working to develop carbon pricing initiatives that align with the federal standard

2-Energy Transition

Progress in decoupling energy from growth continues

- Energy efficiency and investments to boost the efficiency of natural gas usage have contributed to this ongoing trend.
- The trend is projected to continue as energy efficiency, fuel economy improvements, and structural changes in the economy continue to lower energy intensity.

US investments in clean energy tracked 2016 levels, but reported a shift in capital deployment

- This trend continues despite a turn towards a less favorable domestic policy atmosphere.

Alternative energy technologies are approaching an LCOE that is at or below the marginal cost of certain conventional generation technologies

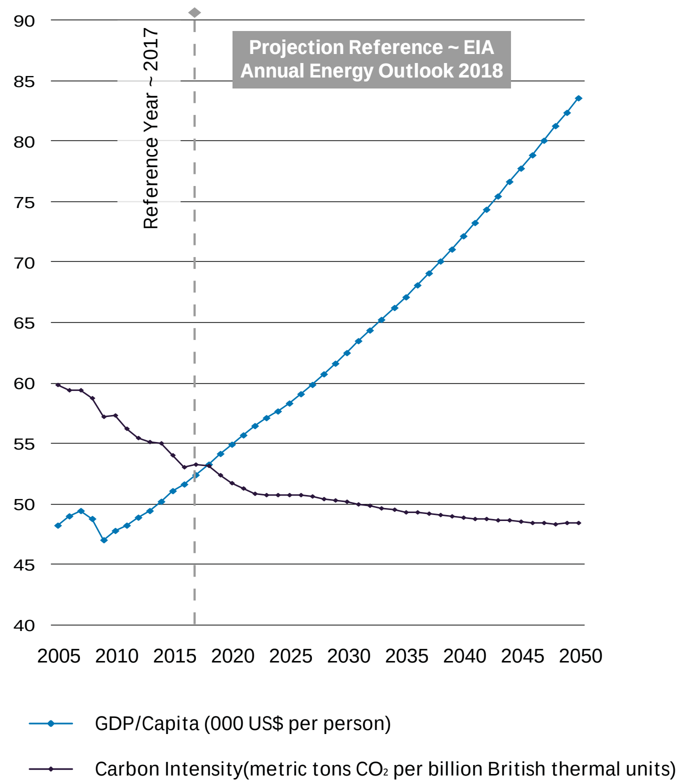
- Wind LCOE is in the US$30-60 range, continuing the trend of cost competitiveness, followed by solar PV.
- The gas combined cycle, with an LCOE of US$42-78, is close behind.
- Despite the sustained and growing cost-competitiveness of certain alternative energy technologies, diverse generation fleets are required to meet baseload generation needs for the foreseeable future.

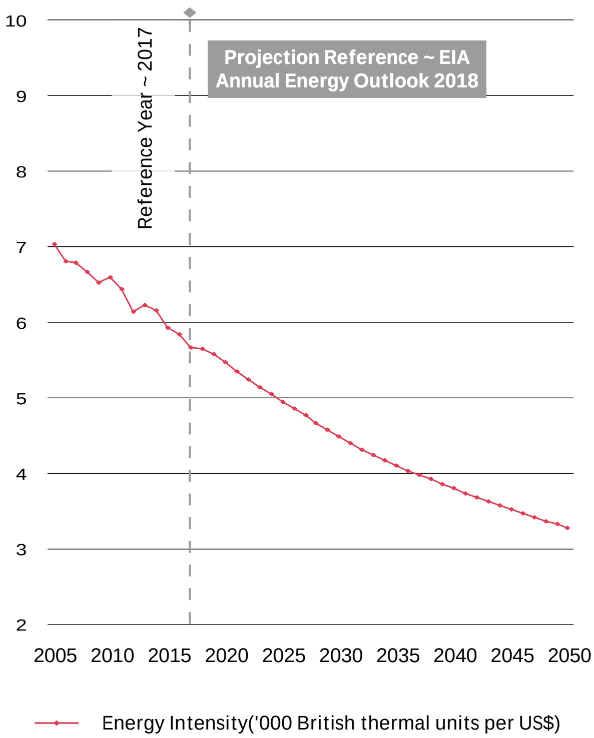
Among commercially deployed technologies, lithium-ion continues to provide the most economic solution across all use cases

- As the energy storage market continues to evolve, several forms of potential revenue streams have emerged in selected US markets.
- Utilities provide valuable revenue sources in exchange for location-based grid services, with the most common applications being in utility demand response programs and T&D deferral applications.
- Tesla predicts unprecedented growth in the near future.

Energy decoupling: Progress in decoupling from growth continues; declines in energy intensity and carbon intensity continue to mitigate emissions growth

Figure 2.1. US - Decline in Energy Intensity and Carbon Intensity vis-à-vis GDP/Capita Growth, 2005-2050





Source: US EIA Annual Energy Outlook, 2018

Energy intensity (the amount of energy used per unit of economic growth) has declined steadily for many years, while carbon intensity (the amount of CO_2 emissions associated with energy consumption) has generally declined since 2008

- Since 2008, energy usage has shrunk 1.7% despite GDP growing by 15.3%.
- Considering the laws and regulations currently in place, energy intensity and carbon intensity are projected to be 42% and 9% lower than their respective 2017 values by 2050.

The trend continues: Energy productivity (the amount of GDP produced by a unit of energy) climbed 2.5% in 2017 as economic growth continued its long-term trend of decoupling from energy use

- The US economy advanced 2.3% in 2017, up from 1.5% in 2016; whereas total energy consumption dipped 0.2% to 97.2 quadrillion BTU.

What is driving this trend?

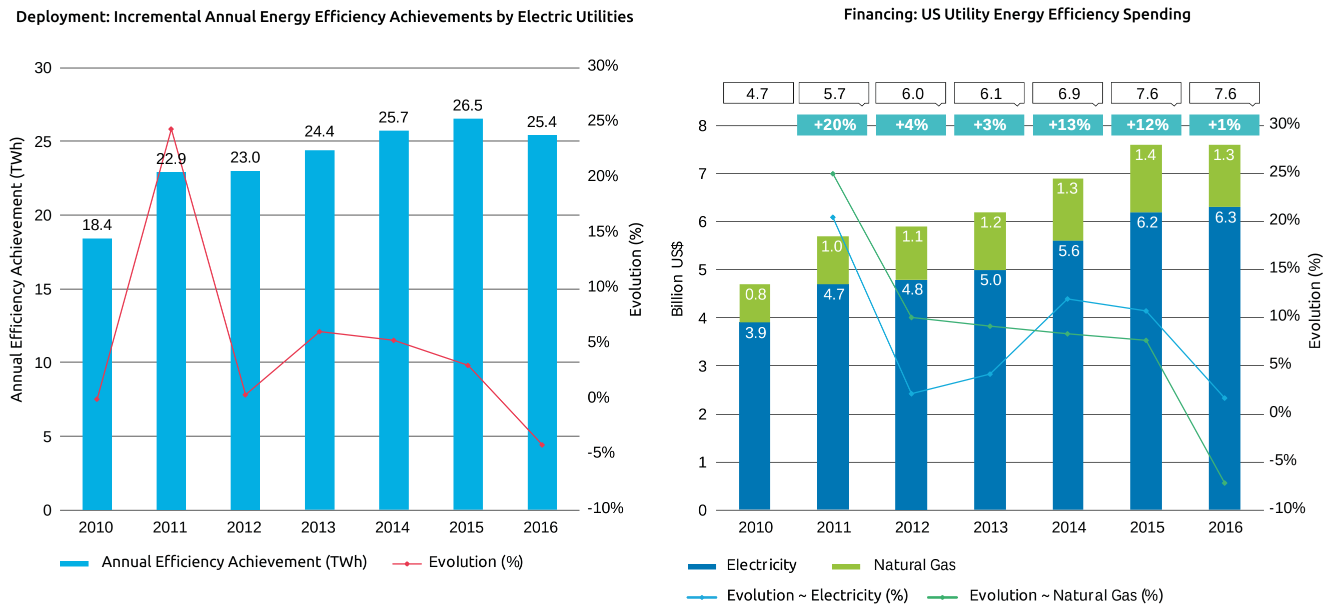
- Annualized electricity consumption, excluding consumption of distributed energy resources, fell 2.6% in 2017 despite stronger economic growth.
- Since 2007, electricity demand has reduced by an average of 0.2% per year.
- Energy efficiency and investments to boost the efficiency of natural gas usage have clearly contributed to this ongoing trend.
- The number of residential customers using natural gas grew by 21% to 69 million in the 20 years from 1998 through 2017.

Trend indicates slowdown in new states introducing Energy Efficiency Resource Standard (EERS) policies and the maturing of many states schemes

- Carbon intensity declines as a result of changes in the US energy mix that reduce the consumption of carbon-intensive fuels and increase the use of low- or no-carbon fuels.

Energy Efficiency: Since 2011, the number of states with Energy Efficiency Resource Standards (EERS) policies in place has leveled off, as has investment

Figure 2.2. US - Incremental Annual Energy Efficiency Achievement/Utility Spending, 2010-2016



Source: BNEF - Sustainable Energy in America Factbook, 2018

In 2016, utility energy efficiency savings decreased for the first time, falling slightly from the previous year

- In the years leading up to 2011 a growing number of states introduced EERS, mandating utilities to invest in energy savings among their customer base.
- There was a corresponding increase in investment in utility energy efficiency programs.
  - Between 2015 and 2016, Arkansas, Illinois and Pennsylvania reported savings increases of 0.19 TWh, 0.16 TWh and 0.15 TWh respectively.
- However, growth has now leveled off:
  - Although 28 states saw an increase in energy savings in 2016, Californian utilities' savings decreased from 5.0 TWh to 3.9 TWh
  - The American Council for Energy Efficiency Economy (ACEEE) attributes the difference to adjustments in qualifying criteria for utility energy efficiency savings, rather than a decrease in energy efficiency activity.

In 2016, growth in utility spending on energy efficiency leveled off at US$7.6 billion, only 1% higher year-on-year

- While investment growth eased at the national level, the scenario has been more dynamic at the state level.
  - Utilities in Washington increased spending by US$34 million (+11%), increases in Indiana by US$34 million (+33%), North Carolina by US$31 million (+21%) and Kentucky by US$30 million (+38%).
- However, these gains were offset by falling investment in California by US$57 million (-3%) and Maryland by US$90 million (-44%):
  - The decrease in Maryland stems in part from a general decline in investment by the state's utilities
  - The drop in California is relatively trivial when compared against the increase from US$1.57 billion to US$1.71 billion between 2014 and 2015.

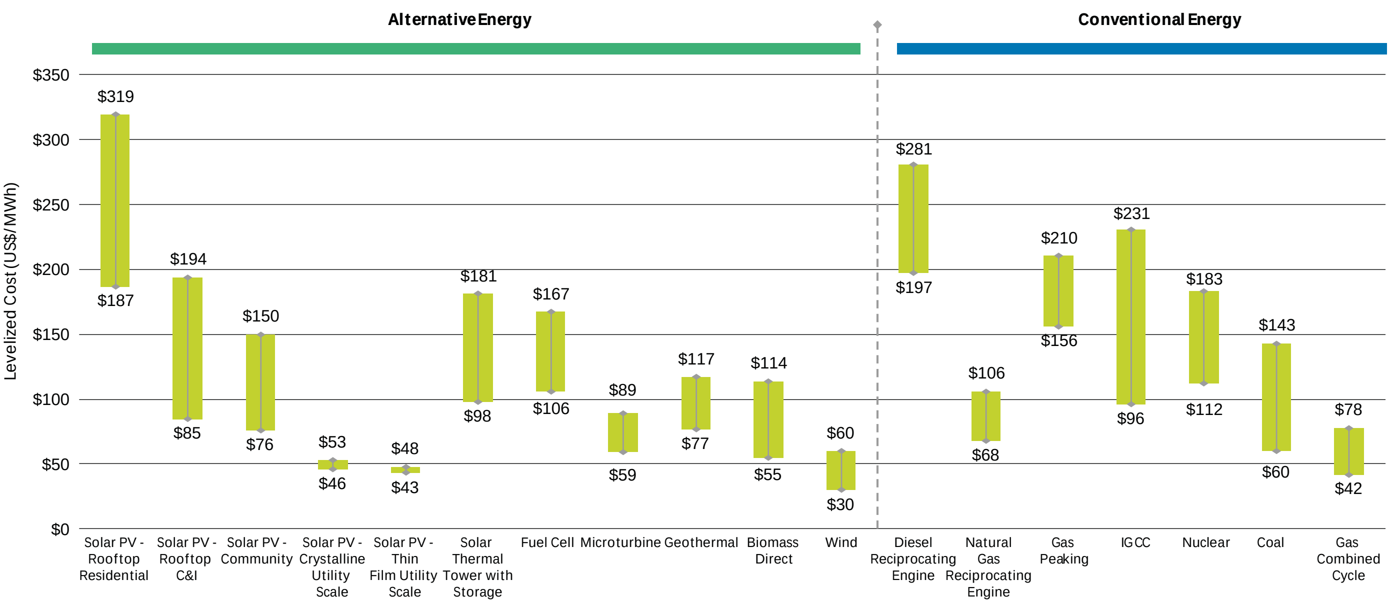
LCOE: Alternative energy technologies, which became cost-competitive with conventional generation several years ago, are, in some scenarios, approaching a LCOE that is at or below the marginal cost of certain conventional generation technologies

LCOE values for alternative energy technologies continue to decline

- Downward pressure on financing costs as a result of continuously evolving and growing pools of capital being allocated to alternative energy.
- Declining capital expenditures per project resulting from decreased equipment costs.
- Increased competition among participants as markets evolve policies towards auctions and tenders for the procurement of alternative energy capacity (away from standard offer programs, feed-in-tariffs, etc.).
- Improving competencies in asset management and operation and maintenance execution.

Wind LCOE at US$30-$60 range, continues the trend of cost competitiveness, followed by solar PV. Vis-à-vis, gas combined cycle, with LCOE of US$42-$78, competes closely

Figure 2.3. US - Unsubsidized Levelized Cost of Energy (US$/MWh)



Source: Lazard - Levelized Cost of Energy, Version 11.0

For the foreseeable future...

- Despite the sustained and growing cost-competitiveness of certain alternative energy technologies, diverse generation fleets are required to meet baseload generation needs for the foreseeable future.
- A rational and cost-based analysis is necessary to enable a modern grid, cost-effective energy development and an increasingly clean energy economy.

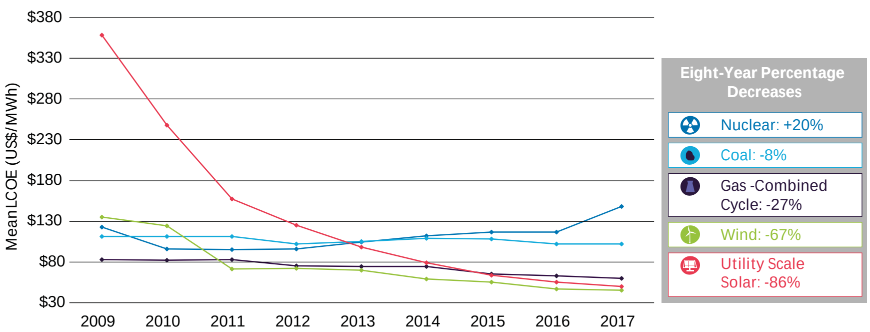
The displacement trend will be moderated by the intermittent nature of alternative energy generation and the current reluctance of capital providers to underwrite merchant exposure, as well as an understanding of the need for resource diversity in a modern electricity grid

Levelized Cost of Energy: Costs continue to decline for alternative energy technologies, albeit at a modest rate

Over the last eight years, wind and solar PV have become increasingly cost-competitive with conventional generation technologies, on an unsubsidized basis, in light of material declines in the pricing of system components (e.g., panels, inverters, racking, turbines, etc.), and dramatic improvements in efficiency, among other factors

- The gap between the costs of certain alternative energy technologies (e.g., utility-scale solar photovoltaic and utility-scale onshore wind) and conventional generation technologies continues to widen as the cost profiles of such conventional generation technologies remain flat (e.g., coal) and, in certain instances, increase (e.g., nuclear).
- Large-scale conventional and renewable generation projects (e.g., IGCC, nuclear, solar thermal, etc.) continue to face a number of challenges: significant cost contingencies, high absolute costs, competition from relatively cheap natural gas in selected geographies, operating difficulties and policy uncertainty.

Figure 2.4. US - Selected Historical Mean LCOE Comparison (US$/MWh)



Source: Lazard -Levelized Cost of Energy, Version 11.0 (November 2017)

Trends

While capital costs for a number of alternative energy generation technologies (e.g., solar PV, solar thermal) are currently in excess of some conventional generation technologies (e.g., gas), declining costs for many alternative energy generation technologies, coupled with uncertain long-term fuel costs for conventional generation technologies, are working to close formerly wide gaps in electricity costs.

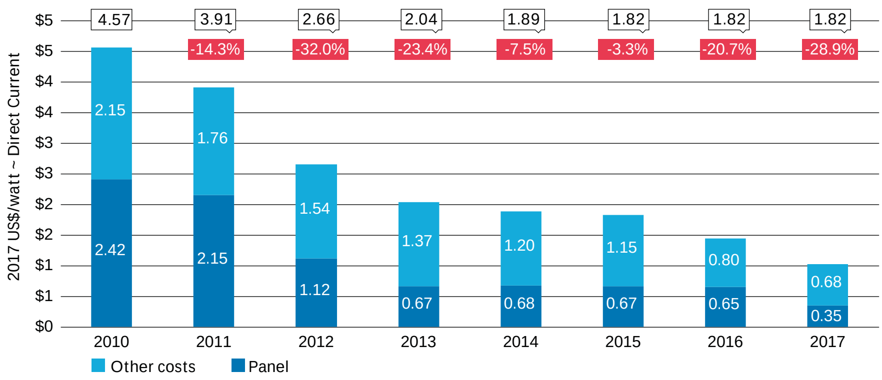
A key issue facing alternative energy generation technologies is the impact of the availability and cost of capital on LCOEs (as a result of capital markets dislocation, technological maturity, etc.); availability and cost of capital have a particularly significant impact on alternative energy generation technologies, whose costs reflect essentially the return on, and of, the capital investment required to build them

Levelized Cost of Energy: The increasing use of technologies has resulted in a decline in costs, particularly for solar PV installations

Costs associated with a utility-scale solar installation in the US from 2010 to 2017 have reported a significant drop

- Total installed costs fell from nearly US$4.5 per watt in 2010 to nearly US$1 per watt in 2016.
- Evolving drivers of change:
  - Amplifying economies-of-scale impacts on EPC contractor and developer costs
  - Lower module and inverter prices
  - Increased competition, lower installer and developer overheads, improved labor productivity, and optimized system configurations, particularly for EPC firms building commercial and utility-scale projects.

Figure 2.5. US - Solar Photovoltaic Utility-scale Solar System Cost Benchmark (2017 US$/watt - Direct Current)



Source: NEB (October 2017)

Although hardware cost reductions (module and inverter prices, in particular) have been an important driver of system cost reductions in recent years, the size of these gains has decreased recently, due to the policy uncertainties in the sector

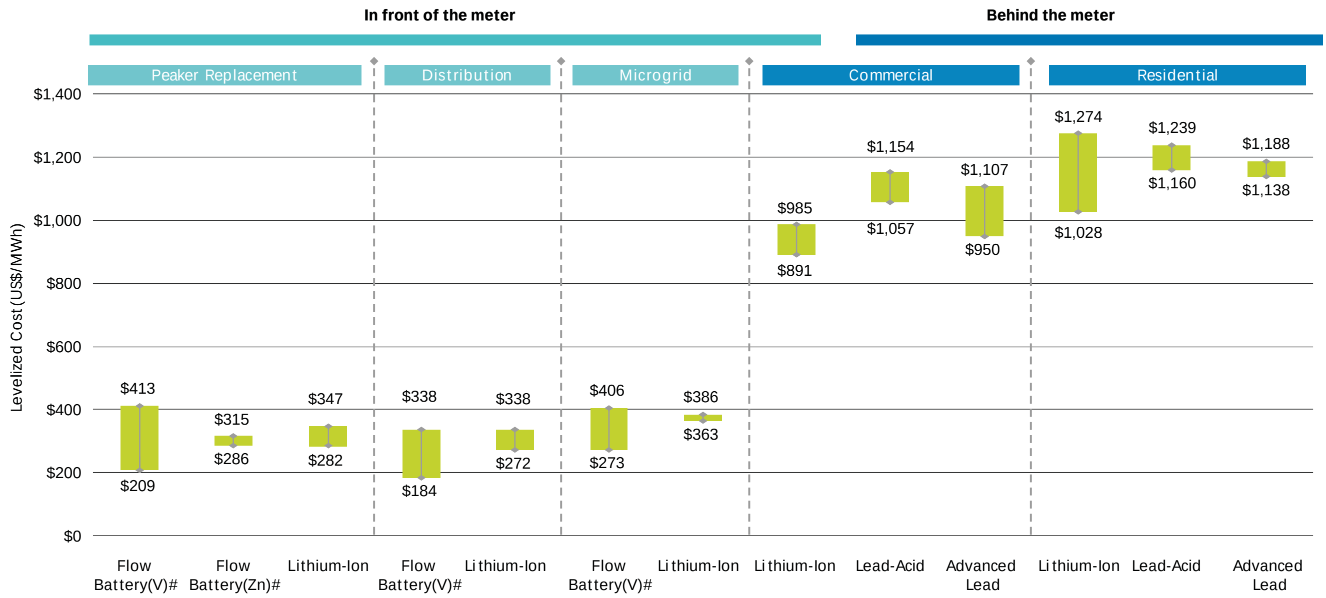
Levelized Cost of Storage - Among commercially deployed technologies, lithium-ion continues to provide the most economic solution across all use cases

As the energy storage market continues to evolve, several forms of potential revenue streams have emerged in selected US markets

Key Findings

- **Continued decreasing cost trends**
  - Cost improvements for lithium-ion modules (particularly lithium-ion deliveries scheduled for post-2019) are offset by increases in engineering, procurement and construction
  - Marginal flattening of projected capital cost decreases for lithium-ion (i.e., median of ~10% CAGR vs. ~12%).
- **Evolving revenue streams**
  - The mix of monetizable revenue streams varies significantly across geographic regions in the US, mirroring state/ISO subsidies and storage-related product design
  - Utility revenue streams for transmission and distribution deferral are highly situation-specific and opaque, and demand response revenues are also diverse and complex; however, in high-cost regions (e.g., ConEd's territory) they can be attractive
  - Customer revenue sources are dominated by bill savings, which are highly lucrative in high-cost investor-owned utility service territories for selected tariffs.
- **Project economics remain highly variable**
  - Commercial use case in CAISO provides an attractive illustrative ~11% IRR, reflecting a combination of Local Capacity Requirements (LCR) and bill management savings
  - Distribution deferral use case in NYISO provides an illustrative ~21% IRR, reflecting T&D deferral plus resource adequacy (estimate based on ConEd's Brooklyn-Queens Demand Management (BQDM) program)
  - Microgrid project revenue sources in ISO-NE were limited and provided negative illustrative returns ; and residential use case in California also reflected negative illustrative project economics due to the relatively high installed cost of the storage unit, which offset revenues from bill savings and participation in demand response.

Figure 2.6. US - Unsubsidized Levelized Cost of Storage (US$/MWh)



Source: Lazard -Levelized Cost of Storage Analysis, Version 3.0 (November 2017)
Note: # Denotes indicative Flow Battery LCOS value | Flow Battery(V) ~ Flow Battery Vanadium; Flow Battery(Zn) = Flow Battery Zinc

For the foreseeable future…

- In many cases, local market/regulatory rules are not available to reward the owner of an energy storage project for providing all (or the optimal combination of) potential revenue streams.
- Although energy storage developers/project owners often include energy arbitrage and spinning/non-spinning reserves as sources of revenue for commissioned energy storage projects, frequency regulation, bill management and resource adequacy are currently the predominant forms of realized sources of revenue.

Cost of Storage Comparison

In front of the meter	Behind the meter
• Flow battery manufacturers have claimed that they do not require augmentation costs and can compete with lithium-ion; however, operational experience is lacking to practically verify these claims. • Flow batteries lack the widespread commercialization of lithium-ion. • Longer duration flow batteries could potentially be used in T&D 8-hour use cases.	• Compared with in front of the meter, behind-the-meter system costs are substantially higher due to higher unit costs. • The low initial costs of lead and lead carbon are outweighed by higher augmentation and operating costs.

Lithium-ion equipment costs continue to decline based on more cost-effective batteries, better integration, and cheaper inverters

- Battery module prices are expected to continue declining, driven by sustained manufacturing competition.
- System integration costs will decline as more and larger electrical equipment manufacturers enter the energy storage market.
- Energy storage inverters continue to follow solar inverter price declines, with sustained price reductions expected in the coming years.

Key drivers of energy storage market growth

- **Enabling policies:** Include explicit targets and/or state goals incentivizing procurement of energy storage.
  – California energy storage procurement targets (e.g., AB2514) require 1,325 MW by 2020.
- **Incentives:** Upfront or performance-based incentive payments to subsidize initial capital requirements.
  – California Self-Generation Incentive Programs (SGIP): US$450 million budget available to behind-the-meter storage.
- **Market fundamentals:** Endogenous market conditions resulting in higher revenue potential and/or increased opportunity to participate in wholesale markets.
  – California Real-Time Energy: 100+ hours with >US$200/MWh locational marginal price in 2016.
- **Favorable wholesale/utility program rules:** Accessible revenue sources with operational requirements favoring fast-responding assets.
  – PJM Reg. D: average prices of US$15.5/eff. MW in 2016, with significant revenue upside for performance for storage.

- **High peak and/or demand charges:** Opportunities to avoid utility charges through peak load management during specified periods or system peak hours.
  - ERCOT 4CP Transmission Charges: ~US$2-$5/kW-mo. charges applied to customers during system coincident peak hours in summer months.

Utilities provide valuable revenue sources in exchange for location-based grid services, the most common applications being in utility demand response programs and T&D deferral applications

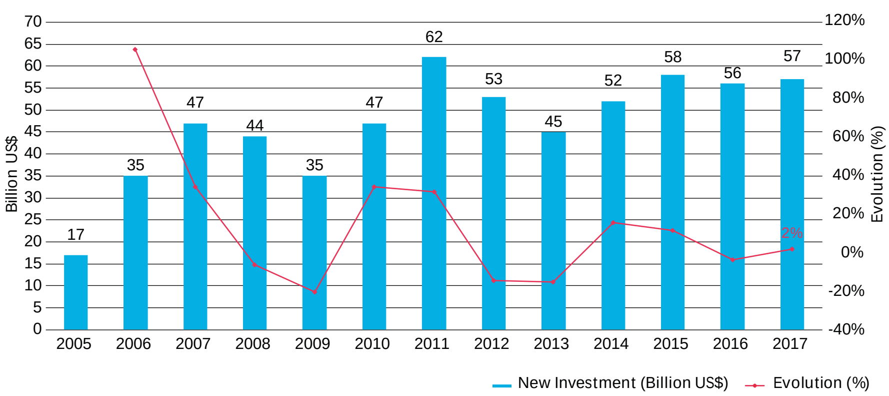
- **California investor-owned utilities**
  - Capacity Bidding Program (CBP)
    - PG&E: ~US$9.9/kW-mo., 6 mo.
    - SCE: ~US$4.5/kW-mo., 12 mo.
    - SDG&E: Varies on notice, from US$10.6
    - US$15.2/kW-mo., 6 mo.
  - Base Interruptible Program (BIP)
    - PG&E: US$8-$9/kW-mo., 12 mo.
    - SCE: US$24-$30/kW-mo., 6 mo.
    - SDG&E: US$12/kW-mo. summer, US$2/kW-mo. winter
  - Demand Bidding Program
    - US$0.50/kWh during events
- **Hawaiian Electric**
  - Fast DR Pilot Program
    - US$5/kW-mo., 12 mo.
    - US$0.50/kWh during events
- **Com Edison**
  - Voluntary Load Reduction Program
    - US$0.25/kWh + delivery payment
    - Completely voluntary
- **Florida**
  - Commercial Demand Reduction Program
    - US$8.20/kW-mo.
    - FPL controls the asset during events
- **ConEd**
  - Commercial System Relief Program (CSRP)
    - US$6-$18/kW-mo., depending on location
    - 5 mo. period, US$1/kWh
  - Distribution Load Reduction Program (DLRP)
    - US$18-$25/kW-mo., depending on location
    - 5 mo. period, US$1/kWh
- **Duke Energy Progress**
  - Demand Response Automation (DRA) Program
    - US$3.25/kW-mo. + US$500/kW for 1st & 2nd event + US$6/kW at each event.

Key takeaways

- Jurisdictional and regulatory concerns have limited deployment thus far.
- Transacted values do not typically equal price; in most installations value substantially exceeds price.
- Assets are typically transacted as a capital purchase by utilities.
- Asset value is highly location dependent.
- Deferral length varies based on factors independent of the battery.
- Projects are rarely transacted in the absence of other revenue streams.

Clean Energy Investment - US clean energy investment, which took second place after China, held its ground at US$57 billion despite a turn towards a less favorable domestic policy atmosphere

Figure 2.7. US - Total New Investment in Clean Energy, 2005-2017 (US$ billion)



Source: BNEF - Sustainable Energy in America Factbook, 2018

US investments tracked 2016 levels but reported a shift in capital deployment

- The moderately stable figure for US clean energy investment concealed shifts in capital deployment.
- Solar investment fell 20%, as policy uncertainty delayed projects and leading residential solar vendors pulled back from the market.
- However, smart energy technologies attracted 25% more funding in 2017 than in 2016 and wind investment expanded 19%.
- The Midwest's system operator, MISO, is overseeing a large build-out of its wires

infrastructure, seeking to replicate Texas' success in reducing wind curtailment rates.

– The construction of the Texas Competitive Renewable Energy Zone (CREZ) transmission lines brought wind produced in west Texas to demand centers farther east, slashing curtailment rates from a peak of 17% in 2009 to under 2% for 2016.

Topic Box 2.1: Energy storage growth traction is picking up pace – and is here to stay

Wood Mackenzie Power and Renewables estimates global annual energy storage deployments will grow from 2.3 gigawatt hours in 2017 to 21.6 gigawatt-hours in 2022

Tesla's energy storage business - monumental growth predictions for the future

	2008	2015	2016 - 2017	2018
Production at Fremont, California	Unveiled Roadster, battery technology and electric powertrain Unveiled **Model S,** premium all-electric sedan	Unveiled **Model X,** sport utility vehicle	Unveiled **Model 3,** low-priced vehicle that began production in 2017 and Tesla Semi, truck	**Production set to increase to a rate of 500,000 vehicles a year by 2018**

Production at Gigafactory, Nevada	**Energy solutions - Powerwall, Powerpack and Solar Roof -** enabling homeowners, businesses, and utilities to manage renewable energy generation, storage, and consumption **Gigafactory 1 -** facility designed to reduce battery cell costs and, by 2018, produce more lithium-ion batteries annually than were produced worldwide in 2013

Tesla executives predict unparalleled growth levels in 2019 of 300% to 400% for its energy storage business

- Company's energy business is likely to catch up with its electric vehicle business in the long term.
- The battery installation the company is building for Pacific Gas and Electric is 1 GWh, and it took the company five years to install 1 GWh of energy storage projects.
- Tesla had shut down a Powerwall battery manufacturing production line in order to make more batteries for its Model 3 car, but is now adding new cell lines to address cell shortages.
- That will enable Tesla to soon triple its storage business.

Yet, challenges remain

- One of the challenges Tesla is facing in growing its energy storage business is a shortage of trained electricians.
- Tesla reported that it installed 84 MW of solar power in Q2 2018, which is 11% higher than in Q1 2018 but down 52% year-on-year.
- The company expects solar growth rates to remain stable for the rest of the year and attributed the slower pace to the difficulty of validating the life span of the company's solar rooftop shingles, which can last anywhere from 30 to 50 years.
- Tesla has projected that solar deployments should remain stable in H2 2018, and will end the year with 329 MW of solar power deployed, its lowest since 2014.

Topic Box 2.2: Federal initiatives ranging from trade cases to tax reform continue to drive uncertainty in the market for clean technologies

Solar under pressure

- In January 2018, President Donald Trump instituted a 30% tariff on imported crystalline silicon solar modules and cells, which is scheduled to step down to 15% by 2021.
- The safeguard measure was imposed in response to a trade complaint submitted by two bankrupt domestic solar module manufacturers.
- The case, lodged by Suniva and SolarWorld, alleged unfair competition from Chinese manufacturers, but the resulting tariffs will apply to practically all countries of origin.
- These tariffs will increase all-in project costs by an estimated 4-10%.

Tax reforms passed around the end of 2017 assure change in favor of clean energy

- While the electric vehicle, wind, and solar tax credits remain unchanged from prior years, the corporate tax rate dropped to 21% from 35%.
- This tax cut raises after-tax earnings for renewable projects, but also reduces the supply of tax equity available for supporting renewable build.
- Additionally, the tax cut may free up utility money for infrastructure investments or for lowering retail electricity rates.
- Under the new law, multinationals with overseas profits are now required to pay a minimum level of taxes on foreign transactions under the BEAT provision.
- Although this can also limit tax equity supply, the negative impact is curbed by a provision that allows corporations to use 80% of the Investment Tax Credit (ITC) and Production Tax Credit (PTC) to offset BEAT.
- The introduction of immediate, 100% depreciation of most capital expenditures can benefit providers of long-lived assets such as energy saving building materials or technology.

In February 2018, Congress passed the Bipartisan Budget Act, which impacted on a range of energy incentives

- Energy efficiency credits and non-wind PTC technologies (biogas, biomass, waste to energy, active geothermal, hydropower, marine and hydrokinetic) received one-year retroactive extensions.
- Several non-solar ITC-eligible technologies (fiber-optic solar, micro-turbines, fuel cells, combined heat and power, and small wind) received five-year extensions with phase-downs.
- The budget law also lifted the end-of-2020 in-service deadline for nuclear plants to qualify for the nuclear production tax credit.
- In addition, it expanded credits for qualified carbon capture and sequestration (CCS) facilities.

Renewables support programs in 2017

- Most customers in 40 states, plus DC, could access net metering at the full retail rate as of August 2017.
- But states across the country are looking at potential reforms to the scheme: over the past year, Arizona, Indiana, and Maine finalized plans to move away from net metering.
- The replacement options vary but generally offer lower compensation rates or set a deadline by which small-scale PV owners can still qualify for net metering.

3-Infrastructures & Adequacy of Supply

Renewable generation soared an estimated 14.1% year-on-year in 2017, the highest ever one-year surge, as output increased by approximately 90 TWh

- Total renewable generation hit 717 TWh, driven by a rebound in hydro (up 13%, or 36 TWh) and new solar and wind build (driving generation up by 53 TWh, including estimates for small-scale solar).

With its ability to store water and to regulate output as needed, Canada's hydro capacity also facilitates the development of intermittent renewable resources such as wind and solar

- Over the past 5 years, policy incentives and declining costs have spurred significant growth in the use of non-hydro renewable resources.
- Multiple initiatives, at both federal and regional level, continue to indicate a considerable decline in coal capacity by 2040.

The projected mix of electricity generation is likely to be most affected by differences in fuel prices resulting in significant substitution by 2050

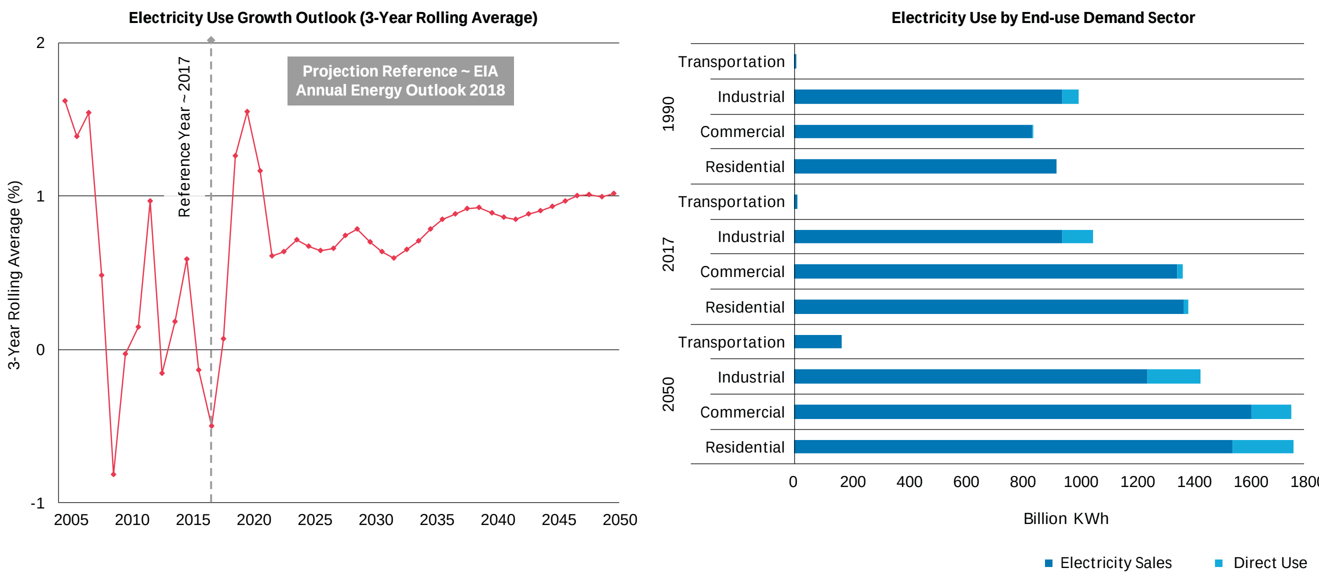
- Fuel prices in the near term would drive the share of natural gas-fired and coal-fired generation.
- Driven by continued favorable economics, generation relative to alternative technologies would more than double between 2017 and 2050, with an average annual growth rate of 2.8%.
- Tax credit phase-outs and coal plant retirements are likely to accelerate additions of near-term renewables and natural gas-fired capacity.
- Nuclear capacity retirements are projected to accelerate along with an anticipated drop in natural gas prices, while also indicating lower revenues in competitive power markets.

Renewable capacity build witnessed a slump in 2017 after record-level additions in 2016, down 19% to 18.4 GW from 22.7 GW in 2016

- 2017 saw policy turbulence for the renewable industry, with tax reform, solar tariffs, and uncertainties regarding grid reliability and resilience.
- Asset finance for solar witnessed a slump for a consecutive year while remaining strong for wind pipeline.

Electricity Use - Electricity use is expected to grow steadily through 2050 driven by growth projections across all demand sectors

Figure 3.1. - US - Electricity Use Growth Outlook, 2005-2050



Source: US EIA Annual Energy Outlook, 2018

After decades of diminishing growth, 2017 saw the US energy sector change gear, indicating a surge in future electricity demand

- While the historical electricity demand growth rates decelerated due to older, less efficient end-use equipment being replaced with more efficient stock, electricity demand going forward will be driven largely by economic growth and increasing efficiency.
- According to the Lawrence Berkeley National Laboratory, the average levelized cost of saving energy through efficiency declined to US$28/MWh in 2013, from US$44/MWh in 2009, down 36%.

Demand growth was negative in 2017, but is projected to rise slowly through 2050

- According to US EIA, the 2017–2050 average annual growth in electricity demand is projected to reach about 0.9%.

Decline witnessed historically; steady growth on the horizon

- Growth in retail electricity demand fell of 2.6% year-on-year (excluding contributions from distributed, small-scale facilities).
- Compound annual electricity growth has been steadily declining, from 5.9% over 1950-1990, to 1.9% over 1990-2007, to -0.2% since 2007.

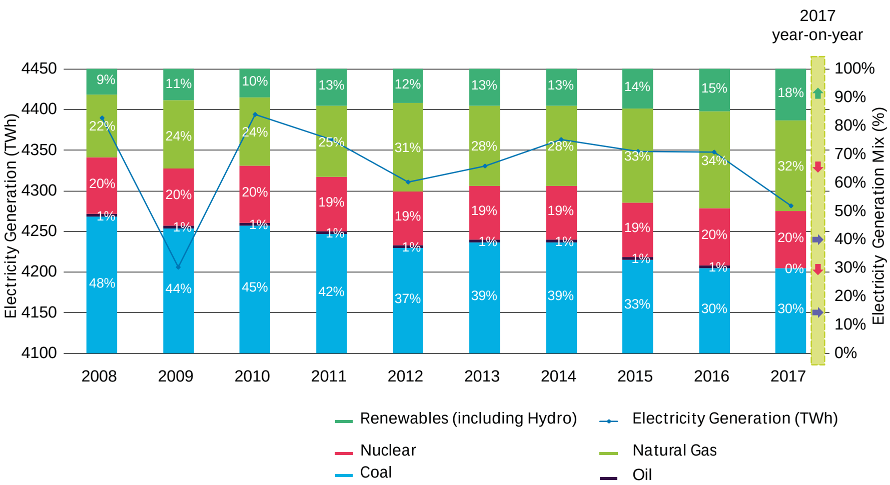
Growth in direct-use generation outpaces the growth in retail sales as a result of the adoption of rooftop photovoltaic and natural gas-fired combined heat and power

Electricity Generation - 2017 witnessed a historical leap in contribution from renewable energy

Renewable generation (including hydropower) soared an estimated 14.1% year-on-year in 2017, the highest ever one-year surge, as output increased by approximately 90 TWh

- Total renewable generation hit 717 TWh, driven by a rebound in hydro (up 13%, or 36 TWh) and new solar and wind build (driving generation up by 53 TWh, including estimates for small-scale solar).

Figure 3.2. US - Historical Electricity Generation Mix - Evolution, 2008-2017 (TWh)



Source: BNEF (February 2018), BP Statistical Review of World Energy, 2018

The moderate slump in contribution to total generation by natural gas (32%, from 34% in 2016) was an underlying factor in the growth in renewables

- In absolute terms, gas generation sank to 1,278 TWh from 1,391 TWh year-on-year. Recovering gas prices and an estimated 1.7% slump in total generation (including estimates for distributed solar) also contributed to a squeeze on gas plants.
- Total coal generation declined by 3% in 2017, but held steady at approximately 30% of total electricity generation.

Nonetheless, natural gas retained its top position. The continuing changes to the structural fundamentals of the US generation mix will likely cement its role here for some years: natural gas build boasted its best year since 2005, as new installations reached 10.7 GW in 2017

Electricity Generation - The projected mix of electricity generation is likely to be most affected by differences in fuel prices resulting in significant substitution by 2050

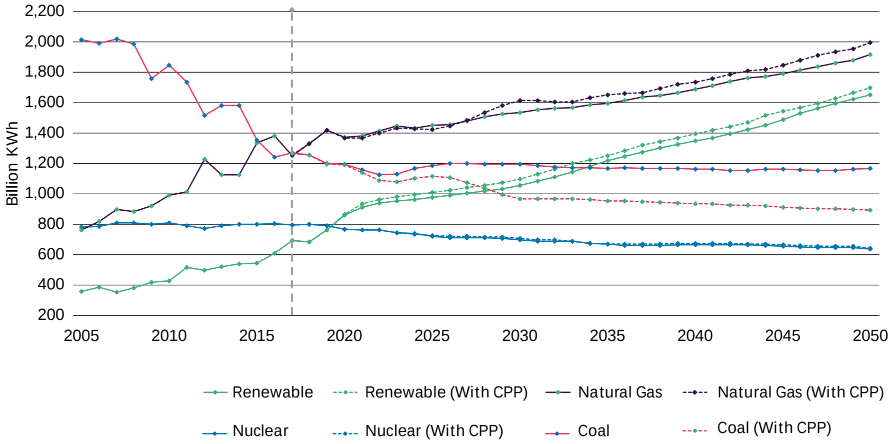
Fuel prices in the near term would drive the share of natural gas-fired and coal-fired generation

- In the longer term, the relatively low cost of coal would moderate the decline in coal-fired generation.
- Federal tax credits would drive near-term growth in renewables generation, moderating growth in natural gas-fired electricity generation.

The significant impact of the Clean Power Plan (CPP) on these projections

- Coal-fired generation would likely remain at a higher level than in the CPP scenario, but growth in natural gas and renewables generation capacity would dampen coal's growth.
- Near-term coal power plant retirements and competition with natural gas-fired generation would result in a marginal decline in coal-fired generation through 2022, before stabilizing at about 1,200 billion KWh through 2050.
- With CPP, coal-fired electricity generation would continue to decline through 2030 to about 1,000 billion KWh, before declining gradually through 2050.

Figure 3.3. US - Projected Mix of Electricity Generation (Select Fuel Type), 2005-2050 (billion KWh)



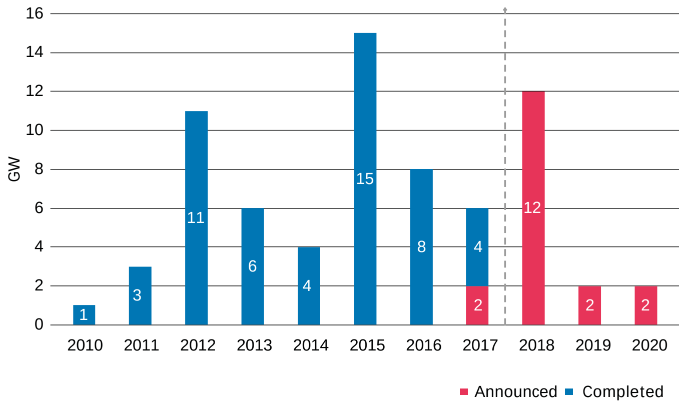
Source: US EIA Annual Energy Outlook, 2018

The share of natural gas-fired generation is likely to surge steadily relative to coal through 2050, minimally affected by the future of the CCP.

Driven by continued favorable economics, generation relative to alternative technologies would more than double between 2017 and 2050, with an average annual growth rate of 2.8%.

Capacity Change Projections - 2018 slated to be a near-record year with an estimated 12.5 GW of decommissioning, second only to 2015's high of 15 GW

Figure 3.4. US - Coal-fired Electricity Generation Capacity/ Retirements, 2010-2020 (GW)



Source: BNEF (February 2018)

Although the pace of coal retirements slowed in 2017, further acceleration is expected, driven by a gamut of factors

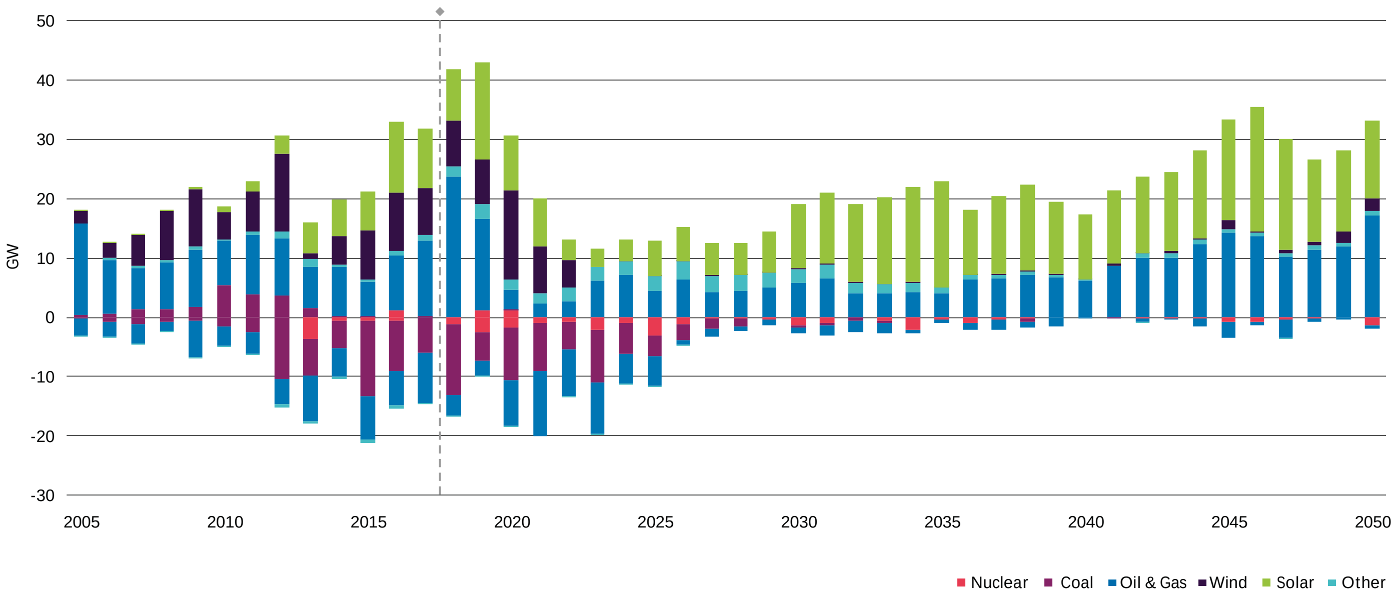
- Since 2011, the coal fleet has shrunk 15% from its peak size of 306 GW.
- Continued low gas prices and flat load have resulted in less runtime and lower revenues for coal plants.
- Additionally, aging boilers and rising operating costs, partly due to US EPA regulations covering sulfur, nitrogen, and mercury emissions from power plants, have forced many coal plants to retire earlier than originally planned.
  - The Mercury and Air Toxics Standards (MATS) is currently engaged in a lawsuit.
  - The New Source Performance Standards (NSPS) is still in effect, which sets emissions limits on new coal and gas plants.

Capacity Change Projections - Renewables and natural gas would comprise most of the capacity additions through 2050

Tax credit phase-outs and coal plant retirements likely to accelerate additions of near-term renewables and natural gas-fired capacity

- Most electricity generation capacity retirements are likely to occur by 2025, driven primarily by lower natural gas prices.
- Approximately 80 GW of new wind and solar photovoltaic (PV) capacity would be added from 2018–2021, driven by declining capital costs and the availability of tax credits.
- New wind capacity additions would decline in pace after the expiration of production tax credits in the early 2020s.
- Although the commercial solar investment tax credits (ITC) would be reduced and the ITC for residential-owned systems would expire, the growth in solar PV capacity is likely to continue through 2050 for both utility-scale and small-scale applications.

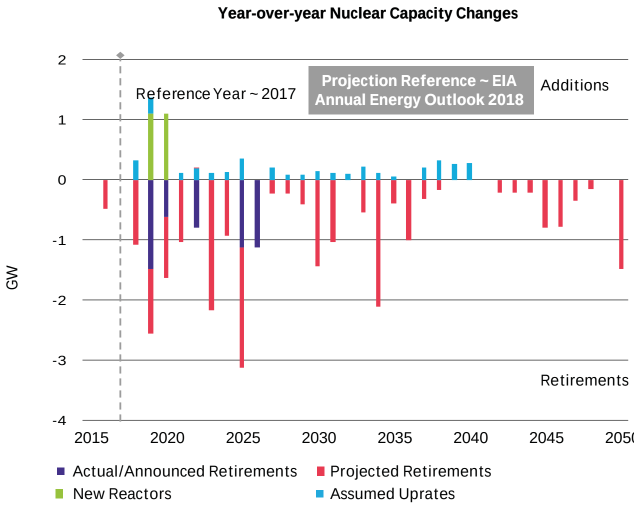
Figure 3.5. US - Annual Electricity Generating Capacity Additions and Retirements, 2005-2050 (GW)

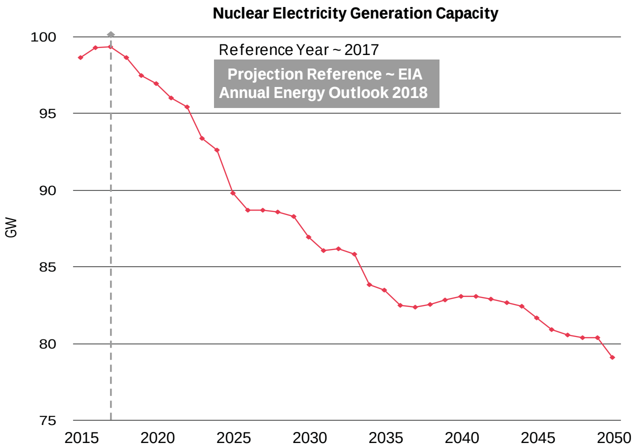


Source: US EIA Annual Energy Outlook, 2018

Capacity Change Projections: Nuclear capacity retirements are projected to accelerate with an expected slump in natural gas prices, power markets also indicating lower revenues in competitive power markets

Figure 3.6. US - Nuclear Capacity Changes - Outlook, 2015-2050 (GW)





Source: US EIA Annual Energy Outlook, 2018

The US EIA projects a steady decline in nuclear electricity generating capacity, from 99 GW in 2017 to 79 GW in 2050, a 20% decline, with no new plant additions beyond 2020

- Federal policies triggering further uncertainty
  - October 2017
    - The US Department of Energy (DOE) requested that the Federal Energy Regulatory Committee (FERC) create rules to subsidize "secure-fuel" power plants within competitive power markets that maintain 90 days' worth of fuel supplies on site.
    - The FERC ultimately declined to implement the proposed rulemaking, citing insufficient evidence that price distortions or retirements were affecting resiliency or reliability in the targeted power markets.
  - February 2018
    - Congress passed the Bipartisan Budget Act, which impacted on a range of energy incentives.
    - The budget law lifted the end-2020 in-service deadline for nuclear plants to qualify for the nuclear production tax credit.

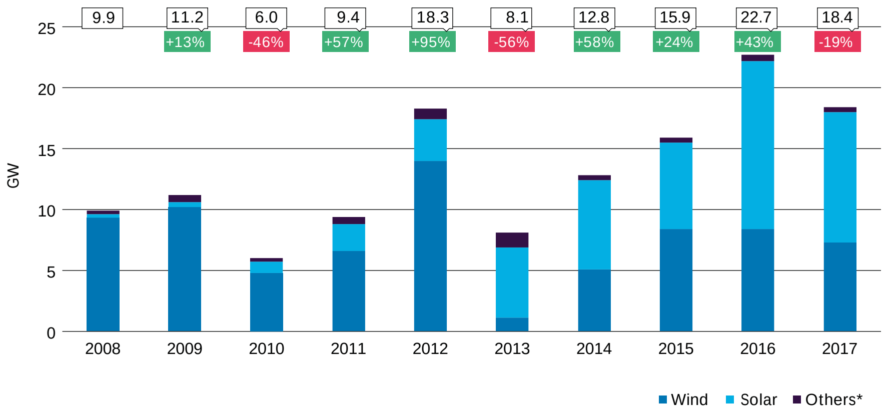
Renewable Capacity Build: Renewable capacity build witnessed a slump in 2017 after record-level additions in 2016, down 19% to 18.4 GW from 22.7 GW in 2016

2017 saw policy turbulence for the renewable industry, with tax reform, solar tariffs, and uncertainties about grid reliability and resilience

Some technologies have been idling without long-term policy support

- Solar
  - Utility-scale developers rebuilding project pipeline following the project commissioning rush in 2016
  - In 2017, the Southeast dominated utility-scale build with 2 GW, twice as much as California
  - Small-scale build driven by larger system sizes, offset by residential vendors scaling back growth plans.
- Wind
  - Developers aiming to bring projects online by the 2020 deadline to qualify for the full Production Tax Credit (PTC), with many waiting to take advantage of falling equipment costs.

Figure 3.7. US - Renewable Energy Capacity Build by Technology, 2008-2017 (GW)



Source: BNEF - Sustainable Energy in America Factbook, 2018
* Hydro, Geothermal, Biomass, Biogas, Waste-to-Energy
All values are shown in AC except Solar, which is included as DC capacity
Numbers include Utility-scale (>1MW) projects of all types, Rooftop Solar, and Small and Medium-sized Wind

In cumulative terms, growth has been driven by wind and solar, which together jumped 471% since 2008, while other technologies remained flat, in part due to weaker tax policy support

Renewable Capacity Spend: Asset finance for solar witnessed a slump for a consecutive year, while wind pipeline remained strong

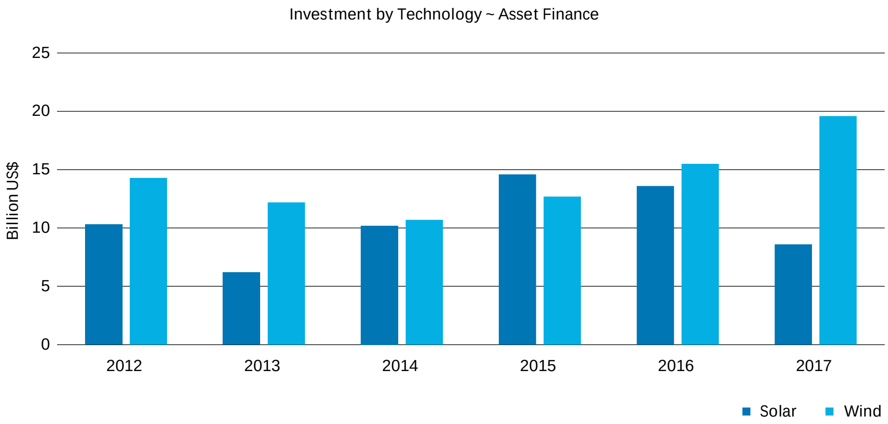
Solar

- Asset finance for utility-scale solar declined for the second consecutive year, dropping to US$8.6 billion, correlating with falling technology costs.
- The 2017 levels are indicative of utility-scale build in 2018, as most assets are typically financed a year prior to commissioning.

Wind

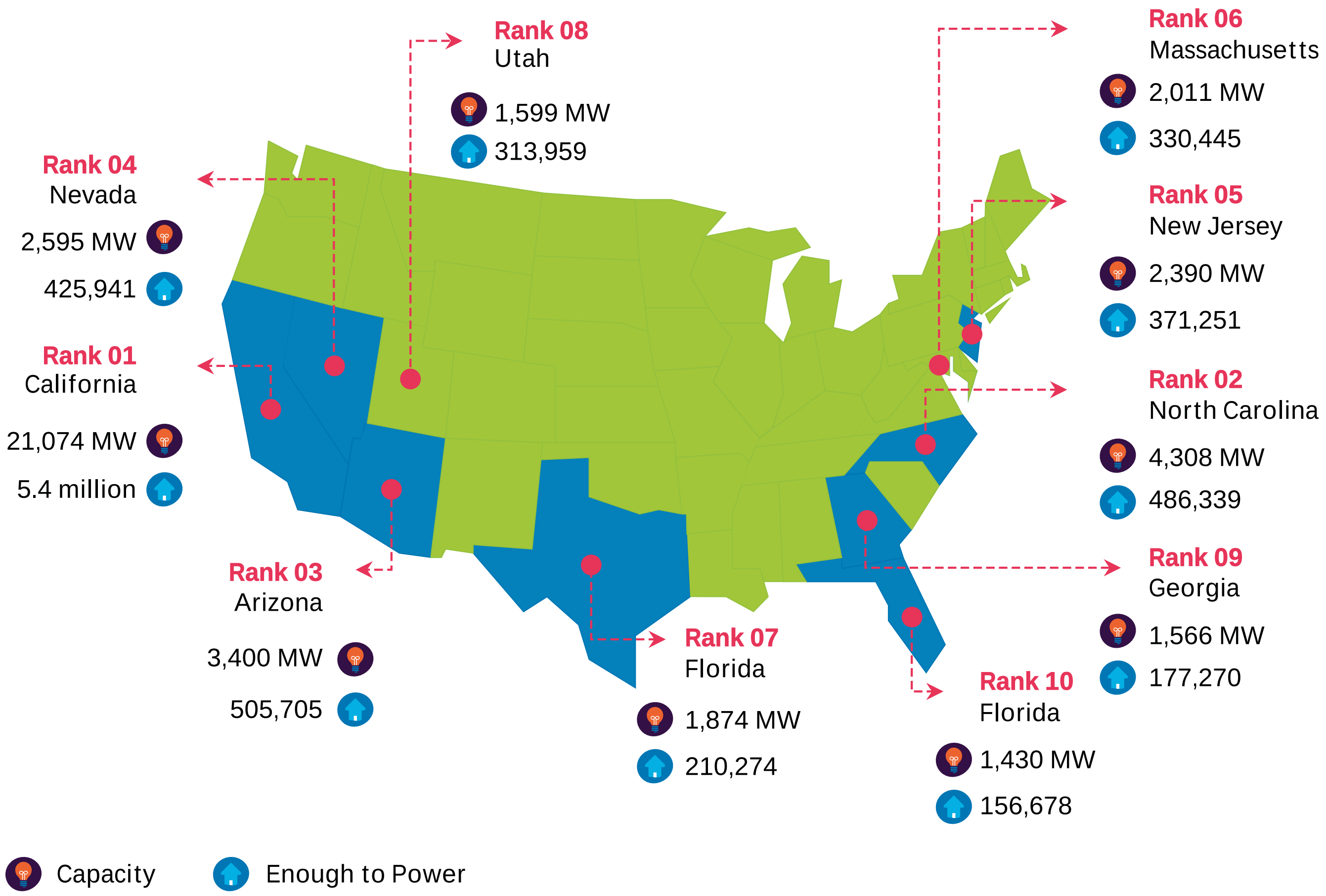
- A large portion of the US$15.5 billion in financing (2016) and the record US$19.6 billion (2017) relate to projects to be commissioned in 2018-2020.
- Asset financing has tracked closely with the status of the Production Tax Credit (PTC), which has expired and been retroactively extended multiple times since 2012.

Figure 3.8. US - Asset Finance for Large-scale Solar and Wind Projects, 2012-2017 (US$ billion)



Source: BNEF - Sustainable Energy in America Factbook, 2018
Note: Solar=Solar Thermal, Utility-scale PV - Wind=Large-scale Wind

Figure 3.9. US - Top 10 Solar States by Capacity, 2017 (MW)

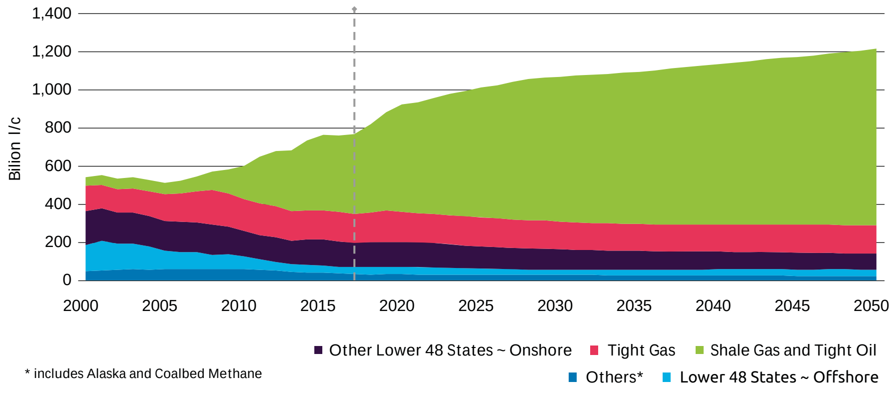


Source: Solar Energy Industries Association

Natural Gas Production: The surge in natural gas production is the outcome of continued advances of shale gas and tight oil plays

"Production from shale gas and tight oil plays as a share of total US natural gas production is projected to continue to grow in both share and absolute volume because of the large size of the associated resources, which extend over more than 500,000 square miles" (EIA, 2018)

Figure 3.10. US - Natural Gas Production by Type, 2000-2050 (billion cubic meter)



Source: US EIA Annual Energy Outlook, 2018

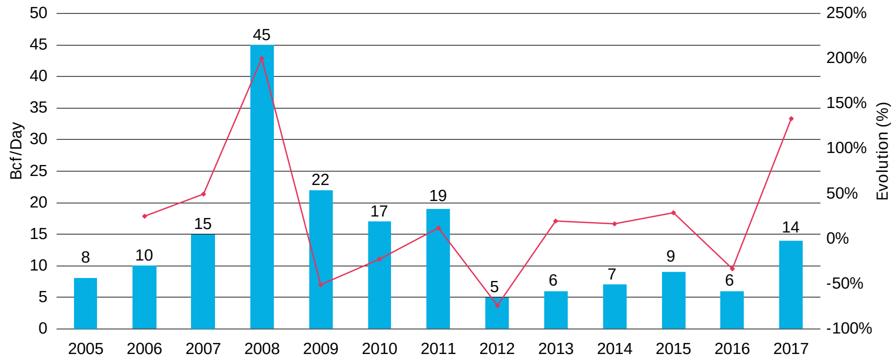
- Over the projection period, offshore output is expected to remain relatively flat as production from new discoveries are expected to offset declines in legacy fields (EIA, 2018).
- Continued development of the Marcellus and Utica plays in the East would drive growth.
- Unfavorable economic conditions would likely impact on coalbed methane through 2050.

Sustained advances in technology and industry practices are expected to lower costs and increase the volume of recovery per well

Natural Gas Pipeline Capacity: The planned capacity addition for 2016 was marginally missed due to a number of delays, pushing the online date of many substantial projects from 2015-2016 into 2017-2018

The short-to-mid term is scheduled to see major increases in pipeline capacity growth

Figure 3.11. US - Natural Gas Transmission Pipeline Capacity Additions, 2005-2017 (billion cubic feet per day)



Source: BNEF - Sustainable Energy in America Factbook, 2018

- Takeaway capacity from the Appalachian Basin expanded by 4.1 Bcf/day in 2017, but only 0.04 Bcf/day (1%) of this brings gas into New England (through the Atlantic Bridge Expansion project on the Algonquin pipeline).
- As a result, natural gas delivery into New England remains constrained.

By the end of 2018, EIA (2018) expects pipeline capacity into the South Central region to reach ~19 Bcf/day, amid a shift from being a source of natural gas supply to a source of growing demand, reversing the historical flows of natural gas in the Lower 48 states.

Similar growth is expected in the North East, with more than three times the takeaway capacity as at the end of 2014 slated to come online by the end of 2018.

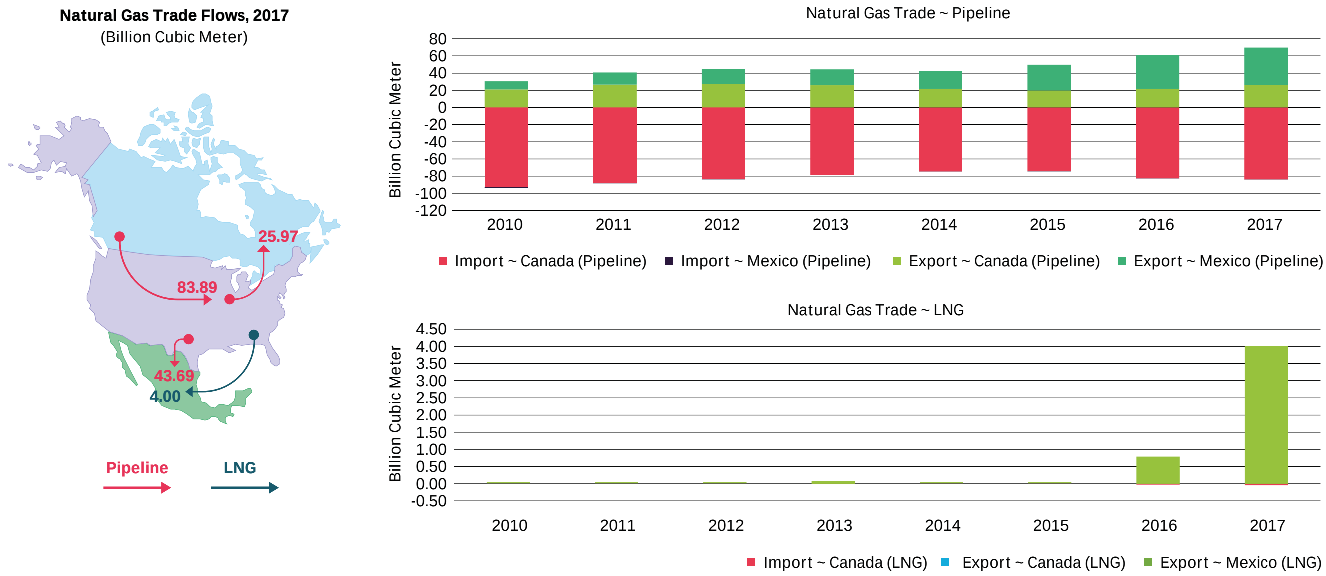
Currently, the growth of natural gas production in the Marcellus and Utica basins in Pennsylvania, Ohio, and West Virginia is constrained by the lack of available takeaway pipeline capacity to move it to new markets

Natural Gas Trade: 2017 marked the US as a net exporter since 1957, driven primarily by sustained growth in production

Continued production growth, especially from the Appalachia region, along with new pipeline capacity coming online, or slated to come online by the end of 2018, indicate a surge in delivery to regions in the Midwest and Northeast, thereby displacing Canadian imports and increasing US pipeline exports to Canada

- Imports from Canada, primarily from the Western region, remain relatively stable.
- Bilateral trade between Canada and US is dominated by pipeline shipments, with 97% of all US imports in 2017 coming from Canada.
- Pipeline capacity into Mexico has witnessed a surge, driven primarily by growth in demand for natural gas from Mexico's power sector and favorable prices compared with LNG shipment.

Figure 3.12. US - Natural Gas Trade with Canada and Mexico, 2010-2017 (billion cubic meter)



Source: EIA, BP Statistical Review of World Energy, 2018

Besides the Sabine Pass LNG Terminal and Cove Point LNG Facility, four other LNG projects are under construction and expected to increase US liquefaction capacity from 3.6 Bcf/day to 9.6 Bcf/day by the end of 2019, further increasing natural gas exports

Natural Gas Storage: Relatively little new underground natural gas storage capacity was built in the Lower 48 states over the last four years

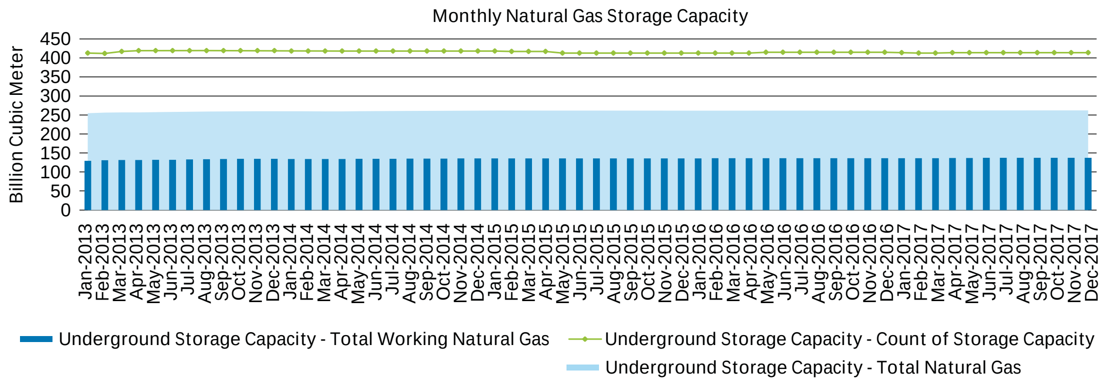
In 2017, design capacity grew by about 1%, and demonstrated maximum working gas volume (demonstrated peak) fell by 1%

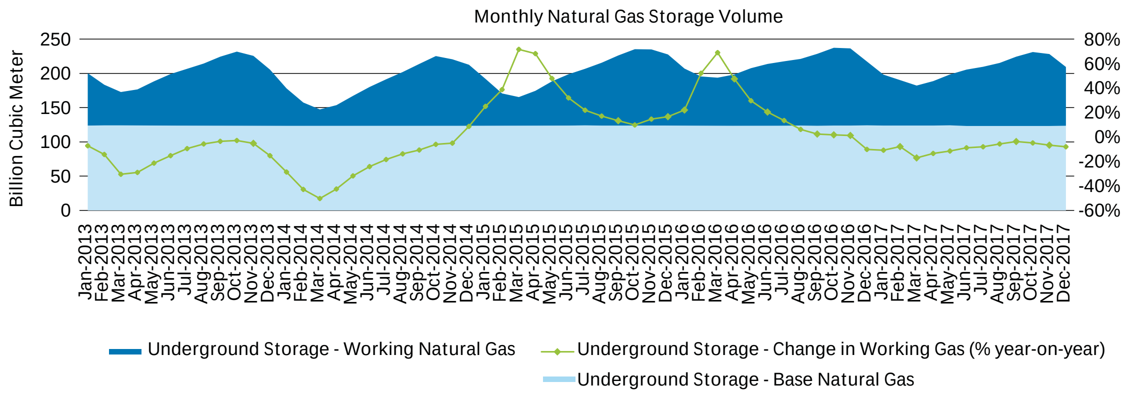
- At a national level, design capacity increased by 34 Bcf (0.7%) between November 2016 and November 2017, driven by expansion to existing facilities, primarily in the East storage region, where design capacity grew by 30 Bcf (2.9%) in 2017.

- Several facilities in Ohio and West Virginia expanded in 2017 to accommodate increasing levels of natural gas production in the Appalachian Basin.

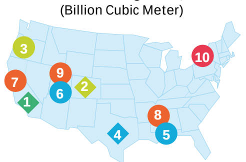
- Demonstrated peak decreased by 46 Bcf (1.0%) in 2017 (over the most recent five-year period - December 2012 to November 2017, i.e. beginning of each yearly heating season).
  - 2012 witnessed high inventory levels because of record warm weather.

Figure 3.13. US - Historical Monthly Natural Gas Storage - Capacity and Storage Volume, 2013-2017 (billion cubic meter)





US - Natural Gas Storage Plan, 2017-2018
(Billion Cubic Meter)



Year in Service - Estimated year that the storage facility or expansion will be completed
◇ 2017
○ 2018

Operational
1.CrowvilleSalt Dome Project Cavern 2, LA ~ 0.12 MCM* (Perryville Gas Storage)

Construction
2.East Cheyenne Phase 2: Lewis Creek Field, CO ~ 0.35 MCM* (NGS Energy)
3.Mist Storage Expansion Project, OR - (Northwest Natural Gas)

Planned
4.Golden Triangle Storage Cavern 3/4, TX ~ 0.63 MCM* (AGL Resources)
5.D'LoGas Storage Cavern 3, MS - (D'LoGas Storage)
6.Magnum Gas Storage Project 1, UT ~ 0.10 MCM* (Magnum Gas Storage)

On Hold
7.Aliso Canyon Expansion , CA - (Southern California Gas)
8.D'LoGas Storage Cavern 1/2, MS - (D'LoGas Storage)
9.Magnum Gas Storage Project 2/3/4, UT ~ 0.29 MCM* (Magnum Gas Storage)

Terminated
10.Seneca Lake Gallery 2 Expansion, NY - (Arlington Storage)

*Note: * Working Gas plus Base Gas capacity in Million Cubic Meters (MCM)*

Source: EIA

The mild winter in early 2017 limited natural gas storage withdrawals, with the first-ever net injection recorded in the month of February. As a result, natural gas storage inventories ended the injection season lower than last year, but higher than the previous five-year average.

However, the end of 2017 witnessed cold weather not seen since the 2013 - 2014 winter, thereby dipping the storage levels and indicating that storage deficit has started to slightly grow again, and the current gas market could easily flip.

Capacity Change Projections - Hydro is the dominant source of electricity in Canada accounting for nearly 60% of installed capacity and generation

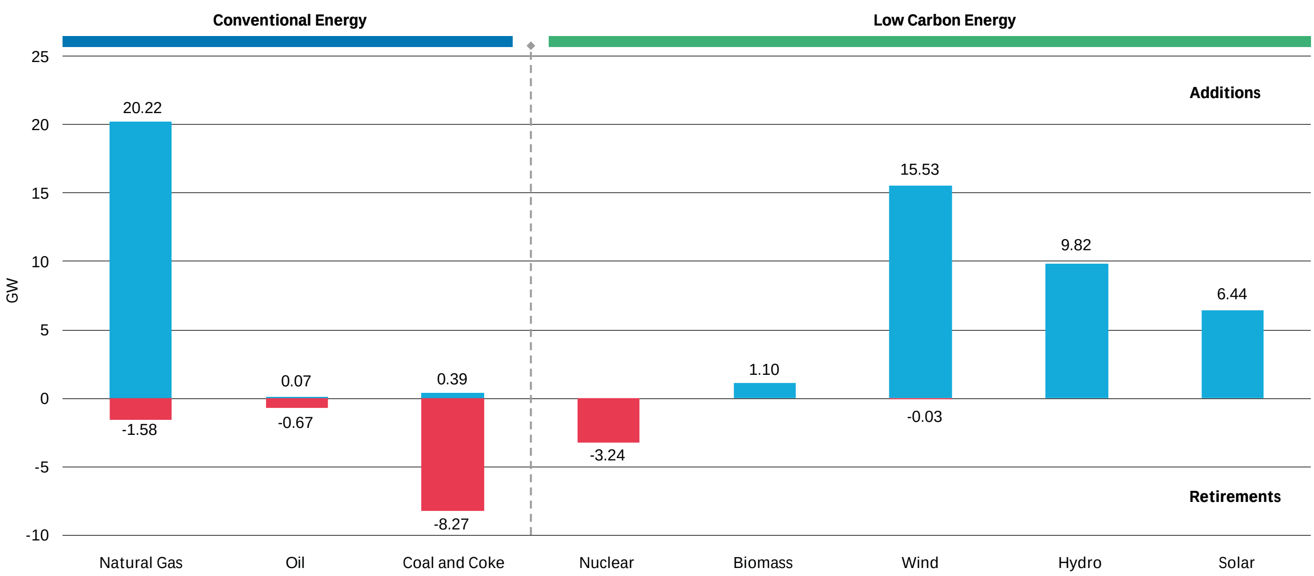
With its ability to store water and regulate output as needed, Canada's hydro capacity also facilitates the development of intermittent renewable resources such as wind and solar

- Hydro capacity, including small hydro and run-of-river facilities, is slated to increase from 80 GW in 2016 to 89 GW in 2040.
- However, due to faster growth in other forms of generation, such as wind and natural gas, the share of hydroelectricity would decline from 58% in 2016 to 56% in 2040.

Over the past 5 years, policy incentives and declining costs have spurred significant growth in the use of non-hydro renewable resources

- Non-hydro renewable capacity would continue to grow, more than doubling to 39 GW by 2040.
- Recent cost declines, particularly for solar, continue to play a significant role in increasing renewable capacity as do various government plans and policies.
- This includes Alberta's Renewable Energy Program, which adds 5 GW of renewable capacity by 2030, and Saskatchewan's goal of increasing its renewable capacity to 50% of total capacity by 2030.
- Annual nuclear generation would likely decline from 92 TWh in 2016 to 82 TWh in 2040 due to the shutdown of Ontario's Pickering Nuclear facility in 2024.
- As a result of relatively low fuel prices and upfront capital costs, natural-gas fired capacity would replace much of the coal capacity that is retired by 2040.

Figure 3.14. Canada - Projected Capacity Additions and Retirements by 2040 (GW)



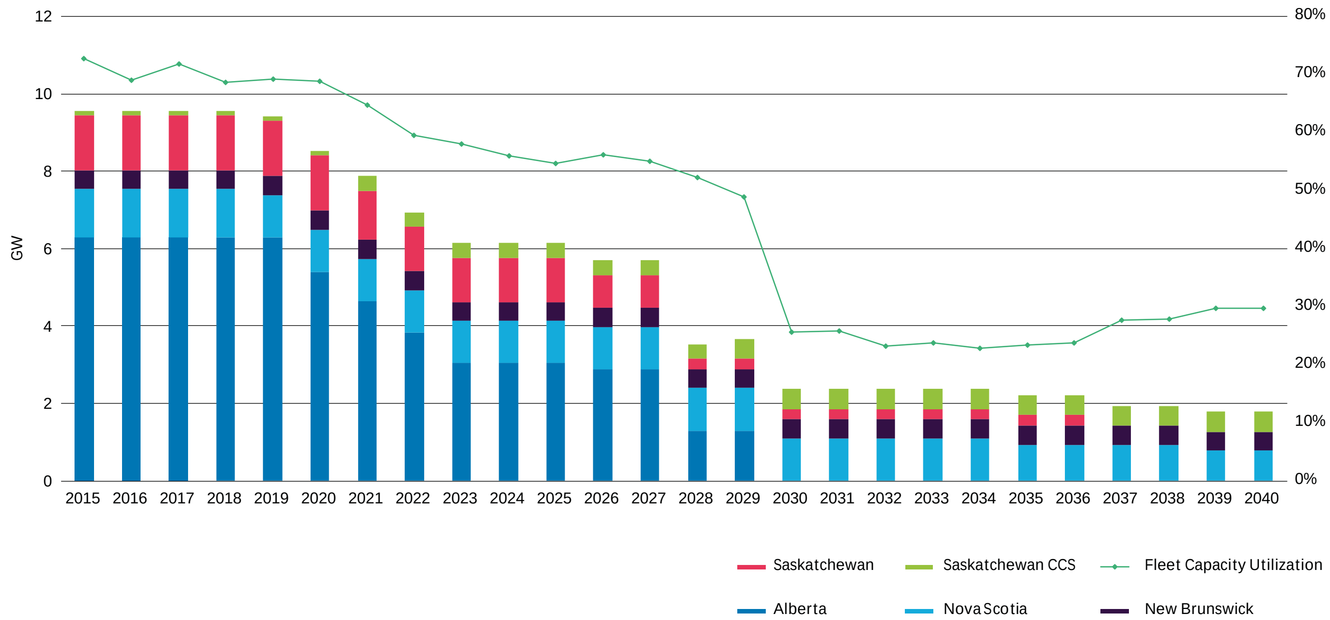
Source: NEB (October 2017)

Capacity Change Projections - Canada's federal regulations apply a strict emissions performance standard to coal units that have reached the end of their useful lives, essentially requiring them to be shut down or retrofitted with CCS technology

Multiple initiatives, at both federal and regional level continue to indicate a considerable decline in coal capacity by 2040

- In 2015, Alberta announced plans to accelerate the phase out of its coal fleet, requiring traditional coal plants to be phased out by 2030.
- In autumn 2016, the federal government announced its intention to amend its existing coal regulations to phase out traditional coal-fired facilities by 2030 rather than at the end of their economic lives.

Figure 3.15. Canada - Coal-fired Generating Capacity by Province, 2015-2040 (GW)



Source: NEB (October 2017)

Driven by equivalency agreements in Saskatchewan, New Brunswick and Nova Scotia, part of the traditional coal capacity would remain in place after 2030, to be used sparingly till 2040

Ideological deterrents and the way forward

The current political climate, further aggravated by a persistent 'not-in-my-backyard' sentiment, has made it difficult, and often financially infeasible, for infrastructure builders to keep pace with energy generation levels. The uncertainty underlying the federal regulatory process is a deterrent to development, thereby hindering the possibility of greater economic growth.

However, amid all the ambiguity, continued and growing interest in accommodating distributed energy resources highlights a move to put modern grid capabilities to the test

Continued penetration across states laying the groundwork

Arizona	California	Hawaii	New York	Illinois
Value-of-solar established an alternative to net energy metering (NEM), and the recent APS rate settlement involves transitioning all new retail customers to a time-of-use (TOU) or demand-based rate by default, beginning in 2018	Residential Rate Reform includes implementing a new minimum bill and transitioning all residential customers to opt-out TOU rates, beginning in 2018	Grid Modernization Strategy prescribes aggressive investments in network infrastructure upgrades to accommodate extraordinary recent growth in DERs, with far more expected in order to achieve 100% renewables by 2045	Reforming the Energy Vision is proceeding rapidly, transforming the utility business model and delivering on aggressive grid modernization initiatives, to set the stage for a distributed low-carbon electricity system in the future	Recent legislative developments are combining elements of traditional ratemaking with performance-based rates to create incentives for utilities to make incremental network upgrades, while directly encouraging DER investments via NEM and renewable portfolio standard (RPS) carve-outs for Illinois-sited resources

4-Supply & Final Customer

US retail electricity sales fell by 80 billion kWh in 2017, to the second-lowest level since the recession in 2009

- Most of the year-over-year changes in sales in 2017 were attributable to changes in weather.
- Other factors such as electricity prices, energy efficiency, and macroeconomic cycles also played a significant role.
- Consumer spending on electricity was the lowest ever recorded, while the share of household expenses on energy costs also drifted near an all-time low.

The upsurge in transmission investment is being driven by the fundamental aim of providing reliable, affordable, and safe power via improved grid operations and clean energy

- The driving factors include the need to replace and upgrade aging power lines, resiliency planning in response to potential threats (both natural and caused by humans), the integration of renewable resources, and congestion reduction.
- The corporate renewable PPA trend is likely to continue as corporate buyers and nonprofit stakeholders organize, share lessons learned, and set aggressive goals.

Prices remained subdued in 2017 but, unlike in 2016, average retail prices witnessed a modest rise across most regions

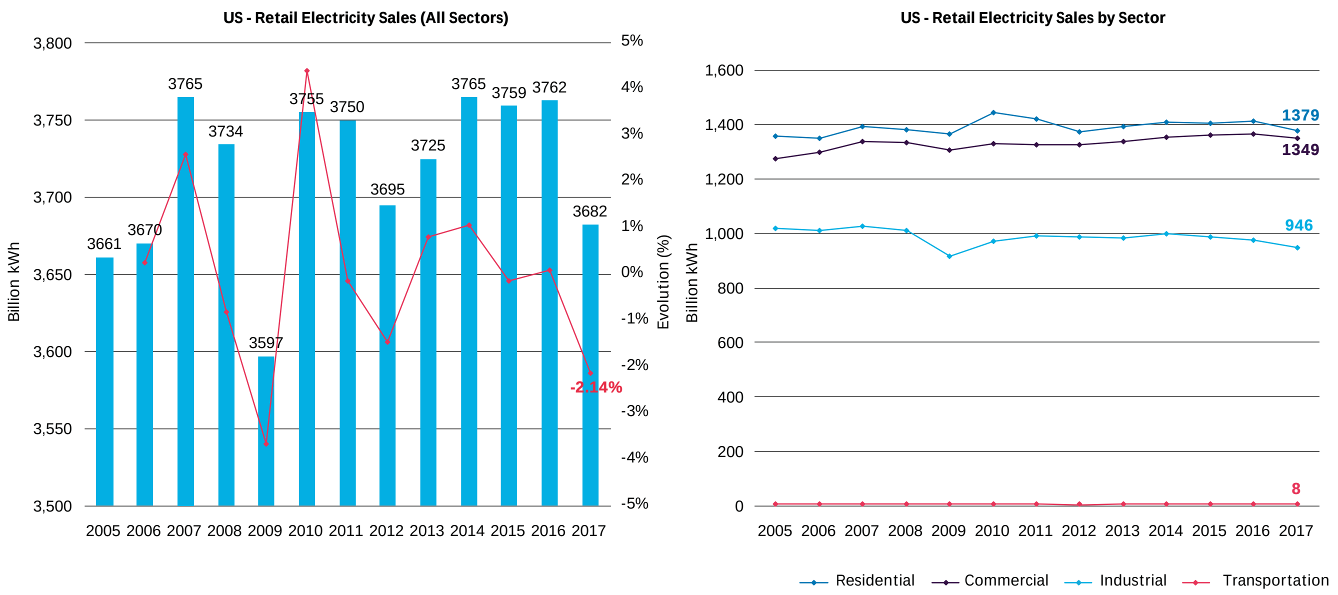
- The surge was primarily driven by fuel cost and infrastructure expenditure.
- The increase in retail prices was offset by lower average usage of electricity, due to milder weather.
- The Pacific states of Alaska and Hawaii have the highest residential electricity prices in the nation.

Natural gas prices have witnessed variances relative to competitiveness with other generation fuels

- Higher natural gas prices contributed to a 6% year-on-year decline in natural gas consumption for power generation, as coal became more competitive with natural gas.

Retail electricity: In 2017, US electricity sales plummeted, to the second-lowest level since the recession in 2009

Figure 4.1. US - Retail Electricity Sales and Sales By Sector, 2005-2017 (billion KWh)



Source: US EIA (July 2018)

US retail electricity sales fell by 80 billion kWh in 2017, with total sales identical to the levels witnessed in 2006, reflecting lower retail sales in the residential, commercial, and industrial sectors

- Apart from, factors such as electricity prices, energy efficiency, and macroeconomic cycles playing a role in the use of electricity in each sector, most of the year-over-year changes in sales in 2017 were attributable to the weather.
- Cooling degree days (indicator of cooling-related energy demand) were 9% lower in 2017 year-over-year, indicating a cooler summer and less demand for air conditioning.
- Heating degree days (indicator of heating-related energy demand) were 1% lower in 2017 year-over-year; in the Southern census region (from Texas to Delaware), heating degree days were 8% to 10% lower than in 2016.

Energy efficiency in action

Consumer spending on electricity was the lowest in history, while the share of household expenses on energy costs also drifted near an all-time low

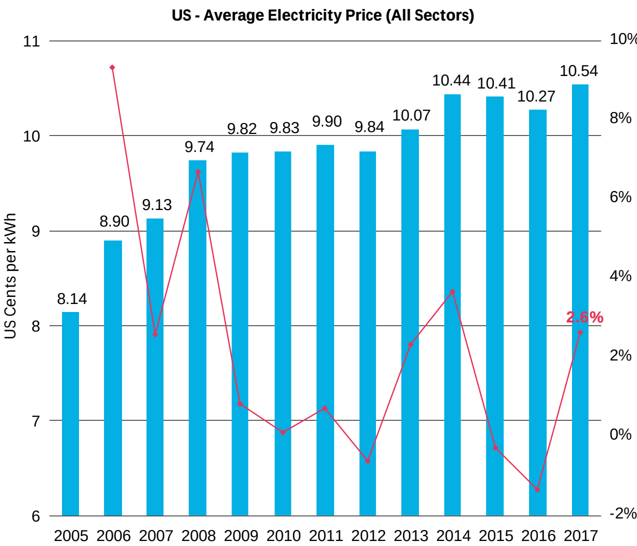
- Consumer spending on electricity contracted marginally in 2017 to 1.3% of personal consumption expenditure, down from 1.4% in 2016.
- Sustained improvements in energy efficiency and the continued availability of cheaper energy sources contributed to keeping electricity costs a modest part of total consumer expenditure.
- Electricity off-takers sourced renewables at ever cheaper price points.
- The most competitive power purchase agreements came in at just over US$20/MWh for solar, while wind power purchase agreements executed in the US wind belt averaged an estimated US$17/MWh in 2017.

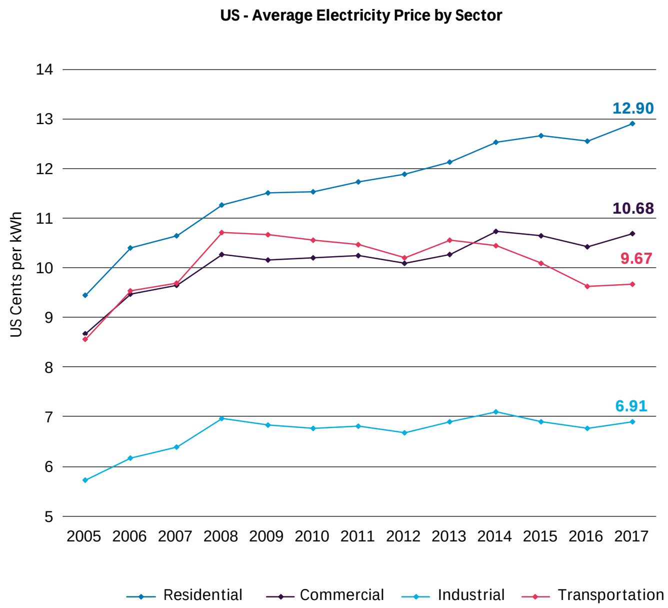
Electricity Prices: Prices remained subdued in 2017 but, unlike in 2016, average retail prices witnessed a modest rise across most regions

Retail electricity prices have increased across the US, despite the drop in electricity usage

- Retail residential electricity prices have witnessed a 4% rise over the last decade, with sharper increases across some areas, e.g., prices in Oregon have surged by ~40% over the last 10 years, while marginal changes have been reported in Florida.
- In 2017, prices witnessed a 2.6% increase, driven primarily by two factors.
  - The early 2017 increase in residential electricity prices can be attributed to the rising costs of fuels used for generating power, e.g., H1 2017 natural gas prices for electric generators were 37% higher year-on-year.
  - Power utilities continued the trend of increasing their expenditure on infrastructure for the transmission and distribution of electricity.

Figure 4.2. US - Average Electricity Price and Prices By Sector, 2005-2017 (2017 cents per KWh)





Source: US EIA (July 2018)

The increase in retail prices was offset by lower average usage of electricity, due to milder weather

Electricity Prices: Hawaii has the most expensive residential electricity but expenditure is highest in South Carolina

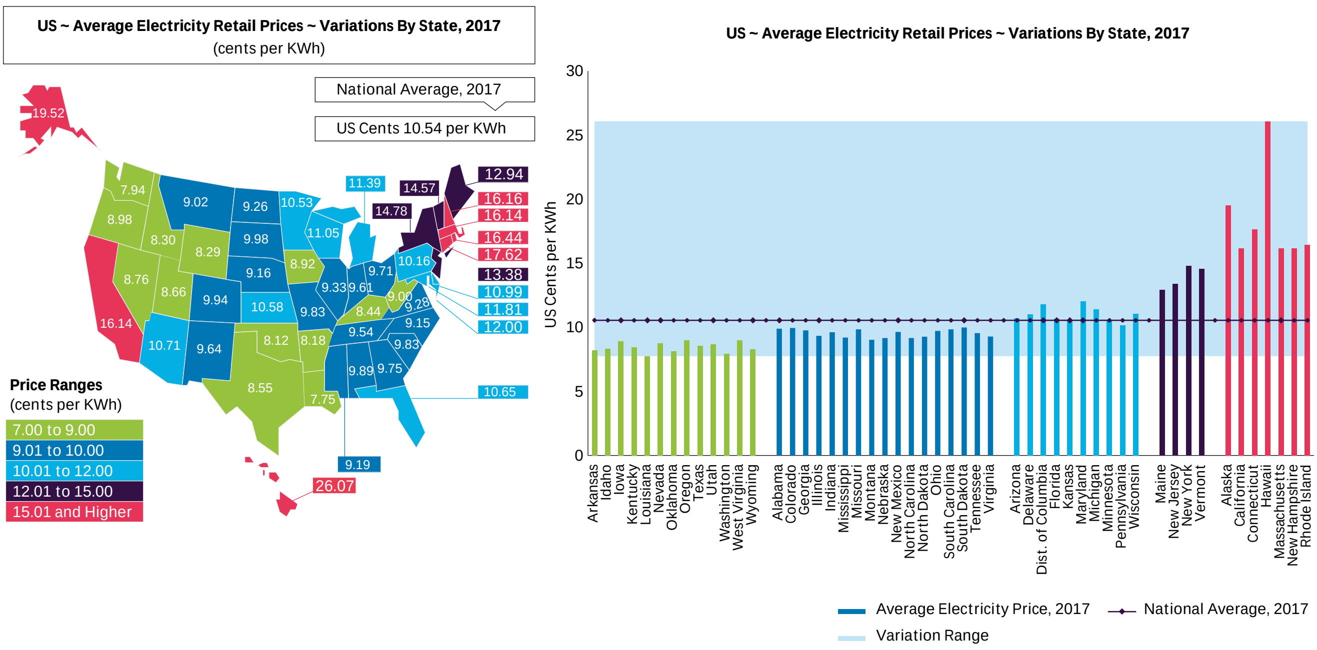
On average, electricity prices certainly seem to be on an upwards trajectory, with notable variations across states

- Prices in the East North Central and West North Central regions have risen faster and more steadily than in other regions.
- Prices in the West South Central states have remained comparatively low.

The Pacific states of Alaska and Hawaii have the highest residential electricity prices in the nation

- Hawaii's high prices are primarily driven by higher fuel costs, primarily oil, and the fixed price of infrastructure.

Figure 4.3. US - Average Electricity Price - Variations By State, 2017 (2017 cents per kWh)



Source: Global Energy Institute (February 2018)

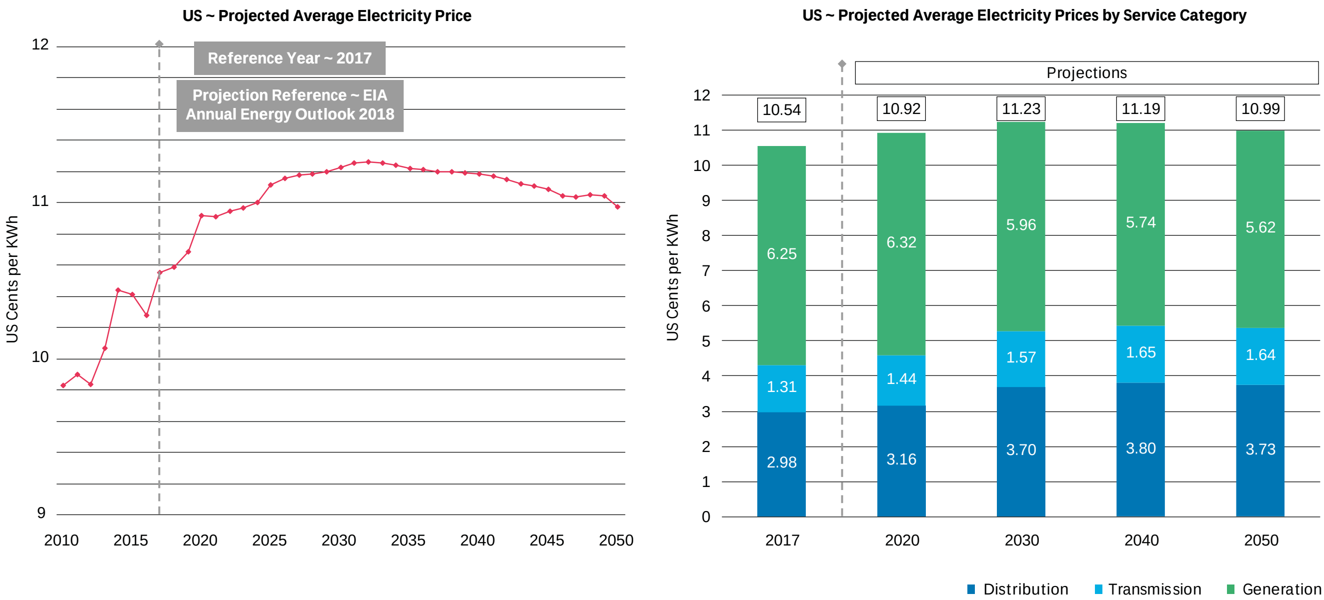
Although the energy mix plays a significant role in state electricity prices, energy-limiting policies in some states act to artificially elevate prices, making the price of electricity much more burdensome for consumers and businesses

Electricity Prices: Falling generation costs are expected to be offset by increasing transmission and distribution costs through 2050

Natural gas prices are likely to have the highest impact on electricity price differences through 2050

- Average electricity prices are expected to remain relatively flat, ranging between 10.6 and 11.8 cents per kWh through 2050.
- Generation costs represent the largest share of the price of electricity, and are projected to decrease by 10% from 2017 to 2050 in response to continued low natural gas prices and increased generation from renewables.
- Transmission and distribution costs are likely to increase by 24% and 25% respectively by 2050, driven by the need to replace aging infrastructure and upgrade the grid to accommodate changing reliability standards.

Figure 4.4. US - Projected Average Electricity Price and Prices By Service Category, 2010-2050 (2017 cents per KWh)



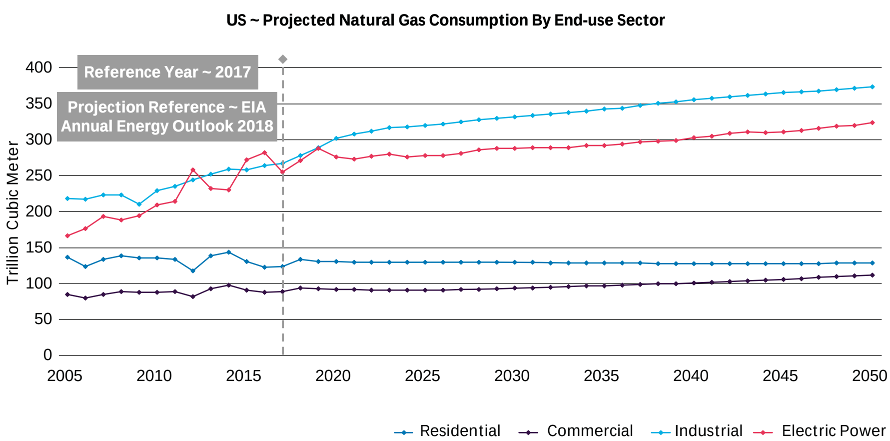
Source: US EIA Annual Energy Outlook, 2018

Natural Gas Consumption Projections: Growth is likely to be driven by industry and the demand for electricity

Consumption in the residential and commercial sectors would remain relatively flat through 2050

- Natural gas consumption for electricity generation is expected to increase, but at a slower rate than in the industrial sector, supported by the scheduled expiration of renewable tax credits in the mid-2020s.
- Efficiency gains and population shifts that counterbalance demand growth would keep residential and commercial sector consumption relatively flat.
- Although the overall share remains relatively small, use in the transportation sector, particularly for freight and marine shipping, is expected to increase.

Figure 4.5. US - Projected Natural Gas Consumption By End-use Sector, 2005-2050 (trillion cubic meter)



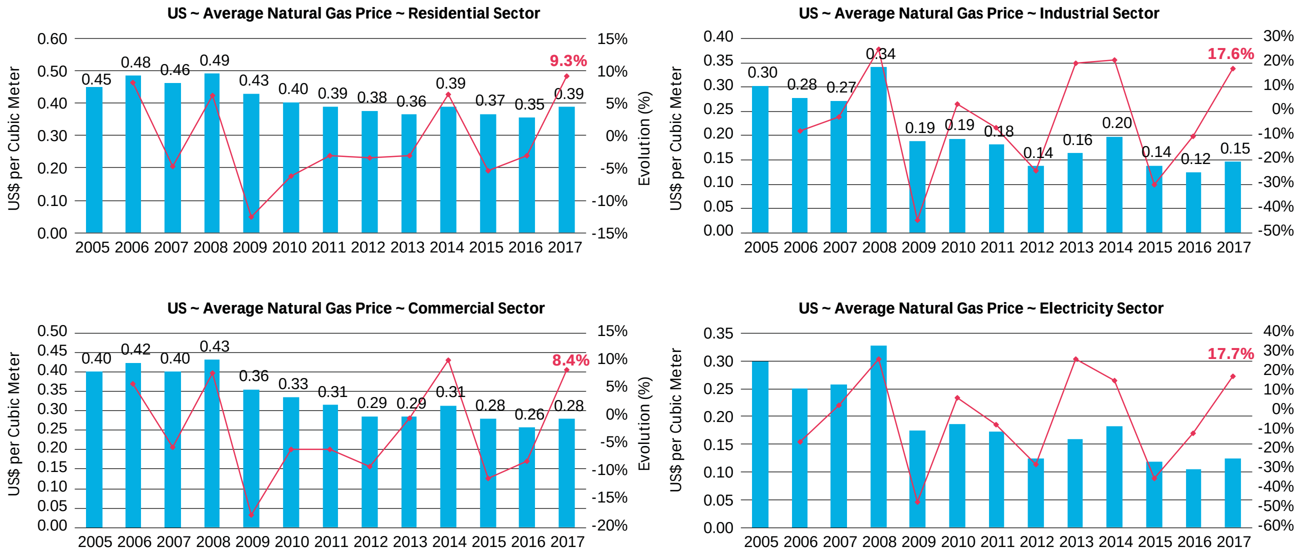
Source: US EIA Annual Energy Outlook, 2018

Natural Gas Prices: Of the two largest sectors of natural gas consumption, industry and electricity, the latter is more responsive to prices, due to more fuel options

Natural gas prices have witnessed variances relative to competitiveness with other generation fuels

- Higher prices in 2017 contributed to less natural gas consumption for power generation.
- In the Northeast, which tends to have large price spikes during periods of cold weather, new pipeline capacity, along with warmer winter weather, helped to moderate price volatility.
- However, record cold temperatures at the end of December 2017 in the Eastern US drove record demand for natural gas and significant price spikes at many trading locations.
- Until the last few days of 2017, relatively warm winter weather in the rest of the US limited natural gas consumption growth in the residential and commercial sectors, year-over-year.
- However, higher natural gas prices contributed to a 6% year-on-year decline in natural gas consumption for power generation, as coal became more competitive with natural gas.

Figure 4.6. US - Average Natural Gas Price By End-use Sector, 2005-2017 (US$ per cubic meter)



Source: US EIA (July 2018)

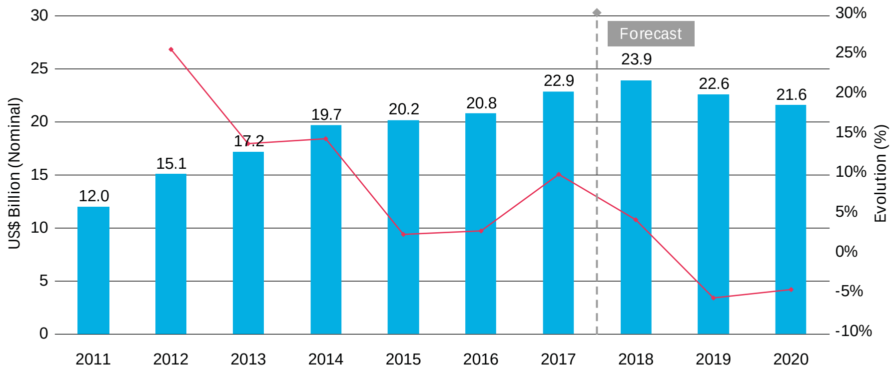
Overall prices at key regional trading hubs were less volatile year-over year, as pipelines that came online throughout the year eased some infrastructure constraints that affect regional prices

Transmission Investment - Current capital expenditure plans suggest that investment will peak at US$23.9 billion in 2018

The upsurge in investment is being driven by the utility's fundamental aim of providing reliable, affordable, and safe power via improved grid operations and clean energy

- According to the Edison Electric Institute, investor-owned utilities and independent transmission developers spent an estimated US$22.9 billion on electricity transmission in 2017, a 10% rise year-over-year, and a 91% rise since 2011.
- Driving factors include the need to replace and upgrade aging power lines, resiliency

Figure 4.7. US - Transmission Investment by Investor-owned Utilities and Independent Transmission Developers, 2011-2020 (US$ billion)



Source: BNEF - Sustainable Energy in America Factbook, 2018 planning in response to potential threats (both natural and caused by humans), integration of renewable resources, and congestion reduction.

- The Midwest's system operator, MISO, is overseeing a large build-out of its wires infrastructure, seeking to replicate the success Texas had in reducing wind curtailment rates.
- Five of the 17 transmission projects under development through MISO's Multi Value Project have already come online, alleviating bottlenecks and cutting curtailment rates by 21% between 2015 and 2016.

- Gas transmission infrastructure is also set to expand, after prolonged delays on several major pipelines caused by the lack of a Federal Energy Regulatory Commission (FERC) quorum, project-specific setbacks, and regulatory hurdles.

Topic Box 4.1: Corporations are driving the transformation to a resilient energy supply, demanding progressively cleaner energy and seeking energy efficiency gains

Sustainability continues to drive activity, although many large corporations have met their medial targets domestically and are now looking to sign deals internationally

- Among the top reasons for renewable energy procurement by corporations, addressing climate goals and demonstrating corporate leadership are the most prominent.
- The majority of corporate renewable PPA contracts are for wind resources, due to their competitive economics:
  - Apple signed the largest PPA ever in the US between a corporation and a utility, a 235 MW PV plant with NV Energy under the utility's GreenEnergy Rider
  - Google signed PPAs for 0.54 GW, making further progress to offset 100% of its global electricity demand.
- A recent Moody's report cites three common attributes among corporate renewable buyers: high credit ratings, significant financial flexibility, and robust liquidity.
- Green tariff programs made up 19% of corporate procurement activity in 2017, as companies are increasingly looking to source clean energy within the same service territory as their load.

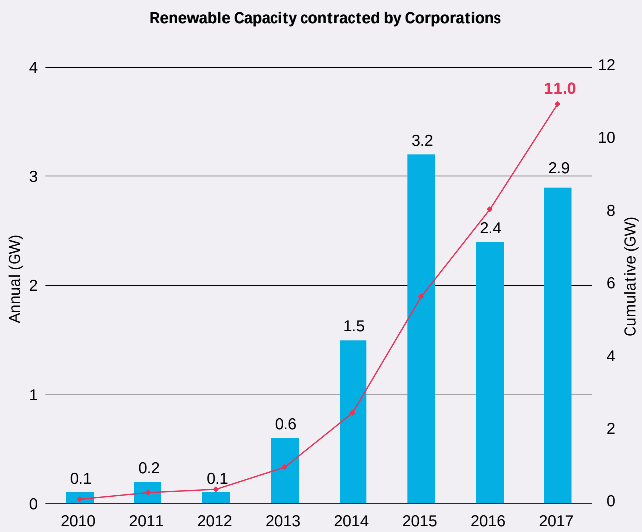
The corporate renewable PPA trend is likely to continue as corporate buyers and nonprofit stakeholders organize, share lessons learned, and set aggressive goals

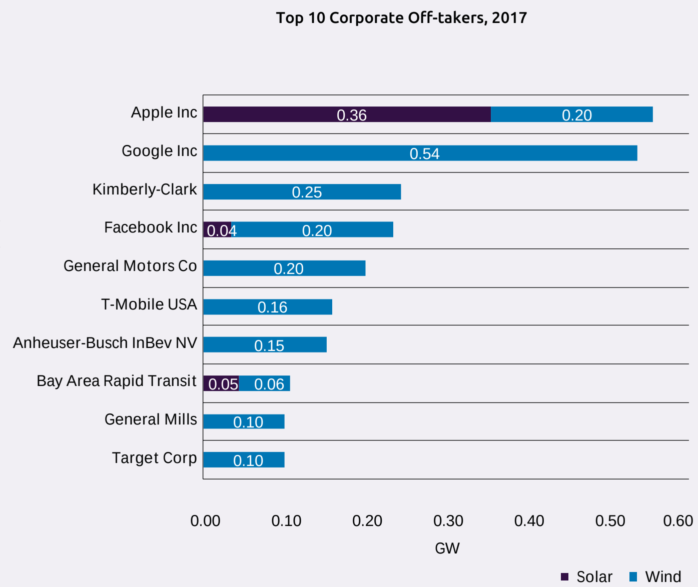
- The Renewable Energy Buyers Alliance seeks to help corporations purchase 60 GWs of additional renewable energy in the US by 2025.

The 'EP100', an initiative launched in 2016 through which companies promise to double their energy efficiency, has gained 13 pledgees

- Corporate clean energy deal volumes for off-site PPAs rose to 2.9 GW in 2017, the second highest on record behind the 3.2 GW of new contracts signed in 2015.
- Companies have also looked increasingly to source clean energy in the same service territory as their load, leading to new engagement with utilities via green tariff programs.

Figure 4.8. Corporate Procurement of Clean Energy, 2017 (GW)





Source: BNEF - Sustainable Energy in America Factbook, 2018

5-New Business Models & Services

2017 saw a year of significant transformation and accelerated disruption, with utilities reacting more aggressively to technological advances

- Energy and utilities companies must now address two seemingly contradictory requirements: the need to innovate and the need to economize.

Eroding revenue streams, declining profits, rising costs, and ever-weakening credit metrics, driven by competition from evolving distributed energy models have been causing utilities to enter a 'Death Spiral'

- Although the underlying risks persist, key opportunities exist that could avoid the foregone conclusion and trigger new streams for utilities.

The rise of prosumers coupled with the ever-present risks from disruptive entrants has triggered the adoption of new 'energy-as-a-service' model

- Per IDC, in two years, by 2020, more than 9 out of 10 utilities will have deployed Energy or Comfort-as-a-Service models to better serve their Commercials and Industrials (C&I) and residential customers.
- Focus remains critical on uncoordinated, siloed initiatives that inhibit the transformation.
- Concentrating efforts on business models with high potential and executing the resulting roadmaps centered on business outcomes will be key for utilities' future success.
- Disruptive non-utility sector entrants like Apple, Google and Amazon continue to cause radical transformation of the sector.

2017 was a year of significant transformation and accelerated disruption, with utilities reacting more aggressively to technological advances

Energy and utilities companies must now address two seemingly contradictory requirements: the need to innovate and the need to economize.

	Rise of renewable energy, innovations in battery storage, increased electric vehicles adoption, new grid transformation models and interactive consumers continue to signal an era of accelerated transformation on the horizon
	Sustained electric generation transformation is being driven by carbon concerns and other environmental considerations, leading utilities to change their fuel mix and deliver efficiency
	Grid transformation is gaining prominence amid disruptive forces getting further integrated with consumer preferences
	The evolution of distributed generation on customer premises continues to drive the modernization of electric grid, transforming it to a smart grid with smart meters, allowing for two-way flow of electricity, incorporating distributed generation and customer battery storage
	While distributed generation represents only about 1% as-on-date, it is expected that over the next decade as energy storage costs continues to decrease and efficiencies increase, distributed generation will account for a much greater market share
	Despite a risk abound to ratings, corporate transformations (M&A) are witnessing a revival, albeit a slower rate, with capital spending expected to remain elevated to serve futur infrastructure needs

The Triggers driving transformation

Disruption to energy models and associated grid configurations is accelerating due to the adoption of digitization

- According to World Economic Forum[1], "The digitalization of electricity could unlock US$3.1 trillion in industrial and societal value over the next decade. Societal benefits stem from value creation for customers and a reduction in emissions."
- Deployment of low-powered sensors, analytics, and big data platforms designed to manage massive amounts of industrial machine data, enabling lower cost of operation, better asset management, refined insights for more profitable business decisions, and bidirectional interactions with prosumers.

Edge and cloud driving industrial innovation

- Proliferation of powerful edge devices that service real-time applications response needs, with cloud providing data consolidation, massive analytic capabilities and profound business insights that help drive more sophisticated enterprise-wide decision making.
- Advanced analytics continues to drive real time monitoring of assets for optimal maintenance management while connecting multiple sites (fossil plants, wind farms, hydro, nuclear) and distributed assets (T&D substation and other assets) for a holistic view to inform more refined capital management business decisions.

Collaborative Robots in practical applications

- According to IDC[2], "By 2020, 50% of all electricity transmission and distribution utilities will be using drones to evaluate service lines, thus reducing asset and inspection costs and achieving savings of up to 5% and 30%, respectively."
- The key areas of application would pertain to safety at places like refineries and power plants and key nodes in the electricity network, connecting equipment health and maintenance apps like asset performance management with the field service workers and drones that complete the maintenance.

Artificial Intelligence (AI) and Machine Learning

- "AI will be the brain of the future smart grid. The technology will continuously collect and synthesize overwhelming amounts of data from millions of smart sensors nationwide to make timely decisions on how to best allocate energy resources. Additionally, the advances made from 'deep learning' algorithms, a system where machines learn on their own from spotting patterns and anomalies in large data sets, will revolutionize both the demand and supply side of the energy economy." - Harvard University[3].
- The stage is set for AI applications to become a reality by combining insights from massive machine data collection with analytic models and analysis that can automate decisions in a power and utility environment.

Eroding revenue streams, declining profits, rising costs, and ever-weakening credit metrics, driven by competition from evolving distributed energy models have been causing utilities to enter a 'Death Spiral'

Traditional business models in the utilities sector have been coming under pressure, primarily due to a convergence of factors including, technological changes, falling costs of distributed generation and other distributed energy resources and increased competition

- Rising prices continue to trigger ever-reinforcing incentives for customers to switch for cheaper power.
- Utility bond ratings have slipped gradually since 1970, reflecting greater risk perception in the finance community.
- Investor-owned utility capital spending on distribution and transmission infrastructure has doubled since 2006, while power sales has been witnessing a slump.

In an article from 2015, William Pentland of Forbes argues that "the predicted casualties of the death spiral have turned out to be the victors and the predicted victors have turned out to be the casualties." In this case, the "victors" are the utility companies and the "casualties" are the distributed renewable energy companies. SunEdison, for instance, a supposed "victor" in the report, had lost more than two-thirds of its market value in 2015.

US utilities have been actively innovating traditional business models of one-way power delivery, and must continue to focus on value creation in order to avoid the ever-increasing risks…

A monumental transition to incorporate evolving business models will be crucial for utilities in the years ahead - Embracing alternative energy technologies and grid modernization entails not only new infrastructure, but new business models that generate returns by maximizing customer value.

Although the underlying obsolescence risks persist, key opportunities exist that could buck this downward trend and trigger new streams for utilities…

1 World Economic Forum (2018): "Electricity: uncovering value through digital transformation"

2 IDC (2018): Utilities' new business models, IDC White Paper

3 Harvard University (2018), "How Artificial Intelligence will revolutionnize the Energy Industry"

The advent of disruptive business models…

Energy price volatility has emerged as a major issue for large-scale consumers from the commercial and industrial sector in recent years. Meanwhile, a strong need for energy efficiency and sustainable energy sourcing comes as a consequence of both regulation and corporate social responsibility targets.

Retail customers are moving from a grid supply model to a mixed-grid/off-grid supply model, and from traditional utilities to intermediaries, aggregators and digital platform providers - Utility CIOs have identified "customer focus" as the highest-ranking short-term strategic business priority.

However, market developments "beyond the meter," including energy technology consumerization, emergence of smart home technology giants (Apple, Google and Amazon), digital ecosystems and virtual assistants are increasingly tempting retail customers to choose new energy-provisioning solutions.

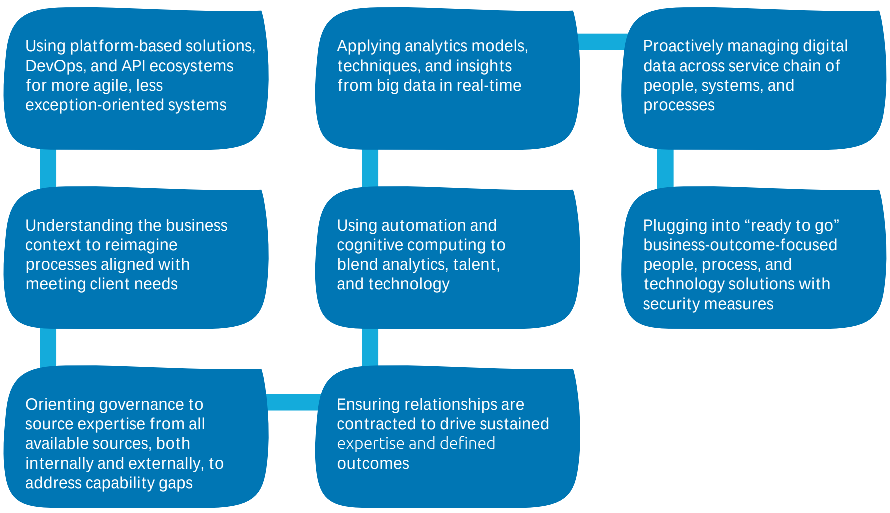
The Key: evolving portfolios	The Drivers	The Future: As-a-Service gaining prominence
• The rise of prosumers coupled with the ever-present risks from disruptive entrants has triggered the adoption of new 'Energy-as-a-service' model • Almost four out of ten utilities believe that within the next three to four years, the impact of new products and services will range from 5% to 9% of their total revenues • Focus remains critical on uncoordinated, siloed initiatives that inhibit the transformation	• Utilities continue to leverage opportunities offered by new energy and digital technologies to reshape and grow their business • The most significant impact on revenues is expected to be driven by electric vehicle (EV) services, generation and storage @home, and microgrid-as-a-service • However, energy-as-a-service and comfort-as-a-service will likely be the top margin contributors	• Beyond the meter services: Energy-as-a-service (solar/storage) and Comfort-as-a-service/Smart Home • Emergence of 'Energy Aggregators', providing bundled services, beyond the traditional portfolio • Energy or Comfort-as-a-Service deployement to better serve their C&I and residential customers • Supply of green energy - a differentiating element • Digital Edge, or, daily energy sharing scenarios that include smart mobility/ charging infrastructure • Smart Building/Smart City/Smart Grid

Beyond the meter: Energy/Comfort As-a-service delivery model and ideals gaining prominence…

Design thinking, intelligent automation, actionable and accessible data, and plug-and-play digital services are rapidly getting adopted in utility operations, with elements of "As-a-Service" ideals becoming pervasive in new contracts

- "As-a-Service" implies engagements that are rooted in more collaboration and focused on bringing together people, process, and technology in services, while also leveraging analytics, plug-and-play platforms, and intelligent automation, and bringing outside-in perspectives and capabilities to deal with the challenges the industry faces.

Figure 5.1. As-a-Service Ideals



Source: HfS, 2017

- "Energy-as-a-service" and "Comfort-as-a-service" has already been deployed by approximately three quarters of organizations (74% and 79% respectively).
  - Depth of the services (integrated client asset management vs. pure asset financing and maintenance) will be subject to the capability of utilities and contenders to take risks.

Innovative disruption is being driven from outside of the traditional utility operators

- New technologies for energy storage, seen in offers from Alevo, Acquion Energy and Tesla, changing the expectations for residential and utility scale storage.
- Coupled with new power generation formats (e.g., wind and solar) could increase the revenue of existing utilities by between US$60 billion and US$100 billion by 2025.
- New customer experience expectations from outside of the utilities market, driven by companies as Google, Facebook, Netflix, Amazon, AirBnB and Uber.

Case: Pepco, Maryland

- Plans to build or buy 700 kW of solar generation at a price capped at US$1,650 per kilowatt with recovery to start January 1, 2019 at a 10.5% ROE.
- The settlement allows the company to initiate a 50 MW battery storage project at costs capped at US$2,300/kW, while deploying a minimum of 530 electric vehicle charging stations at an investment of up to US$8 million, to be recovered over four years after 2021.

Energy Storage: State policies investigating and promoting the trend are boosting adoption rates across North America and radically transforming the sector

Trend - Wood Mackenzie[1] estimates that the annual value of the US energy storage market will exceed US$1.2 billion in 2019

- North America stands among the leaders in commercial and demonstration grid-scale energy storage projects; energy storage market grew 27% in 2017, with 431 MWh deployed.
- Per GTM Research, 100 MWh of grid-connected energy storage were deployed in Q4 2017, marking 1,080 cumulative MWh deployed between 2013 and 2017; while expecting that the US market will almost double this total in 2018 alone, with more than 1,000 MWh of energy storage forecast to be deployed.
- Despite the front-of-meter market gaining the largest share of deployments, the behind-the-meter market made a significant impact, rising 79% year-over-year with record deployments in both the residential and non-residential segments.
- **Use Cases:**
  - The State of California: led the way, primarily in the behind-the-meter demand charge management, driven by its Self-Generation Incentive Program (SGIP), which will likely boost behind-the-meter energy storage deployments over the next five years.
    - Passed in August 2018, the 'Senate Bill 700' bill would authorize the continuation of SGIP through 2025, with funding to supply roughly US$166 million per year in incentives for qualifying behind-the-meter technologies, or US$830 million total, enough to help add about 3,000 MW of behind-the-meter batteries to the state by 2026.
    - Another driving factor is turning to peaking capacity aimed at replacing gas - the aftermath of the 2015 gas leak at Aliso Canyon, California, which led to around 100 MW of energy storage projects being developed quickly as a local capacity resource.
    - In January 2018, the state regulator, the California Public Utilities' Commission (CPUC) issued Resolution E-4909, which authorized Pacific Gas & Electric (PG&E), one of California's three main investor-owned utilities (IOUs), to "procure energy storage or preferred resources to address local deficiencies and ensure local reliability".
    - Energy-Storage.News (2018) has reported in the past on the potential of energy storage to displace peaker plants as a sort of 'first rung' on a ladder of decarbonization, citing batteris as "an economically attractive substitute for many simple cycle gas-fired combustion turbine peaking plants, especially when deployed on a distributed basis and owned and operated by the electric utility".
  - Other markets such as Hawaii, Massachusetts and New York also witnessed a significant surge as well.
  - In Q1 2018, First Solar beat out natural gas peakers in Arizona with its solar-plus-storage system that uses a 50 M battery to store energy for evening peak hours uses.

Drivers

- Falling prices for lithium-ion batteries, due to demand from electric vehicles, and a decline in balance-of-system costs driving energy storage cost competitiveness.
  - Lithium-ion held 98.8% market share in Q4 2017, leading the market for the 13th straight quarter.
- Advances in energy storage technology, in particular battery duration and efficiency.
- Growing constraints on the development of new transmission increased need for new transmission to manage integration elevates storage as an alternative.

1 Green Tech Media, 2018

Energy Storage: To date, California has introduced number of measures related to energy storage

- As of May 2018, three states besides California have set storage mandates/targets.
- Some states allow storage systems to be included in renewable portfolio standards.
- Aside from targets, some states have provided financial incentives for energy storage including grants, support for pilot projects, and tax incentives.
- Many states require utilities to produce integrated resource plans that demonstrate each utility's ability to meet long-term demand projections using a combination of generation, transmission, and energy efficiency investments, while minimizing costs: Arizona, California, Connecticut, Colorado, Florida, Indiana, Kentucky, Massachusetts, New Mexico, North Carolina, Oregon, Utah, Virginia, and Washington.
  - Incorporating storage into these plans can be a challenge because storage is different from conventional generators and demand-side resource.

Solar's growth in Energy-as-a-Service: Net metering (letting homeowners sell excess power back to the grid, driven by solar) triggered a tightly significant shift in North America's power system

California has witnessed the highest progress...

- Driven by energy-efficiency policies and policies supporting utility-scale solar and rooftop solar, California has helped more than half a million customers go solar since 2007.
- California regulators predict that, by 2020, 85% of customers in the state will be using electricity from entities other than investor-owned utilities.

In many locations, utility companies bundle distribution costs for electricity, and charge a uniform per-kWh rate for solar power. When this pricing model combines with net metering, solar customers receive a subsidy partially paid by other non-solar customers in their state.

According to Solar Energy Industries Association (SEIA), the cost of installing solar panels has declined more than 70% since 2010, making it a more attractive as an alternative energy source to homeowners.

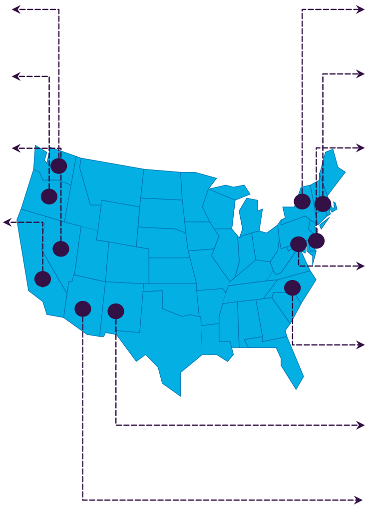
Figure 5.2. US - Select Policy Actions

Washington
Regulators have directed utilities to include energy storage in future integrated resource plans (IRPs)

Oregon
2015: Passed a law directing two electric utilities to each procure 5 MWh of storage energy capacity by 2020

Nevada
Allows storage systems to be included in renewable portfolio standards

California
- 2013: The California Public Utility Commission (CPUC) implemented Assembly Bill 2514 by setting a mandate for its investor-owned utilities to procure 1,325 MW of energy storage across the transmission, distribution, and customer levels by 2020; all of the capacity must be operational by 2024.
- October 2015: More than 60% of the existing battery storage power capacity in California was installed in response to a leak at the Aliso Canyon Natural Gas Storage Facility outside Los Angeles.
- May 2016: To help address reliability risks due to constraints on natural gas supply, CPUC authorized the Southern California Edison electric utility to hold an expedited solicitation for energy storage; by December 2016, 62 MW of battery storage capacity was added.
- May 2017: CPUC implemented Assembly Bill 2868 by ordering its investor-owned utilities to procure up to an additional 500 MW of distributed energy storage, including no more than 125 MW of customer-sited energy storage.
- The Self-Generation Incentive Program, which provides financial incentives for installing customer-sited distributed generation, has designated US$48.5 million in rebates for residential storage systems 10 kW or smaller, and US$329.5 million for storage systems larger than 10 kW.
- 2017: CPUC also expedited ongoing procurement of 38 MW of battery storage by San Diego Gas and Electric.
- August 2018: The 'SB 700' bill would authorize the continuation of SGIP through 2025, with funding to supply roughly US$166 million per year in incentives for qualifying behind-the-meter technologies, or US$830 million total.



New York
January 2018: Announced a target of 1.5 GW of energy storage by 2025

Massachusetts
June 2017: The Massachusetts Department of Energy Resources set an energy storage target of 200 MWh by 2020

New Jersey
Offers an incentive of US$300/kWh of energy capacity for electric storage installations that are paired with renewable energy systems; sets 2 GWs by 2030 storage target

Maryland
2018: Began to offer a tax credit of 30% on the installed costs for residential and commercial systems
Became the first state to offer tax credits for energy storage systems, allocating $750K for systems installed in 2018

North Carolina
Commissioned a study to assess feasibility of energy storage and possible value to consumers

New Mexico
Requires utilities to evaluate energy storage as an energy source in future integrated resource plans (IRPs)

Arizona
Proposed Energy Modernization Plan includes an energy storage deployment target of 3 GWs by 2030
Regulators have directed utilities to include energy storage in future integrated resource plans (IRPs)

Source: EIA (May 2018)

Smart homes: Among the first entrants to the global smart home market, the US continues to hold its top spot in demand for, and penetration of, home automation

North America's installed base of smart home .8 million point solutions, designed for one specific function

- The estimated total installed base at the end of 2016 was 21.8 million smart homes.
- This corresponds to 16.7% of all households, implying that this is the most advanced smart home market globally.
- Adoption of smart home systems is forecasted to grow at a compound annual growth rate (CAGR) of 27%, resulting in 73.0 million smart homes by 2021, reaching US$ 27.2 billion in yearly revenues, at a CAGR of 22% between 2016 and 2021.

By Q1 2018, over 32% of North American households were equipped with home automation systems, with comfort taking precedence over economy in the smart home market

- Point solutions constitute the consumer's first choice in most cases - primarily smart thermostats, security systems, smart light bulbs, network cameras and multi-room audio systems.
- Overall, security and safety, utilities management and wellness monitoring are the key selling points, with smart home gateways reporting the highest adoption (Q2 2017).
- There are a number of connectivity and interoperability technologies in the smart home market - many are competing for a position as the de facto standard for communication between smart home solutions.
- Cross-platform compatible and user interfaces have been gaining traction - Amazon's Alexa service, Apple's HomeKit platform, Google Home have been penetrating the market.

Key Drivers	Key Barriers
Energy efficient smart lighting, advancements in digital analytics platforms, and people living longer but with chronic health issues	Lack of consumer awareness, and inability of security systems installed in smart homes to prevent crimes

Emerging business models with expected implementation plans for the coming 24 months - generation and storage at home

- Encouraging customers to become active prosumers as small-scale production and storage of energy becomes more affordable.
- The rapid drop in PV and storage prices will make it more profitable even for energy providers to sell home generation and storage equipment rather than purely sell commodities.
- Generation and storage @home is very appealing in countries with low population density and/or high solar radiation; Canada has the highest level of plans for deployment (90%).
- Per IDC, approximately four out of ten organizations plan to deploy it in the next two years, totaling 56% when considering companies that are already offering it.

Smart Mobility and the Digital Edge: "Moving from the proliferation to the transformation approach will prompt a significant increase in the value generated"[1]

"In the US, a full transformation generates nearly four times the value of the proliferation; a key reason for the value generation is that more miles would be driven by EVs"[1]

- The proliferation of EVs, with their more efficient engines, certainly contributes to a reduction in urban mobility emissions, along with stricter emissions regulations on internal combustion engines (ICEs).
- However, focusing solely on personal-use EVs will not help to achieve the current climate goals.
- In the US, cutting vehicle emissions by half would require 40% of light-duty vehicle stock to be electrified, or 95 million vehicles; current forecasts predict this percentage will not be reached until 2042.

Transformation...

- The transformation would focus on electrifying high-use

1 "Electric Vehicles for Smarter Cities: The Future of Energy and Mobility", World Economic Forum, 2018

vehicles, such as shared autonomous vehicles (AVs), public transport and commercial fleets.

- Instead of relying on individual customers to replace their ICE with EVs, the transformation would rely on companies making capital investment decisions based on a compelling business case for EVs that operate at a lower cost per mile than ICEs at a high rate of use.
- This transformation would increase the positive impacts of EVs on the environment compared to the current model, representing up to US$60 billion by 2030 for the US alone.
- Case: In cities such as Oslo and Montreal where hydropower generates more than 95% of the electricity, with no emissions and no intermittency, EV charging would be continuously clean. Smart charging would still be useful to deal with any local constraints on the power grid, for example, to reduce the need for grid reinforcements or to shave peaks in demand.
- Case: In cities like Richmond, Virginia, in the eastern US, which is supplied by a mix of wind and conventional coal generation, charging could be timed to match the windiest times.
- Case: Cities that derive an increasing share of their electricity supply from renewable energies, for instance, San Francisco or Houston in the US, could avoid curtailing renewables by adjusting optimal charging times and charging station locations.

Energy...

- The integration of the charging infrastructure with grid edge technologies, such as decentralized generation, storage, smart buildings and smart grids, is limited.
- Policy support in the form of dynamic pricing and other regulatory aids that could accelerate electrification is also limited.

Initiatives...

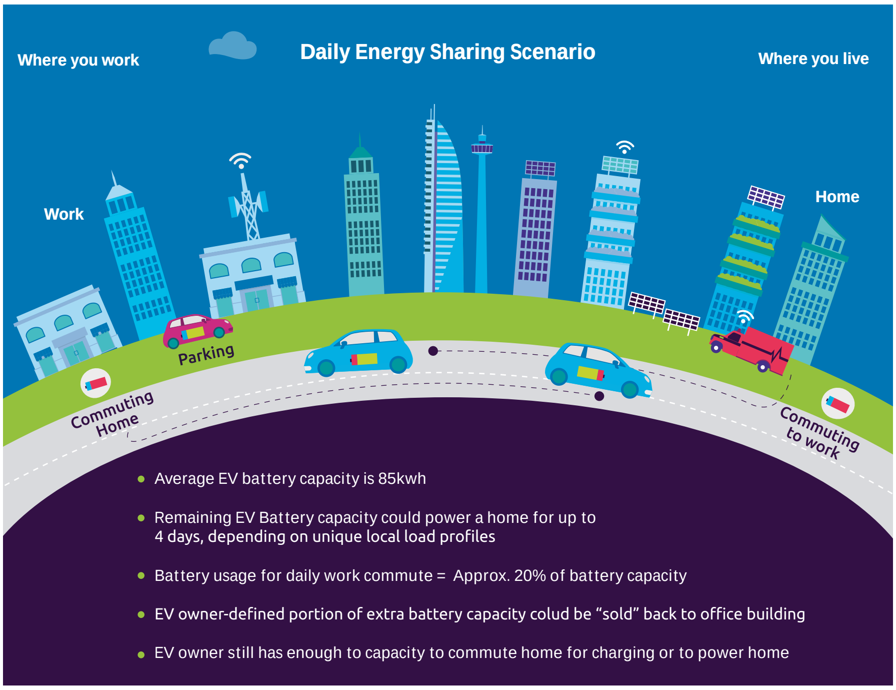
- The Massachusetts Electric Vehicle Incentive Program incentivizes (up to US$7,500 for purchase and US$5,000 for lease) municipalities, universities, colleges and state agencies to electrify their fleets and deploy charging stations.
- The city of Montreal (Canada) has created a multidisciplinary internal committee for electrification of transport with the directorates of environment, transport, urban planning, economic development, municipal properties and rolling stock management and the Montréal Transit Authority.

The fusion of Smart Mobility and the Digital Edge are facilitating utilities to remain relevant in today's connected energy economy...

- EV Infrastructure (battery, plug-in hybrid, and hybrid vehicles, along with the surge in charging infrastructure) continues to disrupt the sector:
  - EV Charging
  - Demand Response
  - Vehicle to Grid
  - Settlements/Payment System
  - Car Fleet Charging Services
  - Security & Tamper Detection.
- Monetization of Customer-Generated Power & Excess Battery Capacity along with Data Valorization and Monetization present opportunities to avoid the risk of dis-intermediation.

The digital edge is enabling the rise and acceleration of Daily Energy Sharing Scenario driven primarily by the integration of technology (gateway sensors, microprocessors), connectivity (telecommunications), and power (grids, micro-grids, photovoltaic)

Figure 5.3. Daily Energy Sharing Scenario



Source: Capgemini Analysis (2018)

- It is estimated tha 40% of large enterprises will be integrating edge computing principles into their 2021 projects, up from less than 1% in 2017.

- IoT and more immersive, interactive UIs will drive one-third of large enterprises to create or use edge locations by 2021.

Per IDC, emerging business models - EV services/infrastructure and Microgrid-as-a-service, currently rank first and second respectively in terms of revenue expectations at industry level, although they do not top the corresponding ranking in terms of companies' gross margins. In terms of adoption, the later is being viewed as a low-margin business model, however, coupled with Edge, the same presents strong opportunities to evolve further and integrate with the changing energy delivery dynamics.

Case: NSTAR Electric, Massachusetts

- Plans to recover US$45 million in investments to accelerate the development of electric vehicle infrastructure and up to US$55 million to construct both a five-megawatt and a 12-megawatt energy storage facility.

New sales of battery, plug-in hybrid, and hybrid vehicles accelerated, especially new, longer-range versions of existing models

- US sales of EVs, including battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV), jumped to over 194,000 units in 2017, up 23% year-over-year. Overall, EVs made up 1.1% of new vehicle sales in the U.S. in 2017, up from 0.9% in 2016.
- The price of lithium-ion battery packs, a key driver of BEV pricing, crashed 23% in 2017. Pack prices tumbled 65% between 2013 and 2017-end, bringing average prices down to US$209/kWh. There are currently 47,117 public and workplace charging outlets in the US, including 6,270 fast charging outlets, up 18% in 2017, year-over-year.

Cases[1]

- The Volkswagen Group, under the terms of a legal settlement with the State of California and the US EPA, created a subsidiary called Electrify America that will spend a total of US$0.8 billion over ten years to deploy charging infrastructure within California and US$1.2 billion over a decade outside California.
- Use of public procurement programmes to stimulate the initial roll-out of EVs:
  - The federal government put forward in 2015 a purchase share target for electric passenger vehicles of 20% by 2020 and 50% by 2025
  - The state of California, which was granted a waiver by the EPA to implement its GHG emission standards in 2009 (Federal register, 2009), has vowed to stick with the stricter rules even if federal standards are rolled back (Davenport and Tabuchi, 2018)
  - In 2016 California's governor issued an executive order to call for 1.5 million ZEVs on the road by 2025 (State of California, 2016)
  - A number of private and public initiatives are considering the development of workplace chargers - Tesla has started to offer free workplace chargers for Tesla users to companies and commercial property owners.

Some market observers suggest that a transformation of the transportation sector may be underway, with EVs poised to quickly replace traditional passenger vehicles in Canada

- Incentives for purchases in some provinces, as well as an EV mandate in Quebec, contribute to a steadily increasing market share for EVs.
- Higher adoption in Quebec is driven by EV mandate policy, purchase incentives, and low electricity prices.
- Ontario, B.C. and Manitoba also have higher EV sales due to their low-emitting electricity grids and vehicle purchase incentives.

North America

Smart Buildings: 2018 witness continued growth in the usage of Internet of Things (IoT)[2]

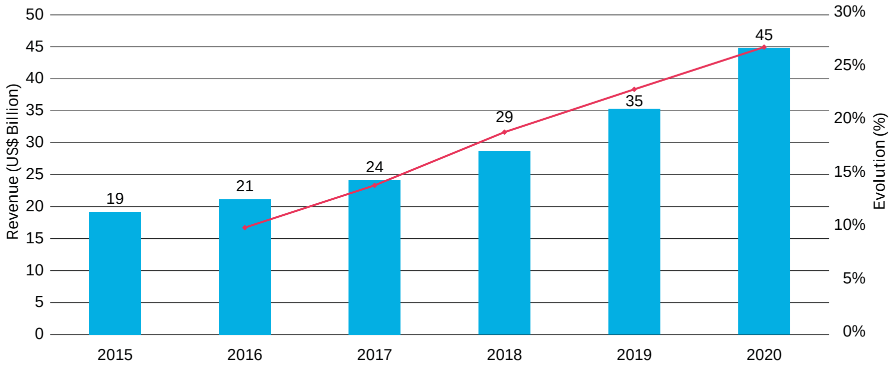
Shifting customer demands, climate change mitigation and sustainability goals, power reliability and resilience concerns, and budget constraints are driving demand for intelligent building solutions

- Predictive Maintenance
  - A new trend expected in 2018 is the use of predictive maintenance in facility management, using IoT sensors and other hardware devices to get a report on the state of a commercial building and all equipment.
- Air Quality Measurement
  - One major trend to watch for in 2018 is how smart building air quality can have an impact on the productivity of workers.
- IoT supported Complex Applications
  - Use of thermal imaging will allow facility managers to check for equipment that are outside of the temperature range; detection of ultra-sonic noises.
- Measurement and Verification using IoT
  - IoT offers the ability to collect near real-time data and analyze it with higher spatial resolution, improving energy-conservation Measures (ECM).
- Real-time Data Accessibility
  - IoT applications allow facility managers to conduct various experiments to check the result of optimization.

1 Global EV Outlook, 2018
2 "IoT Smart building trends to look out for in 2018", Senseware 2018

- IoT for Energy Efficiency
  - Using sensors for temperature control; Using actuators for HVAC controls; Complex applications like providing complete energy automation for a building; Allows for both offline and real-time communication; Considers weather forecasts to save real-time energy costs.

Figure 5.4. US - Projected IoT-enabled Smart Building Market, 2015-2020 (US$ billion)



Source: Statista, 2018

Trends driving smart building adoption

- Rise of "as-a-service" in real estate: popularized by cloud-based software firms such as Salesforce.
- The office as an innovation and collaboration enabler.
- Renewed focus on space utilization and space analytics.
- Continued demand for green buildings: based on certifications like LEED, have become widespread.
- Data analytics are increasingly used to create value within commercial real estate building operations.

According to Persistence Market Research, the global building automation systems (BAS) market, led by North America, valued at US$49.2 billion in 2016, is expected to reach a market value of US$141.1 billion by the end of 2025, expanding at a CAGR of 11.1% during the forecast period (2017–2025)

Smart Grid: Modernization of the grid to accommodate complex and reliable power flows is driving the incorporation of electronic intelligence capabilities[1]

Investing in smart meters is one of the first steps in building a smarter energy infrastructure - as electric companies continue to manage, operate, and invest in an increasingly digital energy grid, the next step is to utilize the data being generated as a strategic asset to improve grid operations

Smart meters continue to pave the way for the transformation of the electric power system, and creating the foundation for a customer-facing, modern energy grid

- Smart meter installations have grown dramatically since 2007, with over 55% coverage of the US household by 2016-end - more than 40 electric companies in the US have fully deployed smart meters, engaging in grid resiliency and operations, integrating distributed energy resources (DERs), and providing customer solutions.
- Expanded services typically include time-based pricing, load control, budget billing, high-usage alerts, push notifications, and web services for energy management by enabling two-way power and information flows.
- Sensing capabilities in smart meters continue to advance, and electric companies now are collecting more complete power characteristics (e.g., voltages and reactive power) in addition to consumption and power on/off status from the meters.
- US smart meter installations approach 76 million; projected to reach 90 million by 2020.

Adoption of Smart Grid technologies has been accelerating, but at varying rates "depending largely on decision-making at utility, state, and local levels" – US Congressional Research Service

Enhancing grid reliability[2]

- During the historic 2017 hurricane season, smart meters were instrumental in the speedy recovery efforts following Hurricanes Harvey and Irma in August and September.
- By integrating voltage and reactive power data collected by smart meters with Distribution Management Systems (DMS), electric companies are implementing distribution automation and circuit reconfiguration, volt/VAR management, device monitoring, and predictive asset maintenance capabilities.

1 "Electric Company, Smart Meter deployments Foundation for a Smart Grid", 2017
2 "Why aren't more focused on reducing power system losses", T&D World, 2017

Another key aspect to grid modernization is addressing the ever-present issue of technical transmission and distribution (T&D) losses, which has annually averaged close to 5% through the period 2012 to 2016

- Technical losses are critical in evaluating system upgrades and key assessments for the implementation of demand side and distributed energy alternatives as well as conservation programs.
- Continued adoption of smart grid technologies increases the importance of routinely evaluating system losses, assessing the numerous variables involved.
- Modernization initiatives, thus call for system upgrades to aging equipment, to ensure a stand at addressing substantial savings for the utilities.
- Besides advanced meter infrastructure (AMI) and analytics, distribution management and automation technologies, demand management systems and energy storage are among the smart grid technologies that can help reduce power losses by leveling, reducing or improving the quality, and thereby the efficiency, of power flows.
  - Case: Ameren Services is utilizing AMI data and data management platform to calculate system losses on every part of the Ameren Illinois grid in near real time, allowing system loss studies to be coupled with valuable functions such as truing-up regional grid energy market settlement calculations.

High cost and cybersecurity are considered the primary barriers to its adoption:

- In its 2014 study, DOE estimated historical and forecast investment in the Smart Grid as approximately US$32.5 billion between 2008 and 2017, averaging US$3.61 billion annually in the period.
- The eventual costs of a Smart Grid build-out may therefore be influenced by new technologies that have yet to be deployed or current technologies that may be modified.
- Using DOE's estimate as a basis, a reasonable assumption may be that Smart Grid spending by the electricity industry of approximately US$3.5 billion annually could continue through 2030 as part of modernization efforts.

Most electric utilities appear to view Smart Grid systems positively, even with the added concerns for cybersecurity - costs could be reduced and system resiliency improved by further integration of automated switches and sensors, even considering the cost of a more cyber-secure environment.

Despite the high costs of a formal transition, deployment of the Smart Grid continues, with a gradual modernization of the system

Case: Public Service Colorado

- Embarked upon an Advanced Grid and Intelligence Initiative, which includes infrastructure investments and other costs related to improving productivity.
- According to a rate increase filed in Q4 2017, the associated cost recovery would focus on "funding investments to better integrate renewable energy, boost grid reliability, offer customers more information for greater control over their energy budget, reduce system fuel and energy costs, and put in place technology to keep costs low over the long term" (Public Service Colorado).

Case: Narragansett Electric in Rhode Island

- Proposed a Power Sector Transformation Plan (PSTP) consistent with the state's Power Sector Transformation Initiative (PSTI).
- Shifting the traditional electric utility business model to a more performance-based model, aligning incentives with customer demand and public policy.
- The company's PSTP has four main components: investments in advanced metering, grid modernization, electric vehicle infrastructure, and energy storage and solar demonstration projects.

Case: Duke Energy, Florida

- A settlement agreement, effective from January 2018, has increased rates to reflect US$1.1 billion in grid modernization investments intended to enhance reliability, reduce outages, shorten restoration time, support the growth of renewable energy and emerging technologies, install advanced metering infrastructure, and upgrade company systems.

Case: Florida Power & Light Company (FPL)

- Has invested heavily in energy grid modernization - physical grid hardening, digital grid technologies, and data analytics to enhance grid resiliency and to improve its understanding of the nature and extent of outages, improving its ability to restore power when outages do occur.
- Installed 4.9 million smart meters that let the company know when individual customers are out of power and has deployed more than 83,000 intelligent grid devices and smart switches.

As Distributed Energy Resources (DERs), such as private or rooftop solar PV, energy storage systems, electric vehicles, and connected home devices like smart thermostats and smart appliances, continue to grow, electric companies need greater visibility into the performance of these systems to better utilize these resources for efficient distribution grid operations

Topic Box 5.1: Canada's US$300 million 'Smart City Challenge' - one of the largest smart city challenges ever undertaken

Over 159 cities applied to the challenge, focusing on six areas: economic opportunity, empowerment and inclusion, environmental quality, healthy living and recreation, mobility and safety and security

Case in Focus: A coalition of the Toronto, Ontario and Canadian governments' contract with Sidewalk Labs, a sister company of Google, to come up with a US$50 million design for "Sidewalk Toronto" on Quayside, a 12-acre plot of land on Toronto's waterfront

- The idea: A "smart city," a sensor-enabled, highly wired metropolis that can run itself - "the world's first neighborhood built from the internet up" - Sidewalk Labs.

Sidewalk Toronto has been marketed as a high-tech community, prioritizing sustainability, safety, and affordability.

The innovation will be underpinned by pervasive data collection through connected sensors and personal information that people would share to access customized programs and services (Mother board, 2018).

Amenities like garbage disposal and goods delivery are to be coordinated and driven by AI and robotics.

An ongoing public engagement process involves extensive community and stakeholder consultation and long-range planning, focused on improving infrastructure and transportation systems, creating new models of affordable housing and flexible retail uses, and establishing clear governance policies related to data protection and privacy (Alphaville, Financial Times, 2018).

"This project offers unprecedented opportunities for Canadian innovators and will create thousands of good, middle-class jobs. The new technologies that emerge from Quayside have the potential to improve city living—making housing more affordable and public transit more convenient for Canadians and their families." - Prime Minister Justin Trudeau.

With the project six months into a public consultation period, data transparency has been cited among the key barriers…

- Privacy watchdogs have raised concern over who will control sensitive digital information - resistance from local officials as well on handling of personal data tracked by sensors that may be embedded in such infrastructure as traffic lights, thermostats and garbage-disposal units.
- Also at issue are ownership rights over any products or techniques developed at the site and sold elsewhere.
- Waterfront Toronto has agreed to negotiate intellectual property ownership and digital privacy rights based on a set of "guiding principles"(Fortune, 2018).
- Data minimization (reducing the amount of data collected to a bare minimum) is another point in concern.

Despite the concerns, and delays, Sidewalk Toronto continues to present a disruptive innovation, aimed not only at addressing housing affordability, but integrating technology to bring in smart city development at the fore.

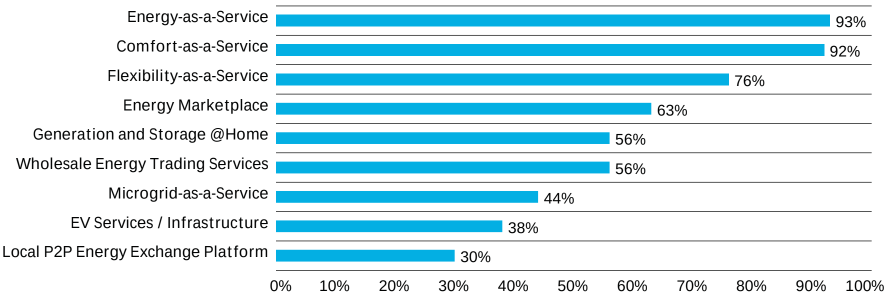
Overall, technological change has made small-scale implementations a reality, allowing municipalities (rather than only states or regions) to independently engage in their own transformational process - utilities appear to be less eager to invest in smart city domains compared to their appetite for implementing the other new business models (IDC).

A 2018 Capgemini-sponsored IDC survey shows that the advent of As-a-Service economy has accelerated utilities' new and evolving business models…

Key findings indicate:

- Evolving utility portfolios
- Siloed initiatives and unclear roadmaps hampering execution
- New business metrics needed to trigger success
- "Business as usual" is being disrupted, with the entry of new contenders offering value propositions beyond simple commodity sales
- The advent of IoT technology and, in more general terms, digital transformation raises the bar with respect to data value
- Coordination and coherence are the key words describing the prerequisites for a successful deployment of innovative business models
- Outdated KPIs are among the biggest challenges in business model deployment
- Concentrating efforts on business models with high potential and executing the subsequente roadmaps centered on business outcomes will be key for utilities' future success.

Figure 5.5. Business Models deployed or planned to be deployed in the next 24 months



Source: IDC Utilities' New Business Model Survey 2018; Interviews commissioned by Capgemini (July 2018)

North America

6-Financials

Generally considered to be defensives, the utilities sector only marginally underperformed the wider market in 2017

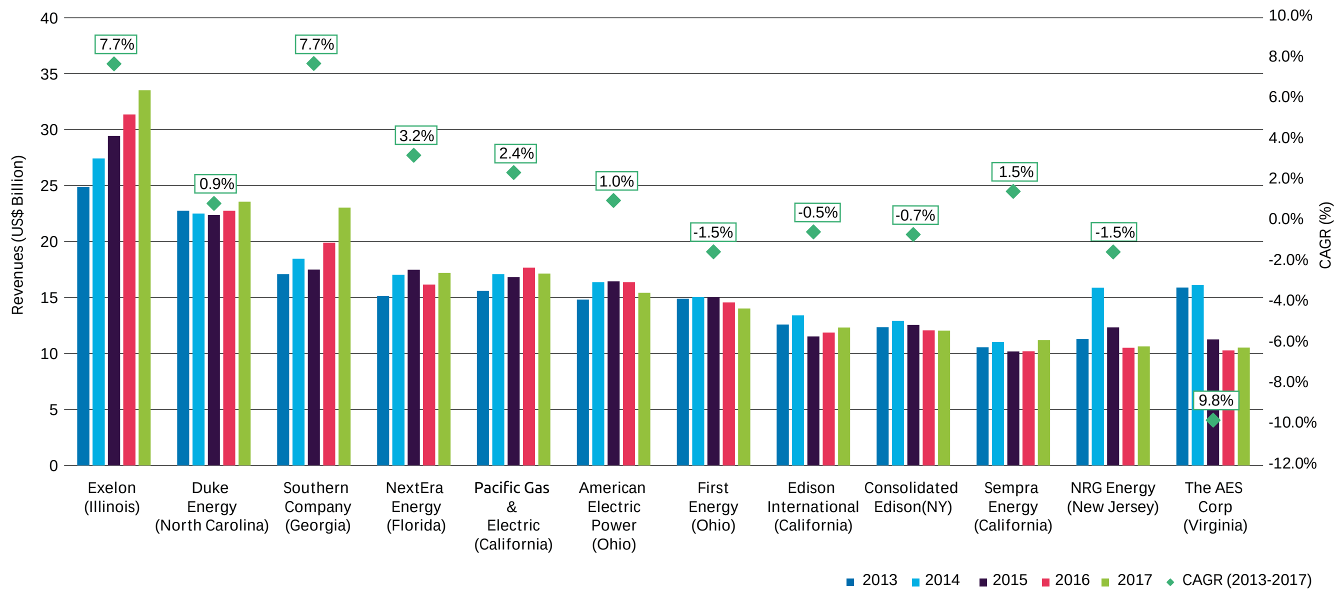
- US utilities have been experiencing flat electricity demand growth for the last few years, driven by increasing energy efficiency initiatives.
- Utilities are thus expanding in renewables, midstream, and gas, while also focusing on customer base growth.
- Customer-centricity and innovative offerings have been among the key drivers for Canadian utilities.

Most analysts see the industry's current earnings growth trend continuing over the next few years, with rising dividends and healthy balance sheets, and with regional pockets of opportunity for higher growth rates

- States are looking at alternative ratemaking approaches to encourage consideration of Distributed Energy Resources, reduce frequency of rate cases, and decouple cost recovery from load growth.
- Regulators and other stakeholders are seeking the right economic incentives to balance efficient deployment of capital, innovation, regulatory lag, retention of service quality, reasonable cost of service, and rate base expansion.

Revenues: The sector's total annual revenue in 2017 increased by US$13.4 billion, or 3.8%, year-over-year

Figure 6.1. US - Revenues and associated CAGR, 2013-2017 (US$ billion)



Source: Thomson Reuters EIKON Data ("Total Revenue"), Capgemini Analysis

Revenue increased for all four of the industry's primary business segments in 2017: regulated electricity, competitive energy, natural gas distribution and natural gas pipeline

- While nationwide electricity output decreased by 0.9% after four years of marginal increases, regulated electricity revenue increased modestly in 2017, rising by US$2.0 billion, or 0.8% year-over-year.
  - This segment's share of industry revenue fell to 68.0% from 70.0% in 2016, yet remained well above the 52.1% level of 2005.
- The natural gas distribution segment experienced the largest revenue growth in both dollar and percentage terms as several natural gas-related acquisitions that closed during 2016 contributed a full year of revenue to 2017.
  - These included Southern Company's purchase of AGL Resources, Dominion Energy's purchase of Questar, Duke

Energy's acquisition of Piedmont Natural Gas and Black Hills' acquisition of SourceGas Holdings.

- Revenue from regulated operations (sum of regulated electricity and natural gas distribution) has grown steadily as a percentage of industry revenue over the past decade.

Utilities have been focusing on customer base growth for the last few years after electricity consumption decreased due to energy efficiency programs

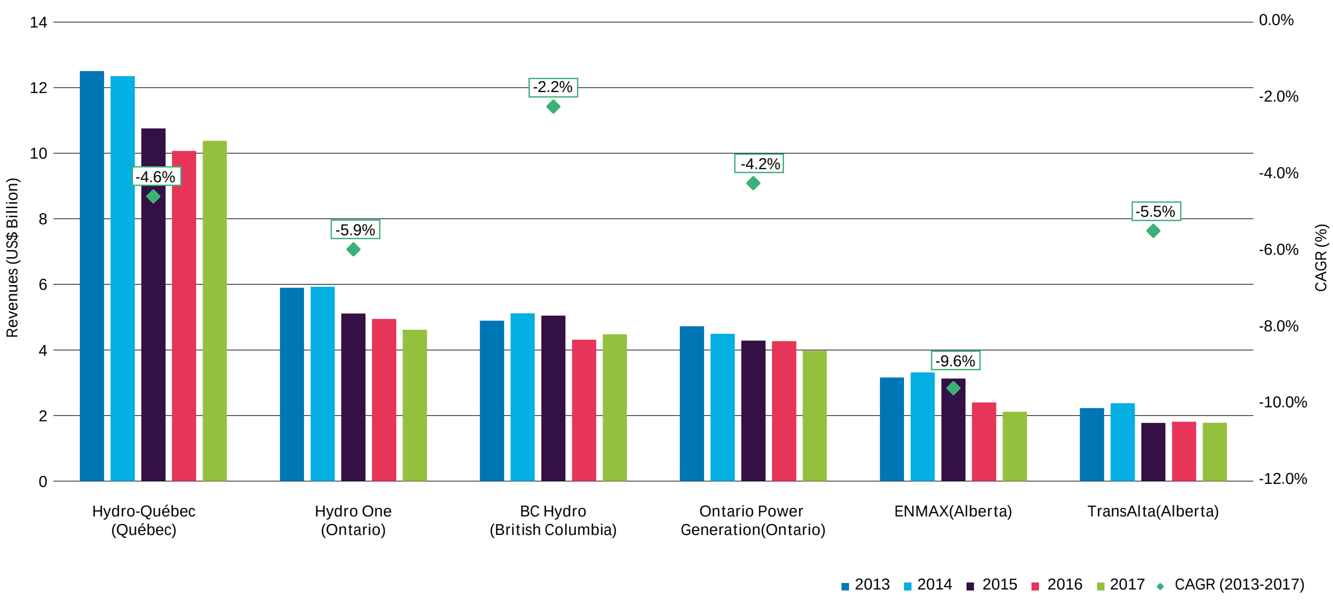
- Exelon, the largest hybrid utility and the largest utility by revenue, attributed earnings to regulatory rate increases and New York Zero Emissions Credits (ZEC) revenue and higher capacity prices, partially offset by a weather-related demand slump.
- Duke Energy's higher regulated electricity revenues were associated with increased pricing and riders driven by new rates in Duke Energy Progress South Carolina, base rate adjustments in Florida and energy efficiency rider revenues in North Carolina, as well as growth in normal weather retail volumes.
- Healthier customer base growth has been the key driver for NextEra Energy.
- NextEra Energy Resources' performance was boosted due to record solar and wind generation capacity additions in 2017.

Revenues: Customer-centricity and innovative offerings have been among the key drivers for Canadian utilities

Utilities have been focusing on seizing growth opportunities, while stepping up wholesale operations in export markets

- Hydro-Québec responded to requests for proposals by the states of New York and Massachusetts, and plans to participate in energy transition in various global regions by purchasing assets or stakes in companies involved in hydroelectric generation and power transmission.
  - Hydro-Québec intends to double its revenue by 2030, with a view to increasing its net income, focusing on three main growth avenues: export markets, investing outside Québec and commercializing innovations.
- Hydro One has achieved CA$89.5 million in savings through operational improvements, besides consolidating Avista Corporation to create a top 20 North American utility focused on regulated transmission as well as local distribution of electricity and natural gas.
- BC Hydro focused on demand side management portfolio in 2017, and achieved 733 GWh of new incremental electricity savings.

Figure 6.2. Canada - Revenues and associated CARG, 2013-2017 (US$ billion)



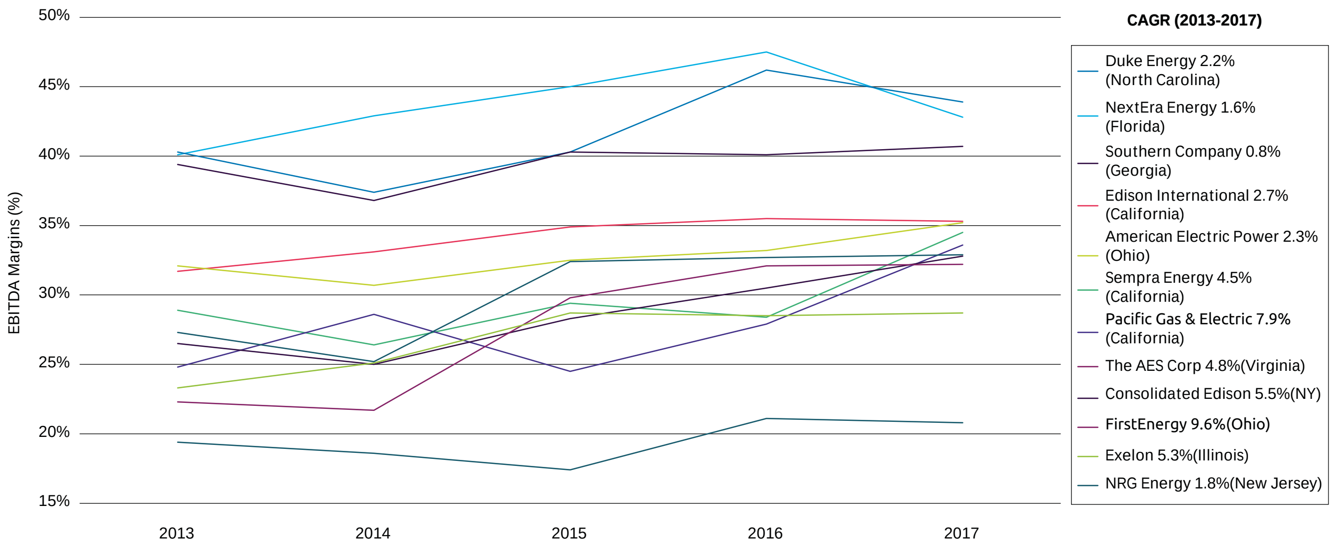
Source: Thomson Reuters EIKON Data ("Total Revenue"), Capgemini Analysis

EBITDA Margins - Cost control, new electric rates and customer growth have helped the utility sector come up with relatively stable earnings growth despite the mild weather-related impact on demand during H1 2017

Relatively flat electricity demand growth for the last several years, driven by increasing energy efficiency initiatives has prompted utilities to expand in renewables, midstream, and gas

- Replacing older equipment with efficient stock and efficiency standards had a drag on the earnings, offset by new power and utilities offerings, such as new storage battery options and smartphone-based thermostat apps.
- Duke Energy, NextEra Energy and Southern Company continue to be the top performers:
  - Duke Energy's result was supported by growth from investments in electric and natural gas businesses, including the full-year earnings contribution from Piedmont Natural Gas
  - Favorable impact of tax reforms and healthy deliverance from the two subsidiaries drove NextEra Energy's earnings amid customer base growth
  - Southern Company's growth was positively influenced by retail revenue effects and lower operations and maintenance costs
  - Southern Company's net debt-to-EBITDA ratio was 5.5x at the end of Q3 2017, while Duke Energy's and NextEra Energy's ratios were 5.6x and 4.2x, respectively
    - NextEra Energy's relatively flat leverage trend over the last three years indicates that its earnings have risen fairly in proportion to its debt and that its financials are sound.

Figure 6.3. US - EBITDA Margins and associated CAGR, 2013-2017



Source: Thomson Reuters EIKON Data ("Normalized EBITDA"), Capgemini Analysis

2017 was the fifth consecutive year in which the industry's operating income growth exceeded the 2.0% compound annual growth rate over the ten years

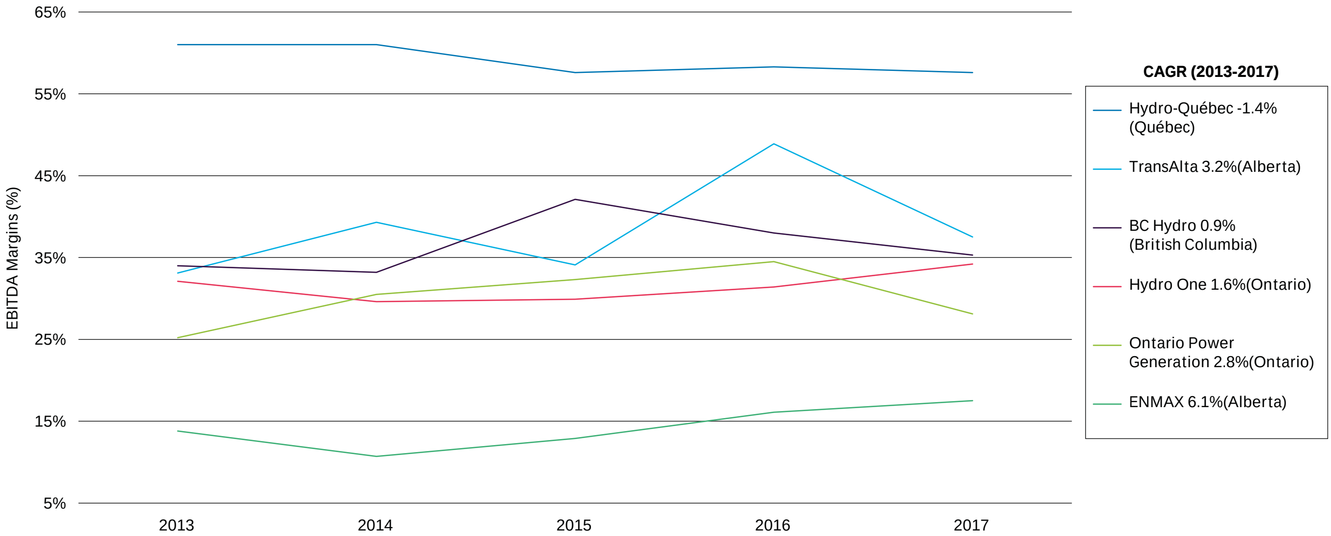
EBITDA Margins: Emerging new technological and regulatory trends in historically stable Canada may have far-reaching effect on utilities over time

In Canada the downturn in energy prices has had a knock-on effect on load in combination with continued conservation initiatives; however, continued efficiency gains have reduced demand tie to economic growth[1]

- Under the earnings-sharing mechanism implemented in 2017, Hydro-Québec TransÉnergie and Hydro-Québec Distribution share with customers any surplus over and above the rate of return authorized by the Régie de l'énergie for a given year.
  - An amount of US$45 million was recognized in this regard in 2017; it will have a positive impact on the rate adjustment that will take effect on April 1, 2019.
- TransAlta's EBITDA from generation increased 13% year-over-year, excluding Canadian Coal, due to strong performance in wind and solar, Australian gas, Canadian gas and US coal segments.

1 "Industry Top Trends 2018", S&P Global rating, 2018

Figure 6.4. Canada - EBITDA Margins and associated CAGR, 2013-2017



Source: Thomson Reuters EIKON Data ("Normalized EBITDA"), Capgemini Analysis

Topic Box 6.1: Evolving Business Strategies…

Rate design for a Distributed Energy Resources (DER) future

- Evolving technologies, especially the distributed generation sources such as rooftop solar, have led many utilities to propose new rate designs and many Public Utility Commissions (PUCs) to initiate alternative rate design investigations (EET, 2018).
  - In January 2017, the Public Utility Commission of Texas issued a final report to the state legislature on new rate designs and recommended phasing in alternative ratemaking mechanisms over three to five years
  - In April 2017, the Missouri Public Service Commission began to explore and gather information on five emerging issues in the utility sector, including the implementation of alternative rate designs, the installation of AMI, and establishing a competitive EV market
  - In October 2017, New York Public Service Commission staff issued a scope-of-study report to examine bill impacts of a range of mass-market rate reform scenarios
  - The big three California utilities have been conducting time-of-use (TOU) pilots throughout 2017 in order to gather information and aid in their transition to default TOU rates in 2019.

Industry consolidation activity slowed in 2017 from 2016's fast pace

- The year's slower mergers and acquisitions (M&A) pace was to be expected as utilities navigated and consolidated the 21 deals announced from 2013 through 2016.
- Stagnant nationwide power demand makes M&A a potential route to faster earnings growth for larger utilities through synergies and cost reductions as well as acquisition of smaller utilities with relatively better growth outlooks.
  - Deal action in 2017 among regulated utilities included Sempra's announced acquisition of Oncor, Canadian utility Hydro One's bid for Avista, and Dominion's offer to buy SCANA
  - Great Plains and Westar revised the terms of their pending combination in response to Kansas state regulators' concerns
  - Canadian utility Algonquin completed its purchase of Missouri-based Empire District Electric.

In the US, the uncertainties on tax reform are now receding, so important parameters on valuing targets and capital costs are now clearer; Canadian and US utilities have been focusing on cross-industry (gas utilities buying electric utilities and vice versa, and even an electric/gas utility holding company starting to build out a water utility acquisition strategy) or cross-border (mostly Canadian holding companies buying US utilities) combinations[1]

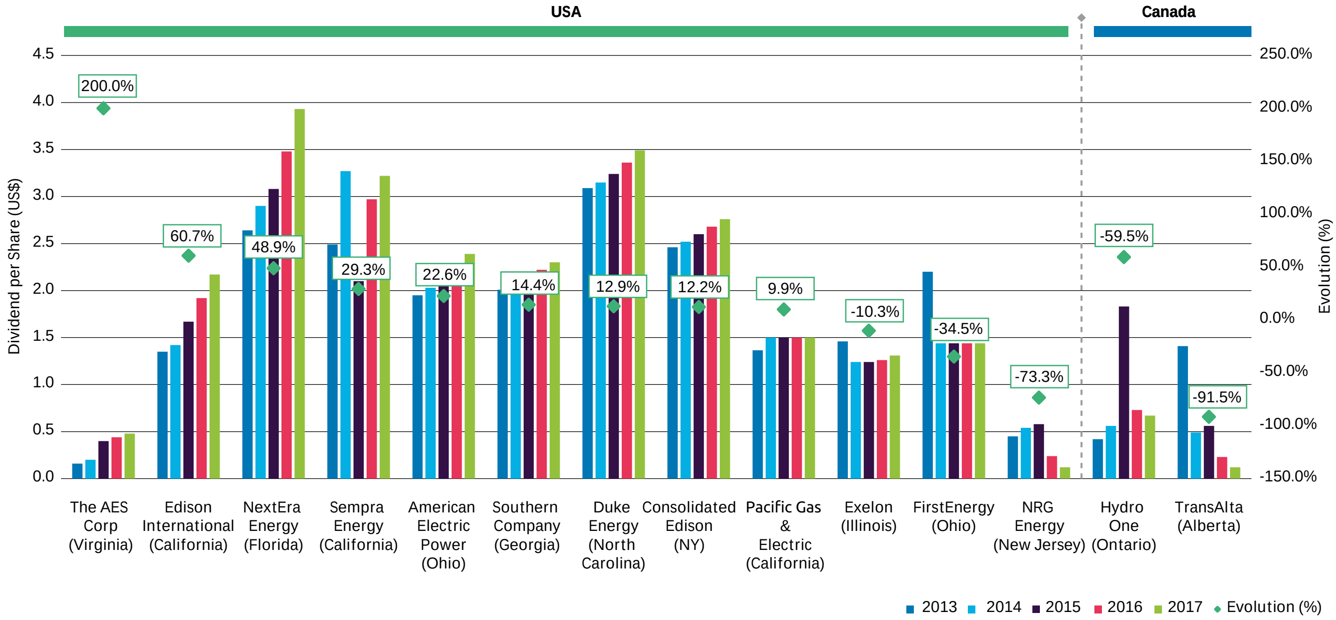
1 "Industry Top Trends 2018", S&P Global rating, 2018

Dividends: The investor-owned electric utility industry extended its long-term trend of widespread dividend increases in 2017

The percentage of companies that raised or reinstated their dividend in 2017 was 88%, the second-highest on record after 2016's 91%

- The industry's average dividend increase per company during 2017 was 5.6%, with a range of 1.4% to 12.9% and a median increase of 5.6%.
- As of December 31, 2017, 42 of the 43 publicly traded companies in the Edison Electric Institute (EEI) Index were paying a common stock dividend.
- The Tax Cuts and Jobs Act signed into law in December 2017 maintained pre-existing tax rates for dividends and capital gains, which is crucial to avoid a capital raising disadvantage for high-dividend companies.
  - AES Corp's strong cash flow outlook and solid balance sheet have allowed it to raise dividend at above-average rates
  - Edison International took a meaningful step in raising its dividend payout ratio toward the upper end of its targeted range of 45% to 55% of subsidiary Southern California Edison's earnings
  - NextEra Energy has been consistent with its plan, announced in 2015, to target 12% to 14% annual growth in dividends per share through at least 2018, off a 2015 base
  - Hydro One has affirmed its long-term intention of maintaining a dividend payout ratio at 70% to 80% of earnings.

Figure 6.5. US and Canada - Dividend per Share in US$ and 2013-2017 Evolution



Source: Thomson Reuters EIKON Data ("Dividend per Share DPS"), Company Annual Reports, Capgemini Analysis

Stock Performance: The industry's stock performance in 2017 was a reflection of its strong fundamentals, which include healthy balance sheets, steady mid-single-digit earnings growth from capital investment programs and an industry average dividend yield just above 3%

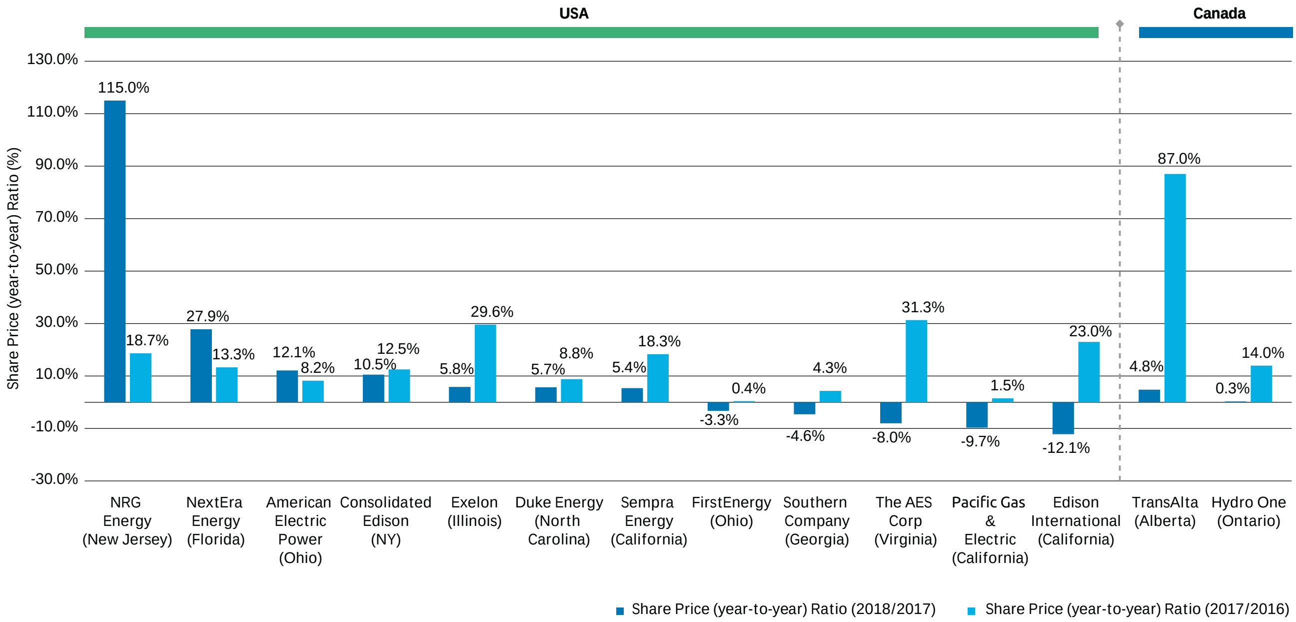
US utilities traded strong despite three rate hikes in 2017

- Since the US Fed began raising interest rates in December 2015, US utilities have outpaced broader markets - in this period, total returns from the Utilities Select Sector ETF came in at around 41%, while the SPDR S&P 500 returned 37% in the same period[1].
- Utilities appear to be trading at a premium based on their PE (price-to-earnings) ratios.
  - On average, they have a PE multiple of 16x, compared with their five-year average of around 14x–15x
  - NextEra Energy and Southern Company have their PE ratios near 18x while Duke Energy is trading at a PE multiple of ~21x
  - Elliott Management stated that NRG was 'deeply undervalued' earlier in 2017 when it disclosed its stake in the largest merchant power player; however, NRG stock more than doubled since then.

1 "An investor guide", Market Realist, 2018

Natural gas prices and low-cost renewable power (mostly wind) have helped fuel costs remain low and have reduced pressure on customer bills that might otherwise be required to fund capital expenditure programs (EET, 2018).
Federal and state policymakers also offered support for baseload coal and nuclear plants through federal energy market reforms set for 2018 along with court rulings and state decisions that supported zero emission credits for nuclear plants, which could improve cash flow and ease concern about decommissioning liabilities.
These moves in part supported share prices for select companies within the EEI Index's Mostly Regulated category, which returned 11.3% in 2017, nearly matching the Regulated category's 11.7% return even as natural gas spot prices held at multi-year lows, ranging from US$2.50-3.00/MMBTU.

Figure 6.6. US and Canada - Utilities' Stock Performance (July 2018)



Source: Thomson Reuters EIKON Data (Stock Prices and Index Values from July 1 2017, 2018), Capgemini Analysis

Topic Box 6.2: Impact of key tax reform provisions on energy companies

After a gap of almost 30 years, corporate income tax rates in the US have been reduced with the Tax Cuts and Jobs Act of 2017 - falling to 21% from 35%

- While this lowers tax liability, a downside implies lower tax shields for depreciation on capital investment.
- According to S&P Global, approximately US$91.4 billion could be returned to ratepayers as utilities' excess deferred income tax liabilities are normalized in state regulatory proceedings.
- Utility cash flows are expected to be reduced due to the return of excess deferred taxes and refunding of over-collections that occur until new rates are in place and because the lower tax rate reduces revenue requirements on an ongoing basis.
- Credit rating agencies have warned that utility credit metrics will be strained as a result of decreasing cash flows.
- Rate base growth is expected across the sector as a result of the tax act, as lower deferred income tax liabilities reduces the offset to rate base in most states.
  - Utilities, including Edison International, Eversource Energy, OGE Energy Corp., Pinnacle West Capital Corp., and ONE Gas Inc. are likely to benefit the most from tax-reform-related rate base growth.
- Bonus depreciation for renewable developers would have a positive impact as deprecation benefits will occur sooner in project life.

The comprehensive legislation contains significant changes in both individual and business taxation but exempts regulated utilities from key provisions limiting interest deductibility and allowing immediate expensing of capital expenditures.

Europe

WEMO 2018 Europe Editorial

Colette Lewiner

Energy transition is progressing in Europe

EU member states continued to grow their renewables installed capacity. 2017 was a record year for wind with 16.8 GW of new capacity added, (up 25% compared to 2016) and photovoltaic (PV) solar capacity that grew by around 6% to 6 GW. Wind energy is the largest intermittent renewables source, supplying 11.6% of the EU's electricity demand.

At the same time, fossil fuel generation capacities continued to be decommissioned (2.2 GW for fuel oil, 2.2 GW for gas and 7.5 GW for coal)[1].

While some EU countries, such as Poland, refused to take the decision to phase out their much-needed coal plants, others, such as France, have committed to close them[2].

In Germany, the governing coalition partners have agreed to come up with a final deadline for coal and lignite fired power production in early 2019. Knowing that coal fired plants represent 37% of German electricity generation, that all nuclear plants should be closed by 2022, and that the North-South transmission lines needed to transport the electricity produced by North Sea wind farms are progressing very slowly, one might wonder how Germany will ensure its security of supply.

Perhaps the solution is to massively increase Germany's gas imports from Russia and also its electricity imports. This means other European countries would have to program additional power capacities to compensate for Germany's reduced contribution. This may or may not be in line with their own energy transition plans.

In addition to government decisions, Utilities are also implementing plans to change their electricity mix towards more renewables sources. The large French utility EDF is now investing more in renewables than in nuclear. In December 2017, it launched its "Solar Plan" aiming to build 30 GW of photovoltaic solar in France by 2035. This volume represents four times the current solar electricity production capacity in France. In March 2018, EDF launched a storage plan to build 10 GW of storage capacity by 2035, representing an €8 billion investment.

Climate change objectives are threatened

The main energy transition goal for Europe is to meet the Paris 2015 Climate Accord objective to limit our planet's temperature increase to 2°C (or even 1.5°C) by 2050 by decreasing greenhouse gas (GHG) emissions.

With global and European economic recovery, 2017 was not a good year vis-à-vis climate change targets.

The EU has a stated target of reducing its CO_2 emissions by 20% from 1990 to 2020 and by 43% by 2030, with a 60% drop by 2040.

However, data released by the European Commission in April 2018 showed that emissions regulated under the European Union's Emissions Trading System (ETS) rose by 1.8% for the first time in seven years in 2017[3].

Higher carbon emissions are attributed to increasing industrial activity resulting from economic growth. These trends were dampened by the 2008 financial crisis, but have been rising again in recent years.

1 https://windeurope.org/about-wind/statistics/european/wind-in-power-2017/#findings

2 In January 2018, the French President has pledged, to shut all of his country's coal-fired power plants by 2021.

3 http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics

Economic crisis was probably the main driver of previous emissions reductions and *the efficiency of the 2020 energy climate package objectives has to be questioned.*

The ETS system contributed little to earlier drops in emissions. It has suffered from excess supply since the financial crisis, but new regulations to be applied in 2019, notably the MSR[4], will remove some of the surplus.

In addition, in February 2018 the EU Council approved an update to the ETS that will apply for the 2021-2030 period. The overall cap on the total volume of emissions will be reduced annually by 2.2%.

- **The carbon price** increased from €5/t in early 2017 to €14/t in June 2018[5]; however, this price is far too low to trigger investments in low carbon projects. The new rules will not be enough to cut emissions in line with the Paris Agreement.
  To enhance incentives to invest in clean energy, the system must be complemented by additional action; for example, by setting a carbon floor price.
  However, it would be very difficult to get approval for an EU-wide carbon floor price as some countries, such as Poland, are opposing it, and as Germany is hesitant (due to the opposition of coal and lignite producers, and the push from renewables operators).
  Nevertheless, carbon floor prices could be adopted at national levels (for electricity generation).
  So far, the only country in Europe with a carbon floor price is the United Kingdom. The Carbon Price Floor (CPF) has doubled since it was introduced in 2013 from £9/tCO_2 to £18/tCO_2. Since the implementation of the CFP, there have been significant falls in coal electricity generation output together with the closure of several coal stations[6]. As a result, in 2017 UK CO_2 emissions decreased by 3.2% (compared to 2016), a very good performance when compared to the global EU emissions increase over the same period.
  Following the UK precedent, in 2018 the Dutch government announced a rising carbon floor price for its electricity sector, reaching €43/t by 2030, and the Nordic countries are considering a carbon price floor to “secure future green investments in the region”.
  According to a recent report[7], if the EU complied with the Paris Agreement, carbon prices would double by 2021 and could quadruple to €55/t by 2030, a level at which technologies such as CCS[8] would be profitable, at least for gas plants[9].
- **EU Energy law**
  Unable to set higher carbon prices, the EU is relying on renewables deployment and energy efficiency to play the main part in GHG emissions reduction.
  In June 2018, the Commission, the Parliament, and the Council reached an agreement which sets a binding target of 32% renewable energy in total energy consumption by 2030 and of 32.5% energy savings by the same date (with a clause for an upwards revision by 2023)[10].
  EU countries have implemented energy efficiency measures in all sectors, producing substantial benefits for Europeans. For instance, new buildings consume half the energy they did in the 1980s; energy intensity in EU industry decreased by 16% between 2005 and 2014; and more efficient appliances are expected to save consumers €100 billion annually – about €465 per household – on their energy bills by 2020.
  With the implementation of energy efficiency programs, further benefits are expected. They include lower demand for EU gas imports, lower energy costs, less need for additional generation and grid capacities, new business opportunities, and new jobs for European companies.
  The electricity market rules will be negotiated in Q3 2018 and should be enforced before the end of the present EU commission (May 2019).
- **Long-term strategy**
  EU leaders have directed the European Commission to produce a long-term climate strategy by Q1 2019. To be in accordance with the Paris Agreement, the new EU long-term strategy will have to set out how to scale up climate action from incremental to transformational, connecting sectors such as power, mobility, the building industry, and agriculture and encouraging investment in clean technologies or usages.
  Electricity development is a key vector in decarbonizing the whole economy and in digital transformation while improving security of energy supply.
  In addition, one cannot exclude the fact that scientific breakthroughs (such as superconductivity) and innovative technology implementation (such as hydrogen

4 MSR: Market Stability Reserve

5 https://sandbag.org.uk/carbon-price-viewer/

6 David Hirst, Matthew Keep, “Carbon Price Floor (CPF) and the price support mechanism”, The House of Commons library. January 2018.

7 https://www.carbontracker.org/eu-carbon-prices-could-double-by-2021-and-quadruple-by-2030/

8 CCS: Carbon Capture and Storage

9 https://carbonmarketwatch.org/2018/02/06/floor-prices-necessary-support-weak-carbon-market/

10 https://www.euractiv.com/section/energy/news/eu-strikes-deal-on-32-renewable-energy-target-and-palm-oil-ban-after-all-night-session/

usage for storage and mobility) would become significant enablers. These research and innovation programs should be funded by the ambitious €100 billion "Horizon Europe", proposed by the commission in June 2018 to succeed Horizon 2020[11].

Europe is going to need more gas imports sooner than expected

as a consequence of increasing consumption and decreasing domestic production.

Natural gas is a potential "bridge fuel" during transition to a decarbonized energy system: it emits less carbon dioxide during combustion than other fossil fuels and can be used in many industries. However, because of the high global warming potential of methane[12] (the major component of natural gas), climate benefits from natural gas use depend on system leakages control[13].

Although sectors other than energy (agriculture, human activities, industry) also contribute to methane released into the atmosphere, Oil and Gas operators as well as Utilities have to significantly reduce their leakages in order to legitimately claim that gas is a "bridge fuel".

After a continuous decline between 2010 and 2014, natural gas demand in Europe started to rise again in 2015. In 2017 it rose by 5% after increasing by 6.5% in 2016[14].
The main drivers of this growth are temperature, continuous economic recovery across Europe, and increased gas deliveries to the power sector notably during the cold period in January 2017 when French nuclear plant availability was relatively low.

According to "BP Energy Outlook"[15], between 2016 and 2040 in the context of a European energy consumption decline, the share of natural gas should increase from 24% to 27%.

- **Domestic European gas production is falling sooner than anticipated.** Following a series of gas production cuts due to earthquakes, production at the Dutch Groningen field is set for 21.6 billion cubic meters (bcm) this year, more than a 50% reduction from its 53.8 bcm 2013 peak. Moreover, the Dutch government announced in March 2018 that it will phase out gas production by 2030.
Consequently, Europe is going to need more gas imports sooner than expected[16].
- **Security of gas supply:** In 2017, the EU imported 69% of its natural gas. Thus, security of gas supply is a concern. However, the market is choosing the cheapest (but not the safest) gas supply.
Liquefied Natural Gas (LNG) is a genuine diversification source[17], but being more expensive than piped gas, LNG imports represent only 9.3% of Europe's consumption.
Despite warnings about the dangers of dependence on Russian gas and EU sanctions after the Ukraine crisis, Russian exports to Europe reached record levels in 2016 and 2017 and were around 40% higher in 2017 than in 2012[18].
Overcoming strong opposition from the U.S. President, the Nord Stream 2 gas pipeline (55 Gm3 capacity, €9.5 billion investment) finally passed the Commission's hurdles and was accepted. By mid-2018, work had started off the German coast and the pipeline should be completed in time to compensate for the decreasing supply from the Netherlands, while reinforcing EU dependency on Russian!

The Utilities landscape is changing quickly

- **Utilities' financial situation** is improving thanks to higher energy prices and higher carbon prices that are triggering electricity and gas markets price increases. On average, the 2017 French spot market price was €45/MWh compared to €37/MWh in 2016.
Capacity markets, now functioning in many European countries (notably UK, Spain, Sweden, France), are providing extra revenue to Utilities having spare capacity, improving not only their top line but also their bottom line.
The clearing prices for 2018 auctions are showing a large spread over Europe, reflecting different needs for extra capacity over years and countries. In the UK the clearing price at the 2018 T-4 auction was an historic low of £8/kW compared to £22/kW in 2017, while the equivalent in France price for 2019 was as high as €18/kW compared to €9/kW in 2017.
In 2017, thanks to increased wholesale market electricity prices and additional capacity market revenue, Utilities' revenue levels[19] improved on average.
However, intensified competition between existing players and newcomers pushed down EBITDA

11 https://ec.europa.eu/info/designing-next-research-and-innovation-framework-programme/what-shapes-next-framework-programme_en
12 EPA (Environmental Protection Agency) currently uses a Global Warming Potential (compared to CO_2) of 25 over 100 years
13 https://www.edf.org/methane-other-important-greenhouse-gas
14 https://www.oxfordenergy.org/wpcms/wp-content/uploads/2018/04/Natural-gas-demand-in-Europe-in-2017-and-short-term-expectations-Insight-35.pdf
15 https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/energy-outlook/bp-energy-outlook-2018-region-insight-eu.pdf
16 https://www.mckinseyenergyinsights.com/insights/the-2017-european-gas-market-in-10-charts/.
17 Shipments come from Algeria, Qatar, Nigeria and more recently the U.S.
18 https://www.ft.com/content/7b86f4be-f08e-11e7-b220-857e26d1aca4

margins.
Due to important CAPEX requirements, Utilities are, on average, increasing their debt level and leverage ratio. However, French Utilities are carrying out, sooner than announced, their large divestment plans: by February 2018, EDF had already implemented 80% of its €10 billion, 2015-2020 plan, and Engie's €15 billion divestment objective was finalized by mid-2018, six months earlier than announced. These divestments are improving the companies' balance sheets and enabling them to convert their portfolio to less carbon-intensive activities.
After a few years of uncertainty, Utilities' successful transformation has reassured financial markets, leading to good 2017 stock performances despite lower dividends per share.
Some additional profits could favorably affect the German Utilities' financial situation. Since the 2011 political decision to phase out nuclear plants, they have battled to obtain financial compensation. The last two years saw some legal victories and they can expect financial compensation linked to their right to property and to their investment in nuclear plants prior to 2011. They also had a favorable outcome to their request for refunding the illegal used nuclear fuel tax. When these Court decisions are implemented, German Utilities such as RWE, Vattenfall and E.ON should receive billion euros, significantly improving their financial situation.

- **Utilities transformation**

Utilities' integrated business model is questioned

In January 2018, the Finnish utility Fortum acquired from E.ON its 47% stake in the fossil fuel asset company Uniper, and made a bid for the other 53%, valuing Uniper at €8 billion. This deal demonstrates that "old fossil fuel type" generation has a value for some Utilities as electricity supplies diminish with the withdrawal from the market of significant gas and coal fired plant capacity, as the increased renewables generation needs schedulable back-up and as electricity prices increase.

Under a complex €43 billion deal announced in March 2018, German utility RWE will combine the renewables businesses of rival E.ON with Innogy (its renewables and networks subsidiary) while E.ON will acquire Innogy's regulated energy networks and customer operations. E.ON and RWE will consolidate assets that make money in Europe's power industry: subsidized renewables and regulated networks. The question is why this could not have been done years ago via a simpler asset swap.

This deal, which results in specialist Utilities in one part of the value chain, could influence other governments or Utilities and push them to split their activities.

This type of split is made possible because spot markets set the electricity or gas prices and thus integrate the value chain from power generation to electricity retailing.

However, each country and Utility has specific characteristics that have to be taken into account in such decisions.

Utilities are entering new sectors and adapting their business model

- Retailers are confronted with new technologies such as digitalization, IoT[20], artificial intelligence, robotics

19 On a sample of 16 of Europe's largest Utilities

(notably chatbots), and block chain, as well as domestic PV panels coupled with storage batteries. They're adapting their client relationship in order to decrease its cost and offer customers a multi-channels approach suited to mobility. They are also adapting their offers in response to customer requests regarding not only price by also environmental considerations and the appetite for self-generation. Many Utilities are converting to bundled offers and positioning themselves as trusted advisers enabling their customers to save energy and create smart homes (e.g. Sowee EDF offer). They're also entering into partnerships that bring new offers to the market (e.g. large retailer Casino and Engie on solar energy related services). In the generation part of the value chain, they are investing heavily in renewables (EDF acquiring Futuren, Engie acquiring the Langa group, an independent producer of renewable energy).

- They are buying dozens of small to medium-size companies to enter nnovative areas such as electric vehicle charging, insulation and smart meters.

Retail markets are changing

- In France, which was slow to open its energy retail markets, competition is finally increasing. For example, the number of alternative electricity suppliers increased from 32 in 2015 to 38 in 2017. In gas they increased from 23 to 29 over the same period. These new suppliers are new players such as Lampiris in Belgium (now acquired by Total), retailers such as Darty or Carrefour, energy companies such as Butagaz, or Oil and Gas majors such as Total (acquiring the new player Direct Energie).
- Contrary to this, in 1998 the UK was the first European country to introduce competition in the gas and electricity retail markets and it is now re-regulating this market. Since 2008, Ofgem[21] and the CMA[22] have argued that the domestic retail energy market (dominated by the Big Six retailers[23]) was not working properly because the less engaged customers are disadvantaged. Following inquiries, in mid-2018 the UK government passed legislation to remedy this situation by capping standard variable and default energy tariffs (those used by the less engaged customers). These energy price caps are set to come into force in December 2018 and, according to the UK government, they will save millions of households up to £100 a year. This new legislation has prompted executives from SSE and German-owned "npower" companies to enter into a merger that would better enable them to cope with these energy caps. At the end of August 2018, they got the green light from the CMA and the merger should be completed by early 2019. This is a major shakeup in the UK energy sector as the Big Six energy retailers will become five. The new company will supply gas and electricity to more than 11 million domestic customers, just behind British Gas, the market leader. Despite the substantial decrease in competition resulting from the merger, Anne Lambert, chair of the CMA's inquiry group, concluded "that with more than 70 energy companies out there, we have found that there is plenty of choice when people shop around". The 34.4% stake held by the German Innogy SE in the new company is expected to be transferred to rival German energy firm E.ON next year, as part of the large asset swap between E.ON and Innogy SE owner RWE (see above).
- For many years, GAFAMs[24] announced their entry to the retail electricity market but nothing significant happened. They are now more visible: with their voice-based devices such as Google Home or Amazon Echo they are competing with Utilities in the smart home space.

Foreign investors are entering the Utilities space

Following the EU directives on deregulation, Utilities that were losing market share in their domestic

20 IoT: Internet of Things
21 OFGEM: Office of Gas and Electricity Markets
22 CMA: Competition and Markets Authority
23 The Big Six are British Gas, EDF Energy, E.ON, npower, Scottish Power, and SSE.
24 GAFAM: Google, Amazon, Facebook, Apple, Microsoft

markets decided to acquire market shares in other European countries. A period (2006-2008) of intensive acquisitions at high prices followed (ENEL/Endesa, Iberdrola /Scottish and Southern, EDF/ British Energy deals) which had a negative impact on Utilities' balance sheets for years. This period ended with the 2008 crisis and private equity funds became acquisitive players (Macquarie in electric and gas infrastructures, for example).

Recently a new player outside the European zone, namely China, has been acquiring Utilities assets, starting in southern Europe with Spanish and Portuguese grid companies. In May 2018, China Three Gorges, already an EDP shareholder, summited an offer to become a majority shareholder. Interestingly the Portuguese government agreed in principle. By entering into south European Utilities, these Chinese players are acquiring interesting connections in South America. Time will tell whether they'll be silent shareholders wishing to learn or more active ones.

Conclusion

Energy price increases are helping Utilities to move more smoothly towards energy transition.

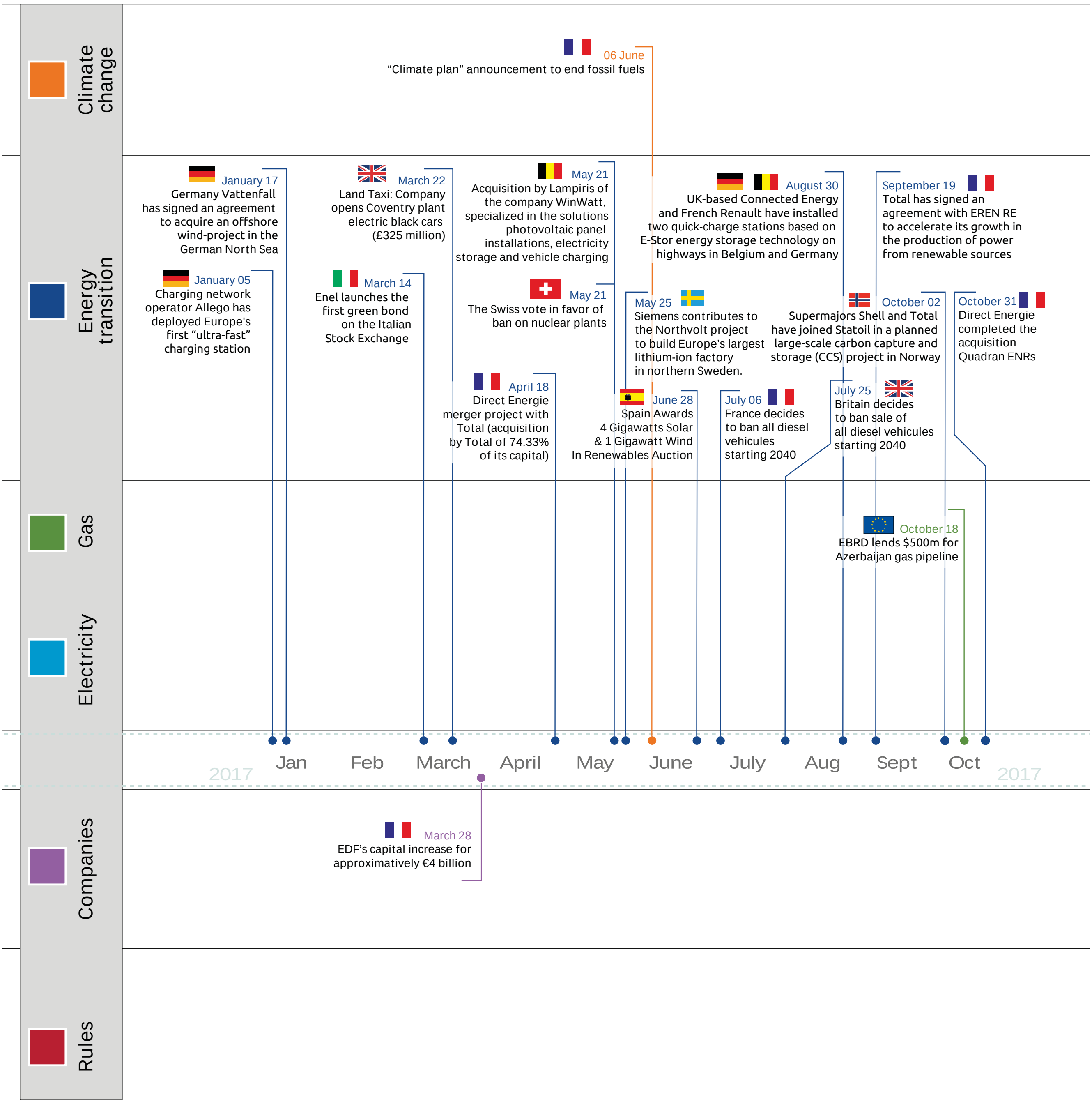
However, the present economic growth is threatening climate change objectives, casting doubt on the efficiency of the 2020 climate and energy package and on the 2015 Paris climate change achievements.

European reforms are helping the return to a sustainable market but without a clear signal on a carbon floor price, achieving the ambitious 2030 GHG emissions decrease target is doubtful. Utilities have continued to transform themselves but need to accelerate as competition from different domains (new entrants, oil majors, retailers, GAFAMs) is increasing.

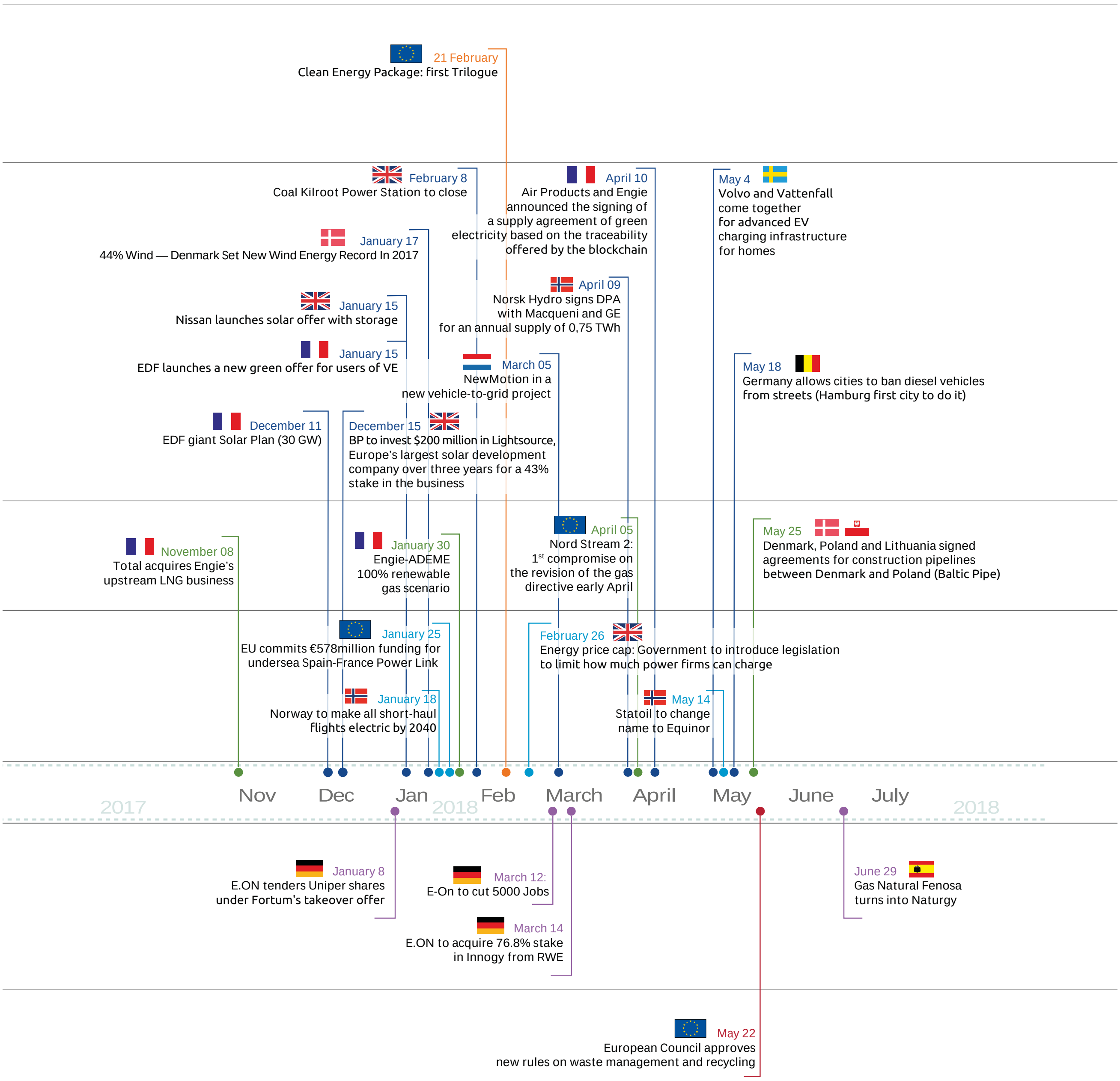
Colette Lewiner

Senior Energy Adviser to Capgemini Chairman
Paris, September, 14, 2018

Major energy events (2017 and H1 2018)



Source: Various industry sources - Capgemini analysis, WEMO2018


21 February
Clean Energy Package: first Trilogue
February 8
Coal Kilroot Power Station to close
April 10
Air Products and Engie announced the signing of a supply agreement of green electricity based on the traceability offered by the blockchain
May 4
Volvo and Vattenfall come together for advanced EV charging infrastructure for homes
January 17
44% Wind — Denmark Set New Wind Energy Record In 2017
April 09
Norsk Hydro signs DPA with Macqueni and GE for an annual supply of 0,75 TWh
January 15
Nissan launches solar offer with storage
January 15
EDF launches a new green offer for users of VE
March 05
NewMotion in a new vehicle-to-grid project
May 18
Germany allows cities to ban diesel vehicles from streets (Hamburg first city to do it)
December 11
EDF giant Solar Plan (30 GW)
December 15
BP to invest $200 million in Lightsource, Europe's largest solar development company over three years for a 43% stake in the business
November 08
Total acquires Engie's upstream LNG business
January 30
Engie-ADEME 100% renewable gas scenario
April 05
Nord Stream 2: 1st compromise on the revision of the gas directive early April
May 25
Denmark, Poland and Lithuania signed agreements for construction pipelines between Denmark and Poland (Baltic Pipe)
January 25
EU commits €578million funding for undersea Spain-France Power Link
February 26
Energy price cap: Government to introduce legislation to limit how much power firms can charge
January 18
Norway to make all short-haul flights electric by 2040
May 14
Statoil to change name to Equinor
2017
Nov
Dec
Jan
2018
Feb
March
April
May
June
July
2018
January 8
E.ON tenders Uniper shares under Fortum's takeover offer
March 12:
E-On to cut 5000 Jobs
March 14
E.ON to acquire 76.8% stake in Innogy from RWE
June 29
Gas Natural Fenosa turns into Naturgy
May 22
European Council approves new rules on waste management and recycling

Europe

1-Climate Challenges & Regulatory Policies

The uptake of carbon pricing policies is on the rise in developing countries but prices remain insufficient to tackle global warming

Countries and provinces accounting for 60% of global GDP have implemented carbon pricing policies (46 countries and 26 provinces or cities).

- Originally circumscribed to European and North American countries, carbon pricing policies are being implemented by developing states and cities.
- The take-up of carbon pricing policies should be sustained in the coming years as 8 geographic areas have pledged to set up their own policies.

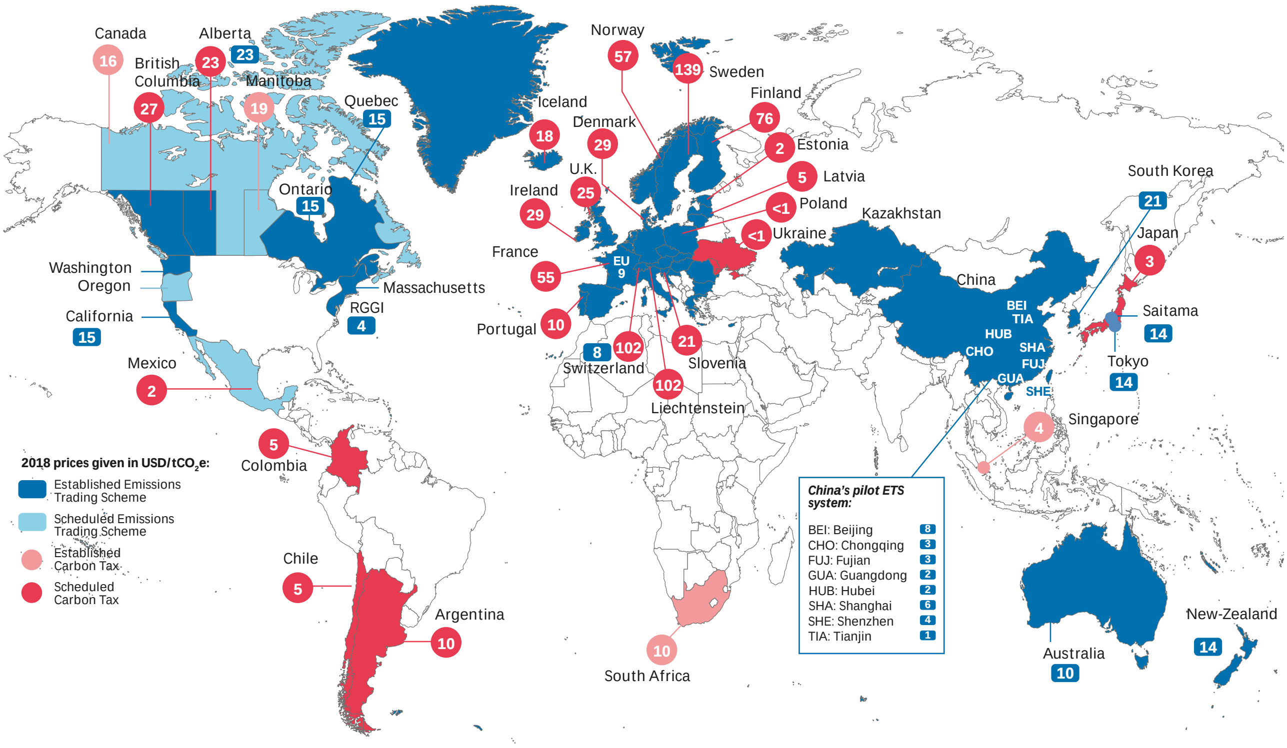
The launch of the Chinese ETS has doubled the global share of GHG emissions covered to reach between 20-25%. The scheme should be fully operational by 2020.

Carbon prices are highly heterogeneous

- Carbon permit prices vary from less than US$1/t$CO_2$e in Tianjin to US$23/tCO_2e in Alberta.
- Carbon tax rates vary from less than US$1/t$CO_2$e in Poland to US$139/tCO_2e in Sweden.

Therefore, **existing schemes are globally insufficient** as most prices are still far below the US$40-80/t$CO_2$e range recommended by the Stern and Stiglitz report (2017) to achieve the Paris target of keeping the rise in average global temperature to well below 2° by 2050. **Further action will be required** to increase coverage and raise prices to meet this imperative.

Figure 1.1. World map of carbon pricing policies in 2018



Source: I4CE - Institute for Climate Economics with data from ICAP, World Bank, government officials and public information, April 2018.

The level of ambition of carbon policies varies considerably regarding sectors and share of emissions covered, with a global coverage of 25% of emissions

ETS schemes all cover the energy and industry sectors

- New Zealand and South Korea's stand out as they also encompass building, transport, waste, aviation – even forestry in the case of NZ.
- California and Quebec's ETS cover the highest share of emissions – 85%.
- Sector coverage is a key feature to assess an ETS but it does not necessarily translate into a higher share of emissions coverage due to local specificities.

Carbon taxes are mostly limited to emissions at source

- They only cover emissions from coal, oil and gas in 18 out of 23 countries.
- In 5 countries, they also cover the energy and industry sectors.
- Latvia's carbon tax stands out as the most encompassing as it covers the transport and aviation sectors as well. Surprisingly, though, it accounts for only 15% of emissions.

China's national ETS is a major development, yet it could be considerably expanded. Only the energy sector will be covered by the scheme, thus covering 30% of national GHG emissions.

Figure 1.2. Detailed characteristics of global carbon pricing policies

Instruments: Established emissions trading scheme; Scheduled emissions trading scheme; Established carbon tax; Scheduled carbon tax

Sectors: Energy; Industry; Building; Transport; Waste; Aviation

Fuels: Coal; Oil; Gas

Jurisdiction	Start year	Price in USD/tCO$_2$ (nominal value) ❶	Share of emissions (%) ❷	Sectoral scope: Energy	Industry	Building	Transport	Waste	Aviation	Fuels covered: Coal	Oil	Gas
Finland	1990	76	36							X	X	X
Poland	1990	<1	4							X	X	X
Norway	1991	57	60								X	X
Sweden	1991	139	40							X	X	X
Denmark	1992	29	40							X	X	X
Slovenia	1996	21	24							X	X	X
Estonia	2000	2	3	X	X					X	X	X
Latvia	2004	5	15	X	X		X		X	X	X	X
British Columbia	2008	27	70							X	X	X
Liechtenstein	2008	102	26							X	X	X
Switzerland	2008	102	33	X						X	X	X
Iceland	2010	18	55							X	X	X
Ireland	2010	29	49							X	X	X
Ukraine	2011	<1	71							X	X	X
Japan	2012	3	68							X	X	X
United-Kingdom	2013	25	23	X						X	X	X
France	2014	55	35							X	X	X
Mexico	2014	2	46							X	X	
Portugal	2015	10	29							X	X	X
Alberta	2017	23	45							X	X	X
Chile	2017	5	42	X	X					X	X	X
Colombia	2017	5	24							X	X	X
Argentina	2018	10	NA							X	X	X
Manitoba	2018	19	50							X	X	X
Canada	2019	16	NA							X	X	X
Singapore	2019	4	80	X	X							
South Africa	2019	10	80							X	X	X

Jurisdiction	Start year	Price in USD/tCO$_2$ (nominal value)* ❶	Share of emissions (%) ❷	Sectoral scope: Energy	Industry	Building	Transport	Waste	Aviation
Euroean Union	2005	9	45	X	X				X
Alberta	2007	23	45	X	X				
New-Zealand**	2008	14	51	X	X	X	X	X	X
Switzerland	2008	8	11		X				
RGGI	2009	4	20	X					
Tokyo	2010	14	20		X	X			
Saitama	2011	14	18		X				
California	2012	15	85	X	X	X	X		
Kazakhstan	2013	0	50	X	X				
Quebec	2013	15	85	X	X	X	X		
China – Beijing	2013	8	45	X	X	X	X		
China – Guangdong	2013	2	60	X	X				X
China – Shanghai	2013	6	57	X	X	X			X
China – Shenzhen	2013	4	40	X	X	X	X		
China – Tianjin	2013	1	55	X	X	X			
China – Chongqing	2014	3	40	X	X				
China – Hubei	2014	2	35	X	X				
China – Fujian	2016	3	60	X	X				X
China – National***	2017	NA	30	X					
South Korea	2015	21	68	X	X	X	X	X	X
Australia	2016	10	50	X	X				
British Columbia	2016	NA	0	X	X				
Ontario	2017	15	82	X	X	X	X		
Washington	2017	NA	67	X	X	X	X	X	
Massachusetts	2018	0	20	X					
Mexico	2018	NA	NA						
Canada	2019	NA	NA	X	X				
Manitoba	2019	NA	NA	X					
Oregon	2021	NA	NA	X	X				

❶ **Price in USD/tCO$_2$:** Less than 10; Between 11 and 30; More than 30

❷ **Share of emissions covered:** Less than 35%; Between 36% and 65%; More than 65%

** ETS prices: mean values observed between April 2017 and April 2018. Tax prices observed on April 1, 2018.*

*** The ETS in New Zealand also covers the forest sectors.*

**** China's national ETS was launched in December 2017, it will be fully operational in 2020.*

Source: I4CE - Institute for Climate Economics, April 2018.

€32 billion in carbon revenue has been collected, mostly by European States, which use 46% for mitigation and adaptation and 44% to improve their general budgets

Globally, **46% of revenue derived from carbon pricing is earmarked for low carbon projects** and **44%** is allocated to States' general budgets.

- ~87% ETS revenues are earmarked.
- ~53% of carbon taxes revenues are allocated to States' general budgets.
- Carbon pricing is therefore not only a means of fighting against climate change, but also of contributing to fiscal policy in general.

More than 67% of carbon revenues came from EU Member States.

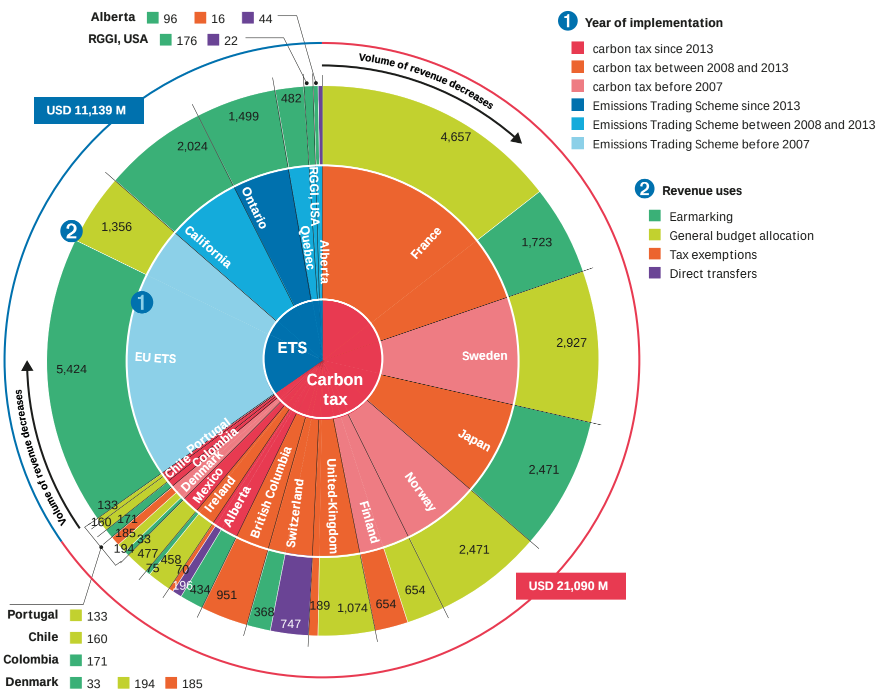
- The EU ETS accounts for 2/3 of revenues derived from all ETS.
- This highlights major revenue opportunities for other countries.
- The deployment of the Chinese ETS should change the picture.

ETSs only represent 1/3 of carbon revenues. This is the direct consequence of low prices observed in all ETS globally.

The French carbon tax accounts for 1/4 of revenue from all carbon taxes

- Sweden's carbon tax generates comparatively more revenue, ~0.6% of GDP compared to ~0.2% for France.
- France's is expected to increase from €30.5/tCO_2e to €86.2/tCO_2e by 2022.

Figure 1.3. Volume and use of carbon revenues in 2018



Source: I4CE - Institute for Climate Economics with data from World Bank, government officials and public information, April 2018.

Only the power sector experienced direct costs from the EU ETS - until the third period (2013-2020) levelled the playing field, forcing the industrial sector to contribute too

The EU ETS is capped

- A maximum number of allowances (EUA) are distributed among corporations in power, industrial and airline sectors.
- By reducing the number of allowances available, the EU increases the cost of GHG emissions for corporations thus incentivising them to reduce them.

During the first periods (2005-2007, 2008-2012) of the EU ETS, costs were mostly borne by the power sector.

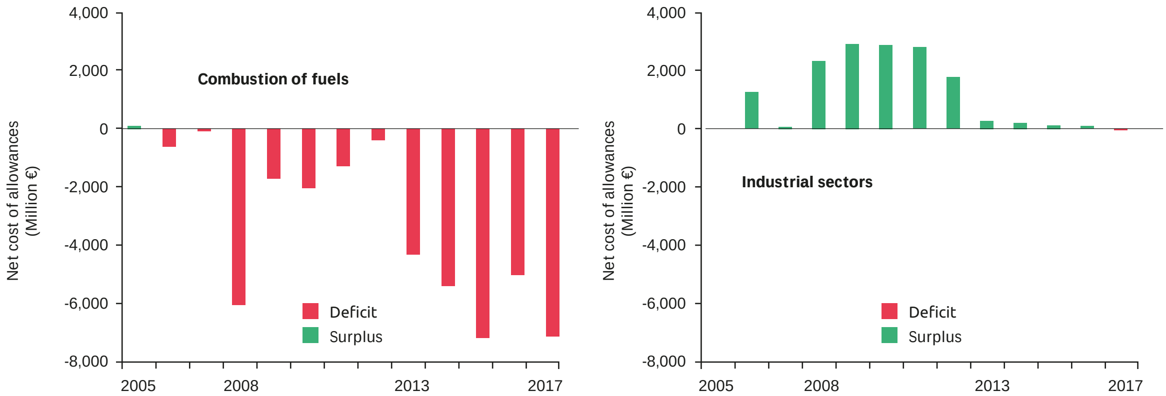
- All years were marked by a financial deficit leading to higher spending for power corporations.
- Industrial sectors collected emissions surpluses during the periods, generating benefits.

The discrepancy has been reduced since 2013

- Industrial companies have stopped accumulating surpluses, entering a net payment period from 2017 onwards.
- Costs for power companies have surged, from €2 billion per year to €7 billion.

The redesign of the EU ETS has levelled the playing field between the power and industrial sectors as both are now bearing the ETS's costs. The power sector still experiences a much more sizeable gap than the industrial sector.

Figure 1.4. Net cost of EU ETS allowances for power and industrial sectors



Note: data for 2017 are based on the EUTL of April 3 - missing gaps are estimated by Wegener Center
Source: EEA,2018 and EUTL, 2018

Topic Box 1.1: The Clean Energy For All Europeans package has been reinforced with EPBD, a 32% target for renewables and annual savings of 0.8% for energy efficiency

Adopted legislative proposal

Essential features of the Energy Performance of Buildings Directive (EPBD)

- Require the use of energy performance certificates, inspection, monitoring and control.
- **Support electromobility infrastructure deployment** in new or largely renovated non-residential buildings by requiring electricity cables for every 5 parking spaces, to become electric vehicles charging points.
- Establish an optional **Smart Readiness Indicator** to show buildings' capacity to use new technologies and electronic systems.

Next steps to be discussed

Ongoing legislative proposals

- The next two points to be agreed are Electricity Regulation and the Electricity Directive. The final points to be addressed are risk preparedness and rules for ACER (Agency for the Cooperation of Energy Regulators).

Agreed legislative proposals (to be adopted)

New objectives for renewables

- Ensure **a binding target of 32% share of renewable energy at the EU-level** by 2030, with an upward revision clause by 2023.
- Achieve targets for renewables:
  - 14% share in final consumption by 2030 in transports
  - Increase of 1.3% yearly average in heat/cooling sector for 2021-2025 and 2026-2030 periods, starting from the level achieved in 2020.
- Set regulatory framework on self-consumption.

Concerning governance, Member States should

- Make sure each country is doing its fair share in reaching targets.
- **Use a template based on the 5 dimensions of the Energy Union Strategy** to update **National Energy and Climate Plans (NECPs)** every 5 years, with a biennial progress report and an annual report on GHG emissions.
- Collaborate to achieve EU target of 15% grid interconnection.

New rules for a higher energy efficiency target

- **Make annual savings of 0.8% on final energy consumption** from 2021 to 2030.
- Achieve 32.5% indicative target for energy efficiency at EU level, with an upwards revision by 2023.
- Establish national rules on the allocation of heating, cooling and hot water consumption in buildings with collective systems.
- Reinforce rules on individual metering and billing of thermal energy.

The Clean Energy For All Europeans package is a set of 8 legislative proposals published by the European Commission in November 2016. The EPBD was adopted in December 2017 and new political agreements were reached in 2018. Other proposals will be addressed in 2019.

Sources: https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans
http://data.consilium.europa.eu/doc/document/ST-10308-2018-INIT/en/pdf
http://data.consilium.europa.eu/doc/document/ST-10309-2018-INIT/en/pdf
http://publications.europa.eu/resource/cellar/ebdf266c-8eab-11e5-983e-01aa75ed71a1.0008.03/DOC_5

Heterogeneous compensation for indirect costs borne by industries distorts the functioning of the EU ETS, but recent reforms might reduce discrepancies

The industrial sector experiences indirect costs as utilities pass EUA's costs to them through their energy bills.

- Costs can be high for energy intensive industries – steel, cement.
- It increases the risk of carbon leakage as they can be incentivised to relocate to countries with less stringent regulations, thus lower costs.

Compensation schemes have been set up by about 1/3 of Member States to reduce these risks.

- All schemes are partial and regressive, but amounts transferred are discretionary.
- France transferred about 59.8% of revenues derived from EUA's auctions in 2016, yet Greece used only 2.6%.

The heterogeneity of measures poses a competitiveness threat as some industries in specific Member States enjoy higher subsidies, even though studies (Ecorys, 2013) have not found evidence of carbon leakage.

Regulatory updates coupled to a reduction in allowances of EUAs could substantially affect the status quo.

Figure 1.5. Map of indirect costs compensation schemes across the EU

Source: 2018 State of the EU ETS report, 2018, pp.23-24, https://www.i4ce.org/wp-core/wp-content/uploads/2018/04/20180416-2018-State-of-EU-ETS-Report-Final-all-logos_-1.pdf

- The fourth period of the EU ETS advocates more strongly the need for all Member States to compensate and reduce discrepancies.
- It also suggests a soft cap of 25% on auction revenues, which is likely to have a strong impact on pre-existing schemes, which all offer substantially higher compensation.

Figure 1.6. Total revenues derived from indirect compensation schemes for selected countries

Member State	Total compensation indirect costs	Auction Revenues	Percentage of auction revenues used
France	140,339,677.00	234,683,755	59.80%
Germany	288,723,308.06	850,000,000	33.97%
The Netherlands	45,000,000.00	142,610,000	31.55%
Finland	36,300,000.00	71,220,000	50.97%
Greece	3,845,242.00	148,050,000	2.60%
Flanders	39,383,616.43	56,917,488	69.19%

Source: Data obtained from Member States, Tieben and in 't Veld, 2017, & Maximiser, 2018

EU climate policies should be stepped up in order to limit temperature rise to well below 2°C by 2050 and match the Union's ambition

The EU's commitment concerning its long-term climate policy conflicts with its stated ambitions

- The European Council concluded in 2009 that emissions should be reduced to 80-95% by 2050 compared to 1990 levels.
- Pursuing the 2030 climate and energy framework adopted following the Paris Agreement would equate falling short of the 80-95% ambition from 2031 onwards.

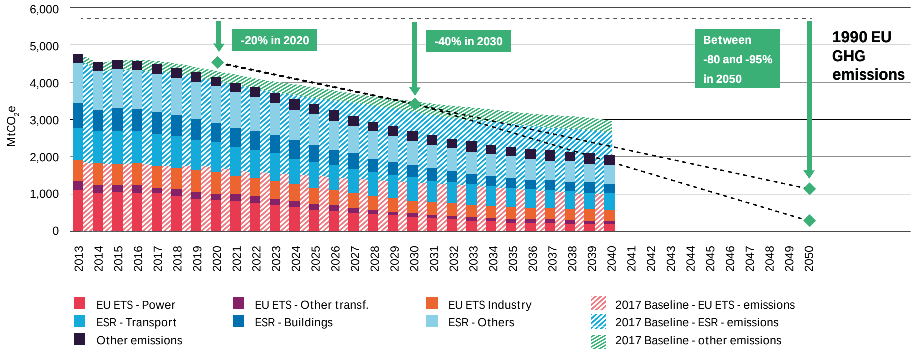
Bolder action is therefore required to limit temperature rise to well below 2°C.

- Under the following scenario, illustrated by stacked bars in Figure 1.7, adoption of and investment in low-carbon technologies should be stepped up.

This could be achieved by assessing counteractive interactions between ETS, Effort Sharing Regulation (ESR) and other policies.

- It would hasten the pace of reduction of the ETS' cap and in ESR targets, which would incentivise power and industry players to increase their investments by 2030.

Figure 1.7. Comparison of the EU's different levels of climate paths and resulting impacts on its stated ambitions



Source: Mind the gap - Aligning the 2030 EU climate and energy policy framework to meet long-term climate goals, 2018, p.42, https://www.i4ce.org/wp-core/wp-content/uploads/2018/06/I4CE-Enerdata_Mind-the-gap-full-report-1.pdf

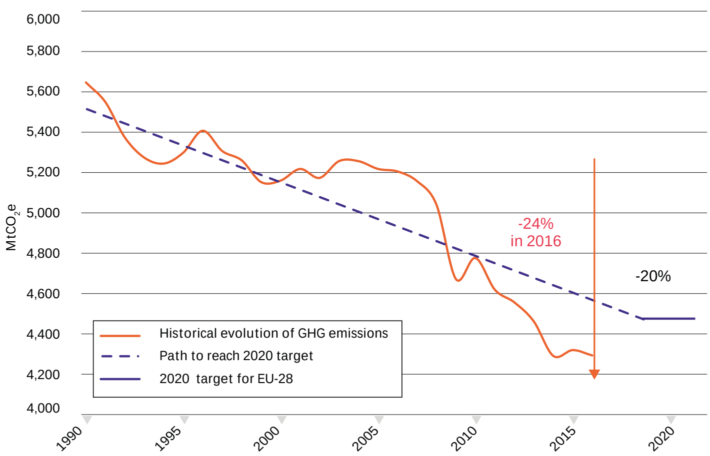
Setting intermediary targets in 2030 and 2040 would enable stakeholders to better plan and adapt to policy changes, therefore easing the implementation of long-term goals.

Europe 2020 strategy objectives should be met for GHG reduction and renewables share, but the primary energy consumption target will be missed

The EU has already exceeded the 2020 GHG reduction targets.

- The EU's emissions have been reduced by 24% as of 2016 compared to the 2005 level, which exceeds the 20% reduction by 2020 target.
- Emissions decreased slowly from 1990 to 2007, threatening to derail the 2020 objective. The 2007 crisis led to a sharp decline in emissions that proved sustainable despite economic recovery from 2012 onwards.

Figure 1.8. Greenhouse Gas Emissions evolutions and targets to 2020

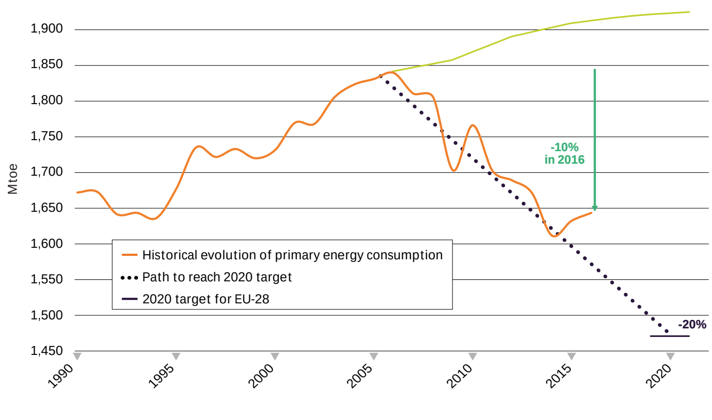


Source: Eurostat 2018 with data from the European Environment Agency and the European Commission 2018

The EU is on track to meet its 2020 renewables target.

- The share of renewables in gross energy consumption almost doubled between 2005 and 2016 to reach ~17% in the EU-28
- Major discrepancies persist between EU Member States. While 53% of Sweden's gross energy consumption came from renewables, only 6% did so for Luxembourg.
- Some countries like France, the Netherlands and Ireland need to bolster their efforts to meet national targets – 50% for France and Ireland, 100% for the Netherlands.

Figure 1.9. EU primary energy consumption evolution and target to 2020

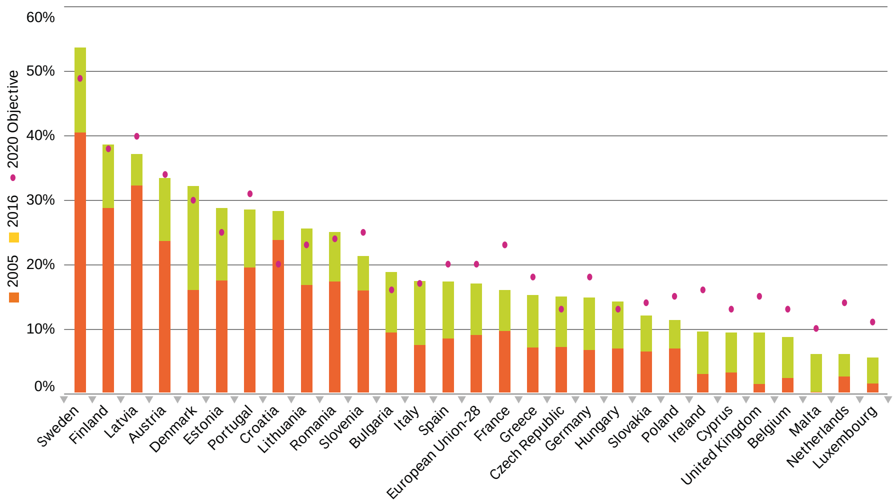


Source: Eurostat, Capgemini consulting WEMO2018I did

The EU is likely to miss its 2020 energy efficiency target.

- EU primary energy consumption peaked around 2007 at 1840 Mtoe to reach 1640 Mtoe in 2016. This only translates to a -10% reduction instead of the -15% required to be on track for the 2020 objective.

Figure 1.10. Share of Renewables in the Member States' gross final energy consumption



Source: Eurostat 2018

Topic Box 1.2: The Mobility Package positions the EU as a regulatory leader for clean and digital transportation

State of play

- The Mobility Package comprises 3 main parts, presented to the European Commission from May 2017 to May 2018.
- **All initiatives are now in negotiations** with the co-legislators and stakeholders.
- The stated objectives and targets may evolve.

1) Europe on the move

- Give 8 legislative initiatives for a transition to a clean mobility, especially in road transport.
- Encourage electromobility and **smart road charging by financing** 1,200 alternative fueling points, including charging points, by 2020.
- Set a **cooperative intelligent transport system** by 2030 to reduce fuel consumption and CO_2 emissions by 1.2% per year.

2) Clean mobility objectives

- Amend the **Clean Vehicles Directive** to stimulate the market by requiring a minimum level of environmentally friendly vehicles in national public procurements.
- **Reduce CO_2 emissions of new cars and vans by 30% in 2030** compared to 2021 and by 15% **for new trucks in 2025** compared to 2019.
- Use Worldwide Harmonised Light Vehicle Test Procedure to measure CO_2 emissions, achieving a target of 95gCO_2/km in 2021 (fleet average).

3) Safe, connected and automated mobility goals

- Become the **world leader in automated and connected mobility** using a digital environment for information exchange in transport (maritime and freight) and advanced safety features for vehicles and pedestrians.

Focus: Action plan for batteries

- Have a European industrial leadership and workforce covering the value chain.
- **Enhance sustainability** by securing access to raw materials, including ones derived from recycling.
- **Promote innovation** (new materials, battery management systems…) with €110 million in 2018-2019 for battery-related research, in addition to €250 million already allocated.
- **Support battery deployment** by allocating €270 million to smart grids and energy storage projects.

The Mobility Package aims at furthering the transition to a low carbon economy by implementing the Strategy for Low-Emission Mobility adopted in 2016. All proposals are now under negotiation with the aim of adopting legislative proposals in 2019.

Sources: http://www.europarl.europa.eu/legislative-train/theme-resilient-energy-union-with-a-climate-change-policy/package-eu-mobility-package
https://ec.europa.eu/transport/modes/road/news/2017-05-31-europe-on-the-move_en
https://ec.europa.eu/transport/modes/road/news/2017-11-08-driving-clean-mobility_en
https://ec.europa.eu/transport/modes/road/news/2018-05-17-europe-on-the-move-3_en
http://wltpfacts.eu/wltp-test-co2-targets/
https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/com20180293-annex2_en.pdf

Europe

2-Energy Transition

Chapter 2 "Energy transition" measures the progress of decarbonation in Europe. It gives an overview of the overall market and technology trends in the energy and transportation sectors. According to the European Environment Agency, the energy and transportation sectors were the two largest emitters of greenhouse gas (GHG) emissions, representing 45% of overall European emissions. The following trends are highlighted in this chapter:

- In spite of growing renewable power additions, **investment in the renewables sector fell by 37%** in 2017 to US$41 billion.
- **Onshore wind and utility-scale solar photovoltaic (PV) continued to see an improvement in their cost-competitiveness,** with the average levelized cost of electricity (LCOE) estimated at €60/MWh and €70/MWh respectively for new projects commissioned in 2017.
- **The battery storage market accelerated in 2017,** increasing from 410 MWh to 590 MWh battery storage capacity installed. Growth is happening both in front of the meter (e.g. large-scale batteries providing grid stability services) and behind the meter (e.g. small-scale installations used for self-consumption).
- **Biomass was the largest renewable energy source** in 2017 (including power, heat and transportation) and will play a key role in meeting European renewable energy targets because of the benefits with the rural economy, its contribution to base-load power and injection into the gas grid as well as with vehicles.
- **Electric vehicles sales soared to approximately 230,000** in 2017, nevertheless representing only 1.5% of total European light vehicles.
- **The role of hydrogen sees modest progress through several demonstration projects,** like ENGIE's installation of a multi-fuel station with 50 Renault Kangoo cars in the French international market of Rungis.

Clean energy investment at its lowest levels since 2006 in Europe

Clean energy investment tumbled in Europe to US$41 billion, despite additional renewable power capacity.

After 3 years of stable investment and renewable additions ranging 20-22 GW, 2017 saw a 37% drop in investment in clean energy sources compared to 2016 (investment here includes asset finance, government funding and R&D funding). 2016 had seen major transactions like the UK's 1.2 GW Hornsea offshore wind project but in contrast no major offshore wind deals were signed during 2017.

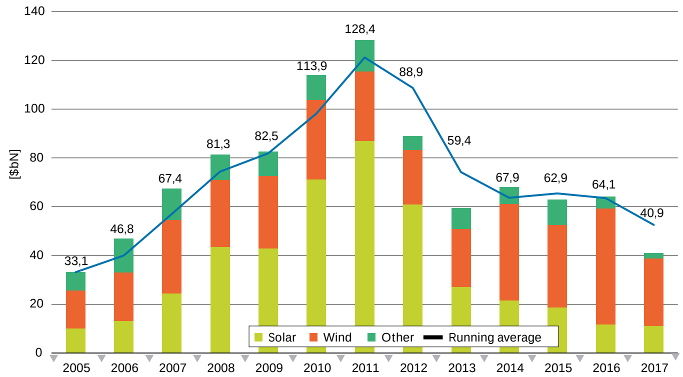
Steady investment in solar

The solar PV market is becoming resilient to changes in policy support as costs come down and PV projects are less dependent on government subsidies. Solar power additions were stable (the EU-28 added 5.91 GW in 2017, compared to 5.89 GW in 2016 according to Solar Power Europe).

Germany and the UK experienced major slowdowns in investment on the back of fewer offshore wind transactions.

Lower investment in Germany and the United Kingdom contributed to the decline. In Germany investments dropped by 35% to US$10.4 billion as the regulatory framework for renewables moved towards auctions. The UK suffered from the closing of biomass, onshore wind and solar subsidy programs and a huge gap between wind auctions leading to a 65% decrease (US$7.6 billion).

Figure 2.1. New investments in clean energy in Europe: 2005-2017 (US$ billion)



Nominal values: Total values include estimates for undisclosed deals. Excludes corporate and government R&D, and spending for digital energy and energy storage projects (reported in annual statistics only).
Sources: BNEF Q1 2018 report

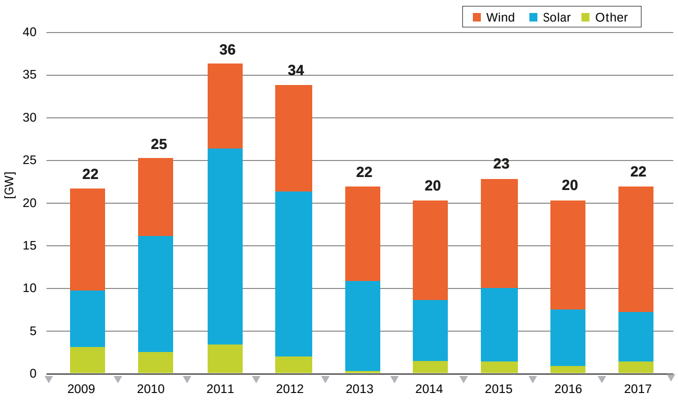
Sweden jumped to become the third-largest clean energy market in 2017 behind Germany and the UK: the country saw a rapid rise in investment (€3.7 billion ~ 127% growth on 2016) owing to a dynamic onshore wind market.

Employment in Europe grew by 3% in 2016

The global renewable energy sector employed 9.8 million people in 2016 with 1.19 million jobs in Europe.

The **biomass** sector was the leading employer and represented 10% of the European share (389,000 jobs), making Europe the leader in global biomass employment. Biomass is the most labor-intensive renewable energy sector and has been boosting the economy in rural regions.
Europe accounted for 30% of **global wind** employment and the wind industry is the second best employer in Europe after biomass (344,000) with Germany responsible for 47% of this total.
In spite of steady investment in **solar PV projects**, employment dropped by 8% in Europe in 2016. According to SolarPower Europe, the enforcement of import duties on Chinese PV cells had curbed job potential in Europe until now. These restrictions were removed on 3 September 2018.

Figure 2.2. Net renewable power capacity added in Europe (GW)



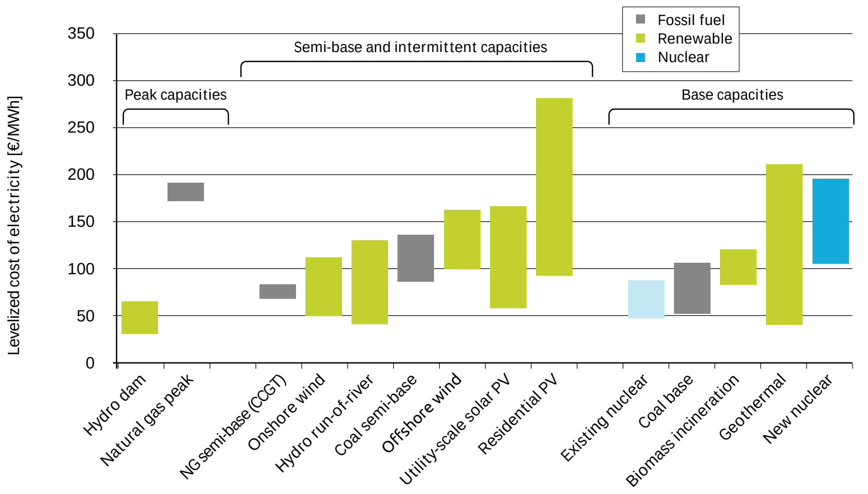
Source: IRENA

Average wind and solar costs have come down by ~20% compared to 2016

Onshore wind and solar PV are the most cost-competitive sources of power generation for semi-base generation.

- Due to a rapid fall in system costs and improved capacity factors, **solar PV** has seen the fastest cost reduction between 2016 and 2017.
- In contrast, costs reductions were more limited for **onshore wind** but new efforts for digital tools are promising greater cost reduction in the future (see topic box on digital wind).
- **Gas and coal prices** saw a 17% and 24% increase compared to 2016 owing to higher demand for gas, and to a sharp reduction in Chinese coal production and sustained coal demand in the Asia-Pacific region and Europe.
- The cost of **small hydro** depends on the location and varies greatly. In Western Europe, potential will be limited to a few greenfield sites and mostly repowering of ageing turbines.
- **Offshore wind** LCOE is stable, at roughly double the cost of onshore wind despite having a higher capacity factor. Projects are complex and located far from the shore, and average installation costs were reported at US$4,700/kW.

Figure 2.3. Leverage cost of electricity (LCOE) comparison of selected power generation sources in Europe starting production in 2017-2018



Notes:
Analysis shows LCOE range for major European markets (UK, France, Germany, Spain, Italy). Assumptions on CAPEX and cost of capital are based on literature research and company interviews. The range for geothermal reflects projects in Eastern Europe and best-in-class enhanced geothermal systems (EGS) in Germany. Analysis excludes carbon price impact. Assuming current EU ETS price at 18 €/tCO$_2$, LCOE would increase by €18/MWh for coal and by €7/MWh for gasThe cost of nuclear is based on future pressurized water technology under construction in the UK and is based on the UK Department for Business, Energy & Industrial Strategy estimates. Distinction is made between "first of a kind" (FOAK) and "nth of a kind" (NOAK)
Source: Capgemini Consulting, IRENA, BP database, Fraunhofer Institute, Commodity Markets Annual prices

Nuclear is forecast to be the most cost-competitive baseload generation but the future price remains uncertain.

- Due to an additional delay in Flamanville PWR commissioning, EDF raised the total project cost to €10.9 billion compared to the €3.3 billion announced in 2003.

Geothermal is the second best option but resource potential is limited to Turkey and Iceland. In other parts of Europe, costs are much higher owing to enhanced geothermal technology and deeper wells.

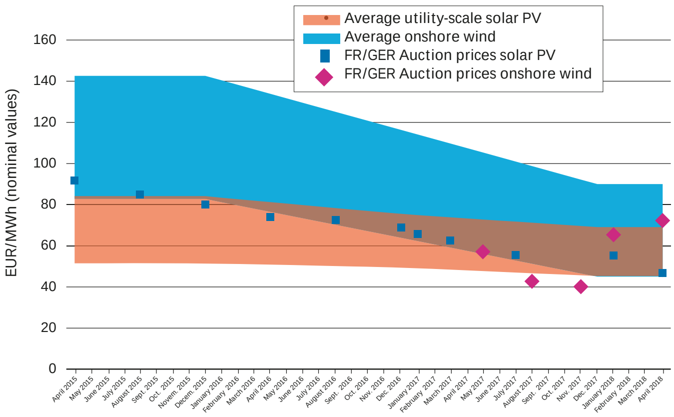
- **Wood-based biomass** LCOE ranges from €80-120/MWh and additions are steady, but potential is curbed by supply availability.

Utility-scale PV and onshore wind cost of electricity converge

In 2017, the weighted average LCOE of utility-scale solar PV declined by around 30%, mainly driven by module price reduction.

- Lower installation costs and increased capacity factors (use of trackers, better sizing of the inverter) are improving the economic competitiveness of utility-scale PV.
- In some markets utility-scale PV costs are already comparable to those of fossil fuels. In July 2018 Portugal saw its first subsidy-free solar plant coming online (46 MW).
- In 2018 the PV module market is suffering from over-capacity, mainly due to the abrupt withdrawal of China's incentives; Bloomberg New Energy Finance (BNEF) expects a 34% decline in module prices in 2018, to reach a global average of €23.2 ct/W by the end of 2018. With module prices representing nearly 50% of solar capex, solar LCOE are bound to decrease further during 2018.

Figure 2.4. Comparison of onshore wind and solar PV LCOE vs. auction prices (€/MWh) since April 2015



LCOE value in nominal
Sources: WEMO2017, EEMO 2016, Capgemini Analysis
Federal Network Agency (Bundesnetzagetur) & French Ministry for Economy & Finance (CRE)

Topic Box 2.1: How digital is transforming the wind sector ?

Some of the current digital trends (which are already a part of this new changing wind industry picture) and actor's move to go further in this changing environment

Drones for optimization of inspections & repairs

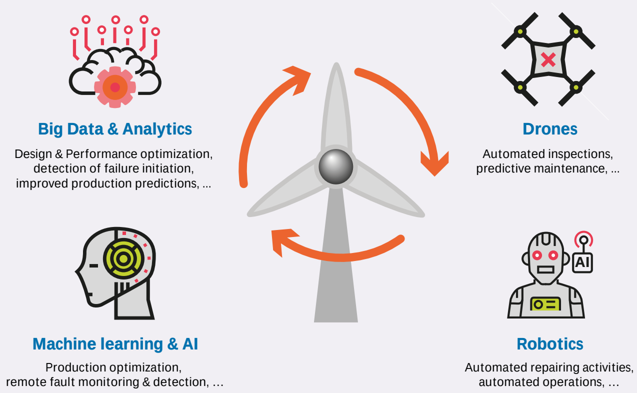
Self-piloting drones, flying autonomously during the inspection and using an advanced damage identification system, could **capture high-quality images, detect wind turbine cracks and collect valuable data.**

- **Ørsted partnered with SkySpecs** to investigate automated drone inspection on the world's largest offshore wind turbine at Burbo Bank Extension (July 2018). **Iberdrola and Arbórea Intellbird** is using the Arachnocopter, a specialized drone able to fly longer distances over electric power lines, combined with the new software with a focus on wind farm evacuation lines to improve power line inspection (July 2018). **Blueye Robotics** has developed an underwater drone for inspection of offshore wind turbines cables and the surrounding sea bed to increase the response time to potential problems.

Tailor-made robots for remote maintenance & repair of blades

Use of specialized robots for the less accessible assets such as wind turbine blades have significant impacts on maintenance & repairing activities and some basic services such as cleaning and polishing.

Figure 2.5. Digital levers that transform wind industry



- **Helical Robotics** created the small robots travelling up and down on a wind turbine surface and inspecting the blades and other mechanics. **SGRE** is developing blade robots for monitoring basic services by partnering with Rope Robotics, to develop blade maintenance robots which is planned to be commercial by 2019. **GE Renewable Energy** has been working on this question since 2012 and they are using GE blade robot, with a microwave scanner, to check the structural integrity of blades.

Wind and solar average bidding prices in Germany and France converge

- In 2018, France and Germany awarded Utility-scale PV projects at €55.3/MWh and €48.2/MWh respectively.
- The gap between German and French average bidding prices is wider for onshore wind (€47.3/MWh and €65.4/MWh respectively for auctions awarded in January and February 2018). Although wind resources are more attractive in France, the cost of onshore wind in France is 20-40% higher than in Germany because of a longer development time and more regulatory hurdles.
- In February 2018 Germany launched its first technology-neutral renewables auction (200 MW). Onshore was left empty-handed while solar projects won all the bids. One reason for the challenge for onshore wind was a new temporary rule requiring all bidders to have environmental permits before submitting a bid (source: WindEurope).

Data analysis to maximize assets' value through performance assessment, plan optimization and active monitoring

1. **Artificial Intelligence (AI) to increase the efficiency of wind farms: GE** offers a technology that predicts power output via AI based on changing weather data, helping to improve overall efficiency and stabilize energy supplies. A better prediction of low-output days will enable the operator to plan more effectively its maintenance schedule and reduce the amount of overall lost production.
2. **Machine learning (ML) for improving wind turbine operational efficiency and availability:** ML algorithms are applied to data gathered from IoT systems to predict asset failures better and extend operating hours by defining accurate optimal repair time. Considering the number of sites and the remote locations of wind farms, there is convincing economic benefit, as unplanned shutdowns could result in minimum four weeks of turbine downtime.
3. **Big data techniques optimize cost models and energy production: Vestas acquired Utopus Insights** (July 2018) to offer customers digital solutions capable of delivering increased predictability, **increased renewable energy production,** more efficient operations, and better integration with energy grids, Vestas added. LiDAR technology (Light Detection and Ranging—is a remote sensing method used to examine the surface of the Earth) and **predictive weather modelling techniques,** enabling to provide a robust **3D representation of the complex flow field dynamics, could be used to improve predictive weather models and energy production forecasts.**

Topic Box 2.2: The market for energy storage continues to grow; however, its full potential is hindered by lack of clarity around regulations and business models

The future for battery storage looks promising as penetration of renewables surges and battery module costs decrease.

- According to Bloomberg New Energy Finance (NEF), renewables penetration is expected to rise to 87% by 2050. Solar and wind, emerging as the cheapest source of bulk generation, could represent as much as 50% of power generation. In order to make this a viable alternative to fossil fuel power, flexibility in the form of battery storage will become vital. Simultaneously, due to the dramatic increase in EV production, battery prices have tumbled and are expected to decrease another 66% by 2030[1]. The price points of combined solar/wind with storage, are challenging fossil fuel energy on all three fronts; bulk generation, dispatchable generation, and flexibility. Hence, as wind and solar continue to penetrate the energy mix, the demand for accompanied storage capacity will also likely follow.

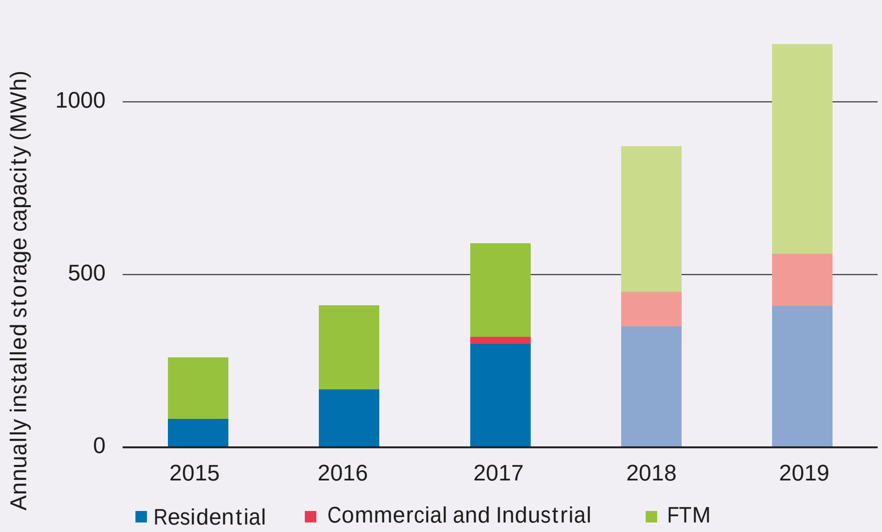
Growth is expected to continue in both behind-the-meter (BTM) and front-of-meter (FTM) storage.

- Overall, 49% more capacity was installed in 2017 compared to 2016, with BTM storage doubling in growth[2]. FTM has a tendency to react as the ancillary market structure evolves in various countries (launch of DS3 program in Ireland for example). In more developed markets, such as the UK and Germany, the FTM market has started to settle down with larger BTM projects beginning to take the spotlight. Although specific drivers influence growth according to geography, generally, BTM growth is expected to continue as the desire to self-consume increases and business models mature.

Lack of clarity around regulatory frameworks, ownership, and business models challenges market growth.

- C&I storage has a strong case in many geographies. It is mostly driven by a desire to self-consume PV or wind power, level high demand charges, and stack services to widen income streams. However, it is hindered by an unclear structure. Specifically, the challenges are lack of clarity on how to monetize storage services most efficiently, as well as unfavorable contract lengths for many industrial clients.
- The biggest challenge for the storage market in 2018 is the uncertainty around energy storage in the EU regulatory framework, where lack of storage as a defined element in the energy system and ownership are the two most prominent concerns. Lack of definition in the energy mix often causes double charging as a consumer and a generator, while ownership of system results in debates around anti-competitive behavior. As a result, many larger scale storage projects are beginning to move to C&I applications, being viewed as less risky long-term investment due to more flexibility in income streams. Furthermore, undefined regulations on Distribution System Operators (DSO) access to residential units hinder full utilization of available storage capacity.
- Establishing a common EU regulatory framework and showcasing more success cases and best practices may further stimulate market growth.

Figure 2.6. Annually Installed Electrical Energy Storage Capacity (MWh)



European Market Monitor on Energy Storage (EMMES), EASE and Delta e-e

1 Bloomberg NEF New Energy Outlook 2018

2 Delta-EE/EASE European Market Monitor on Energy Storage (EMMES) 2.0

Can Europe become a leader in battery technology?

In October 2017 the European Battery Alliance was launched by EU Commission Directorate-General for Energy to make Europe the powerhouse of the global battery market. The announcement underscores the growing role that batteries will play in the power, chemical and automotive sectors, but is also a reminder that European manufacturers are lagging behind their Asian counterparts.

It is widely accepted that Li-ion batteries will be the dominant energy storage technology in the next decade because of the versatility both in terms of power and energy. However, their performance needs to be improved in terms of energy density, charge/discharge speed and reliance on raw materials. In particular their supremacy has been challenged in recent months because of fear over lack of raw materials, in particular cobalt. The price of one tonne of cobalt went from US$32,500 to US$81,000 between 2016 and 2017. Cobalt is a key component of the cathode and most of the resources are located only in the Democratic Republic of Congo.

This is why battery technology promoters are pursuing different approaches to find the optimal materials for the different battery components: the anode, the cathode, the separator and the electrolyte.

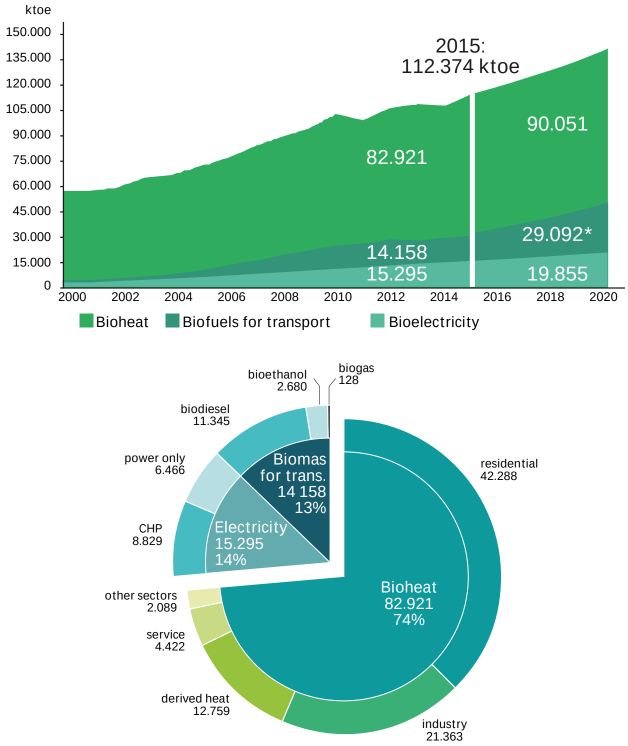
In recent years battery startups have emerged to propose alternatives to Li-ion. Conamix, a U.S.-based start-up, raised several million dollars in June 2018 to develop a cobalt-free electrode (the company is backed by Albermarle and U.S. utility Exelon). Other options considered are sodium-ion – i.e. replacing lithium by cheaper sodium – or zinc-air batteries.

However, the recent bankruptcy of the promising AquionEnergy battery technology illustrates that the sector remains highly competitive and the future technology uncertain. AquionEnergy had developed saltwater electrolytes to reduce environmental risk. However, its technology was not cost-competitive for short-term duration needs and the company went bankrupt in March 2017 to be then acquired by an unknown investor in July 2017.

* Sources:
https://www.chemistryworld.com/news/battery-builders-get-the-cobalt-blues/3008738.article
https://www.greentechmedia.com/articles/read/saltwater-aquion-emerged-from-bankruptcy-new-owner#gs.uruBWQk

Biomass is the largest renewable energy source in Europe meeting 10% of final energy consumption

Figure 2.7. EU-28 gross final energy consumption of bioenergy per market segment (2015)



** Target for liquid biofuels for transport includes multiple countings*
Source: Eurostat, National Renewable Energy Action Plans 5NREAPs), AEBIOM's calculations, WEMO2018

1. According to Eurostat, in 2015, the total EU-28 biomass supply for electricity, heating and transport fuel amounted to 112,37 Mtoe. This amount is **projected to increase by nearly 24% up to 139 Mtoe by 2020.**
2. Bioheat represents 74% of the total final energy consumption ofbioenergy in Europe with 82.921 ktoe in 2015. **Bioheat is used mainly in residential and industrial sectors (respectively 50% and 26%).**
3. **Electricity production from bioenergy continues to increase in Europe, albeit at a slower pace than other renewable technologies**
   - Electricity coming from bioenergy increased by 2% between 2016 and 2017 (from 190 TWh to 196 TWh).
   - At the same time, electricity coming from overall renewable energy increased by 10.6% between 2016 and 2017 (from 607 TWh to 679 TWh).
4. **The bioenergy mix is more or less similar in every country of Europe** exept for Malta and Luxembourg for which biofuel for transport represents around 50% of the final energy consumption of bioenergy. And in the United Kingdom, shares of bioheat and electricity are respectively 44% and 40%.
5. Looking at national consumption, the **5 largest bioenergy consumers represent more than half of the EU's total bioenergy consumption (54%).** All these countries have been benefiting from political supports for the development of biomass. Germany remains the leading country with 17% of total EU-28 consumption, followed by France with 12%, Italy and Sweden with 9% each, and Finland with 7%.

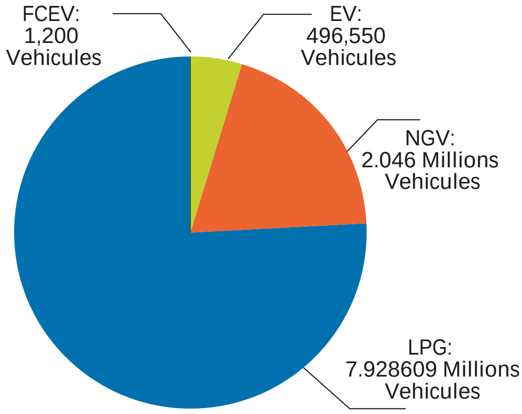
Liquefied petrol gas and natural gas vehicles are the biggest contributors to alternative mobility in Europe, but electric vehicles are catching up

The transportation sector contributes to roughly a quarter of European greenhouse gas emissions (GHG) and is predicted to fall behind its 2020 reduction targets (emissions from transport in 2015 – including aviation but excluding international shipping – were 23% above 1990 levels according to the European Environment Agency). Reducing the share of gasoline and diesel-fired engines is of the utmost importance to decarbonate the sector.

In this report Capgemini chose to look at the status of three types of vehicle technology contributing to the decarbonization of the sector: **Liquefied Petrol Gas Vehicles (LPGV) and Natural Gas Vehicles (NGV), Electric Vehicles (EV), and Fuel Cell Electric Vehicles (FCEV).**

1. Driven by the Italian market, **LPG and NGV** represent the majority of all alternative vehicles in Europe enabling decarbonation, **respectively 75.7% and 19.5% in 2016.**
2. **EV represented 4.7% of the European stock of alternative vehicles in 2016.** As the carbon emissions reduction targets and environmental standards increase, the share of EV is poised to increase.
3. **Sales of FCEV remain anecdotical in Europe.** Some 180 FCEV passenger cars were sold in 2017 according to the European Commission with Toyota and Hyundai being the main vendors. As for light commercial vehicles, 50 Renault Kangoo vehicles were sold to the Rungis market in France. Capgemini estimates 1,200 FCEVs (passenger and commercial) circulated on European roads in 2017, primarily in Germany and France.

Figure 2.8. Fleet of alternative vehicles in Europe (2016)



Source: IEA, IANGV,EAFO, Capgemini Consulting analysis

The EV charging network is growing exponentially, outpacing investment in CNG and H2 fueling networks

The European network of public and private EV charging stations is growing rapidly.

- A total of 3.3 million EV charging stations existed in Europe at the end of 2017, of which nearly **half a million EVs** were added in just 2017[2].
- In comparison, there are ten times fewer compressed natural gas (CNG) stations in Europe (3,408 according to NGVA Europe 2016 market report).
- Finally, there were **139 hydrogen stations** in operation in **Europe** as of February 2018[1] (106 as of January 2017). Out of the 33 stations opened in Europe since January 2017[1], 24 opened in Germany.

Figure 2.9. 139 Hydrogen reflueling stations

Sources: H2Stations

Figure 2.10. 3.3 million EVs charging stations

Sources: Chargemap

Cost, ease of installation and strong government push underpin EV infrastructure growth.

- An increasing number of manufacturers are now offering EV charging stations both to the public and for private use. Costs now range from a couple of hundreds euros for homes to €50,000 to fast charging station[2].
- However opening a hydrogen refueling station requires to install a facility composed of several systems to store, compress and distribute gas.

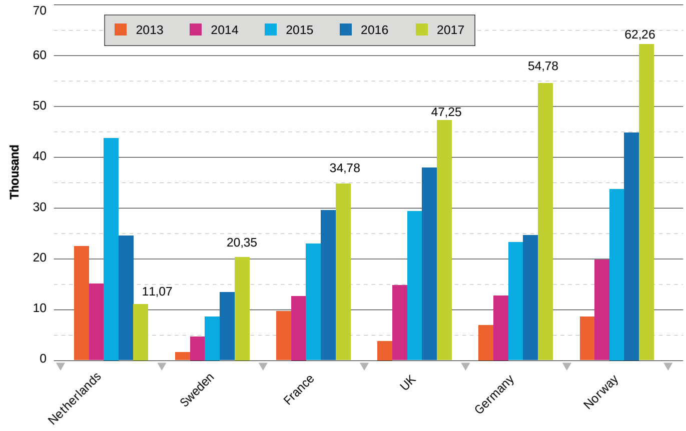
With very few H_2 stations in place, installation costs are still very high. For example the **Avia Orly Ouest station** built in the Paris area by Air Liquide in December 2017 was estimated at **US$2 million[3].**

1 LBT; TUV SUD; https://fuelcellsworks.com/news/germany-had-the-highest-increase-of-hydrogen-refuelling-stations-worldwide-in-2017
2 Newmotion, https://newmotion.com/en_GB/about-us/press-room/electric-vehicle-charging-on-the-rise-across-europe
3 Automobile Propre; http://www.automobile-propre.com/hydrogene-air-liquide-inaugure-nouvelle-station-orly/

Germany on track to overtake Norway as the largest European EV market

1. **EV sales increased by 21% in 2017 in Europe and reached around 230,270 units** when at the same time overall vehicles sales increased by only 3.4%. In 2017, electric vehicles represented 1.5% of overall vehicles sales (~15.6 million) in Europe.
2. **Norway and Germany were the largest EV markets in 2017:**
   - Norway is the European leader in terms of market share with 39% of new car sales being electric. In comparison, the value is six times higher than Sweden which has the third-highest global market share (6%), after Iceland (12%, not included in the figure) (IEA, 2018b).
   - Germany saw the biggest increase in electric vehicles sales with 54,560 EV sold in 2017 against 24,000 in 2016. The uptake of electric vehicles is still largely driven by the policy environment. The ten leading countries in electric vehicle adoption all have a range of policies in place to promote the uptake of electric cars.
3. **The Netherlands is the only country where sales of electric vehicles decreased between 2015 and 2017.** This trend could reflect a change of taxation system in the Netherlands related to the private use of company cars. This change ended the tax incentive for Plug-In Hybrid Electric Vehicles (PHEVs) in early 2017 while retaining a tax advantage for Battery Electric Vehicles (BEVs).

Figure 2.11. New electric vehicle (EV) sales in Europe (BEV & PHEV by country)



Sources: International Energy Agency, WEMO 2018

Germany focuses on hydrogen mobility initiatives

The use of hydrogen in mobility is expanding in buses and commercial fleets:

- **Public transportation with hydrogen buses**
  - Hydrogen buses lead to no additional operational constraints compared to combustion engine buses: refueling takes only 5-10 minutes and the range can be as much as 400 km thanks to the high energy density of H_2 fuel cells[3].
  - As of 2018, 386 hydrogen buses are either in operation or planned mainly through 5 initiatives (CHIC, HyTransit, High V.LO-City, JIVE, 3Emotion) supported by the Fuel Cell and Hydrogen Joint Undertaking (FCH JU): a unique public private partnership supporting research, technological development and demonstration activities in fuel cell and hydrogen energy technologies in Europe[3].
  - The largest fleet will be deployed mainly through the JIVE 1 & 2 projects by the early 2020s (financed by the FCH JU): 291 new buses in 5 different clusters spread all over Europe[3].
- **Commercial fleets**
  - Captive fleets are well suited for the deployment of hydrogen projects: they have predictable recharging patterns and vehicles make regular stop-overs at the same location equipped with a single hydrogen refueling station[4].
  - In June 2018, ENGIE Cofely opened a hydrogen station to power 50 utility vehicles to be used by the company's technicians (project supported by the FCH JU)[5].

Other early stage H_2 applications aiming at reducing gasoline and diesel consumption:

- **Rail transportation**
  - In November 2017, the Lower Saxony transport authority (Germany) signed a contract with Alstom for the delivery of 14 hydrogen Coradia iLint trains[6].
- **Heavy-duty transportation**
  - The H_2-Share project started in 2017 aims at testing a one ton rigid hydrogen truck and its own flexible mobile refueler on North-West European roads[7].

Europe

3 AFHYPAC, http://www.afhypac.org/documents/divers/ElementEnergy%20Brochure%2007-18%20web.pdf
4 AFHYPAC, http://www.afhypac.org/documents/divers/H2%20Mobilit%C3%A9%20France%20EN%20FINAL%20UPDATED.pdf
5 ENGIE, https://www.engie.com/en/journalists/press-releases/largest-hydrogen-utility-fleet-alternative-multi-fuel-station/
6 ALSTOM, http://www.alstom.com/press-centre/2018/07/coradia-ilint-hydrogen-train-receives-approval-for-commercial-operation-in-german-railway-networks/
7 NWEUROPE, http://www.nweurope.eu/projects/project-search/h2share-hydrogen-solutions-for-heavy-duty-transport/

3-Infrastructures & Adequacy of Supply

Electricity market

In Europe adequacy of supply was maintained in 2017 in spite of increased intermittency and a slight 0.5% growth in consumption.

- Renewables' share in the capacity mix continued growing steadily (+6.7%) while carbon capacities were steadily decommissioned (-2.6%).
- The renewables upwards trend is confirmed in the long term to reach 58% of forecast generation capacity in 2025.

The European Union took further steps towards market integration.

- All network codes have been published and their implementation is ongoing. TSOs' roles are now evolving to meet the new regulations.
- The first cross-border intra-day market coupling (XBID) went live in June 2018.
- The European Commission strengthened its commitment to interconnection infrastructure with new principles for setting interconnection targets.

On a local level, the gradual transformation of the electricity market revolves around system operators .

- Local consumption and production patterns are evolving and require adapted local infrastructures and a strong collaboration between Transmission System Operators (TSOs) and Distribution System Operators (DSOs).
- Smart meter deployment keeps moving forward as the first stage in the transformation of local markets.

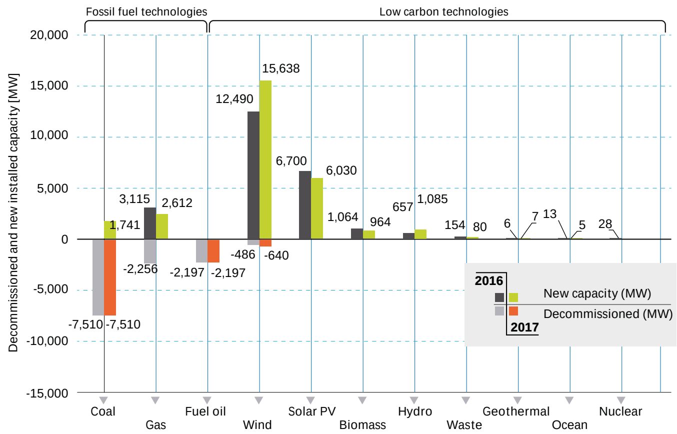
Evolution of the capacity mix

Net EU power capacity increased by 17.8 GW (1.8%) in 2017, with the 10.3 GW decommissioning of fossil fuel capacity compensated for by 28.1 GW of new capacity

Just as in 2016, renewable capacities were invested in to ensure the EU's move towards a more renewable mix.

- With 15.6 GW capacity installed in 2017, wind broke a new annual record [1] and led the way in renewable energies (up by 23.8 GW). Fourteen projects for offshore wind farms were connected in 2017, including for example:
  - 570 MW at Race Bank in England (connected in May 2018)
  - 30 MW at Hywind in Scotland, the world's first floating wind farm (generating since October 2017).
- Fossil fuel capacities continue to be decommissioned in the EU, with a decrease of 10.3 GW in 2017 led mainly by a constant decline in coal capacity (7.5 GW):
  - Closure of Germany's Wardohl-Elverlingsen coal plant accounted for the loss of 310 MW (disconnected in March 2018)[2].
- However, with 2.6 GW capacity commissioned in 2017, gas is the only fossil fuel with a positive balance of installed vs. decommissioned capacities for two years in a row. This evolution is explained by the reopening of previously mothballed gas capacities to face small adequacy challenges occurring in 2017.

Figure 3.1. Installed and decomissioned generation capacity per type of source (2017 versus 2016)



Source: WindEurope Annual Statistics 2017

1 WindEurope annual statistics 2017

2 https://beyond-coal.eu/2018/03/23/coal-plant-retirements-gain-pace-europe/

Evolution of the generation mix

The EU power generation in 2017 increased slightly by 0.7% (+21TWh) to reach 3,089 TWh generated in 2017

The share of renewables energies generation stabilized at 30% of the mix in 2017 after increasing for many years.

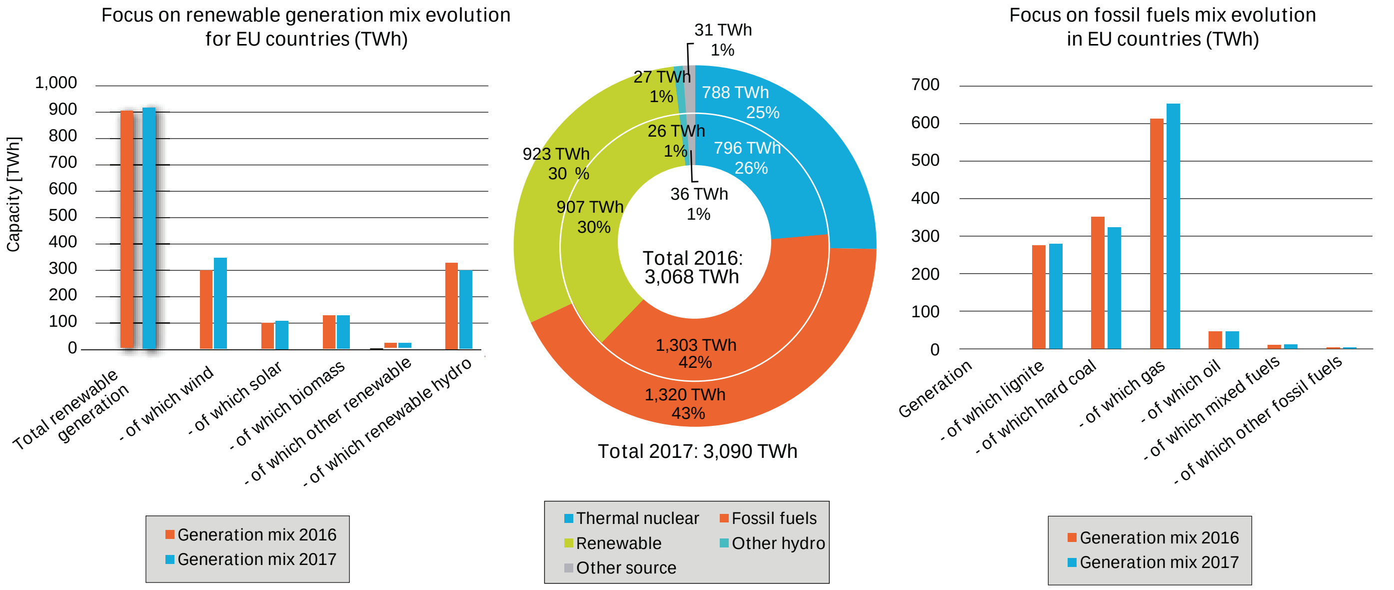
In 2017, hydro was the only renewable source to decrease in the generation mix. Hydro reservoirs were close to historical lows in Mediterranean countries, leading to generation unavailability for this source[1].

The winner in this hydro situation was natural gas, the only fossil fuel to have an increased share in the EU generation mix[1]. For example, in Portugal, natural gas met 69% of summer 2017 portuguese consumption while being exported to Spain.

However, exceptional wind conditions benefited countries with strong wind capacities such as Germany and the UK:

- Germany: wind power generation increased by +26.5 GWh to reach 106.6 GWh, 16.2% of the total mix[2].
- United Kingdom: on June 7, it established a renewables peak power output record of 19.3 GW (incl. 9.6 GW wind), covering 55% of the midday power demand in the country[3].

Figure 3.2. Overview of 2015-2017 generation mix evolution in EU countries (TWh)



Source: ENTSO-E database – Capgemini analysis, WEMO2018

Evolution of energy consumption

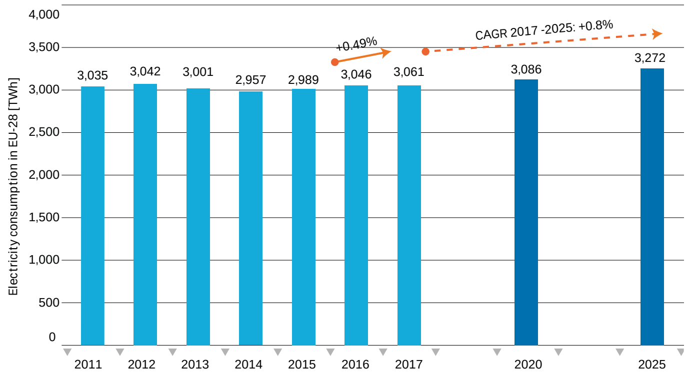
Electricity consumption increased by 0.5% in 2017 to reach 3,061 TWh

For the third year in a row, electricity consumption increased in the EU-28. Compared to the 1.9% rise the previous year, consumption appeared to stabilize.

This slight increase in power consumption follows the hottest (2016) and the second hottest (2017) years globally since 1880[4], joined by the coldest winter in several year, reaching some record lows in Eastern and Central Europe.

- In Poland, electricity consumption increased by 2% after being strongly affected by the 2017 cold spell. In Italy, Spain and Portugal, electricity consumption also

Figure 3.3. Electricity consumption in EU-28 (2011 to 2017 and 2020, 2025 projections)



Source: ENTSO-E database – Capgemini analysis, WEMO2018

1 Winter Outlook 2017
2 https://ag-energiebilanzen.de/28-0-Zusatzinformationen.html
3 https://www.telegraph.co.uk/business/2017/06/07/uk-sets-new-renewable-energy-record-wind-solar-surge/
4 NASA, https://www.giss.nasa.gov/research/news/20180118/

increased, by 2%, 1.6% and 4% respectively,[1] with high demand peaks in January 2017[2].

- Other European countries were more or less stable, with for example a 0.5% increase in Germany and a 0.4% decrease in France[1].

Overall adequacy of supply

Adequacy of supply was maintained during 2017 despite difficulties caused by various extreme weather conditions and political events

Winter 2017-2018 would have been uneventful if not for the Serbia-Macedonia-Montenegro power deviation[3].

- In January 2018, the political disagreements by the Serbian and Kosovar authorities caused a frequency deviation for the following three months, a never yet encountered situation in Continental Europe, where the missing energy amounted to more than 113 GWh.

Adequacy was endangered but maintained despite summer 2017 events[4].

- Several overloading events occurred on AC lines in the south of France due to the high flows between France and Spain.
- Transmission capacities were affected and interconnection infrastructure damaged in Greece, Portugal (forest fires), Hungary and Poland (extreme wind).
- In August and September, half the nuclear power plants in Sweden were under maintenance, increasing the need for imports to the south of the country. Further maintenance for some of them led to a strained few hours of high prices in Sweden but also in Denmark and Finland.
- The non-availability of two nuclear power plants in Germany and numerous outages in the Czech Republic endangered the voltage stability in the region.

Evolution of imports, exports & prices

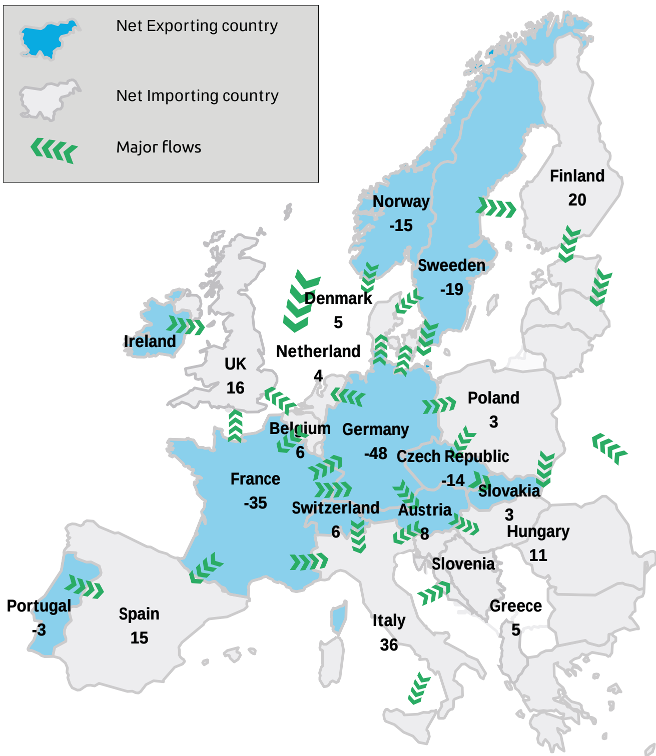
Electricity flows mainly from north to south.

- France and Germany remain the main exporters of electricity. In contrast, Italy keeps its rank as the biggest importer[5].
- To secure its electricity supply, and due to poor hydro conditions in Spain, flows from France to Spain have increased.
- Sweden's net exports increased in 2017 as its nuclear generation capacities returned to normal.
- To secure its electricity demand, Bulgaria imposed a 27-day export ban from January 13 until February 8, the longest ever.

Average spot prices rose in 2017 and are projected to stabilize in H1 2018.

- This surge in European wholesale prices is mainly connected to the greater use of natural gas in electricity generation to mitigate the hydro situation, as mentioned earlier, coupled with an increase in gas prices[5].
- CO_2 prices increased from €8-20/tCO_2e thus affecting the average prices of fossil-fuel generation.
- The majority of European markets noted a high increase in electricity prices in January due to the cold spell. However,

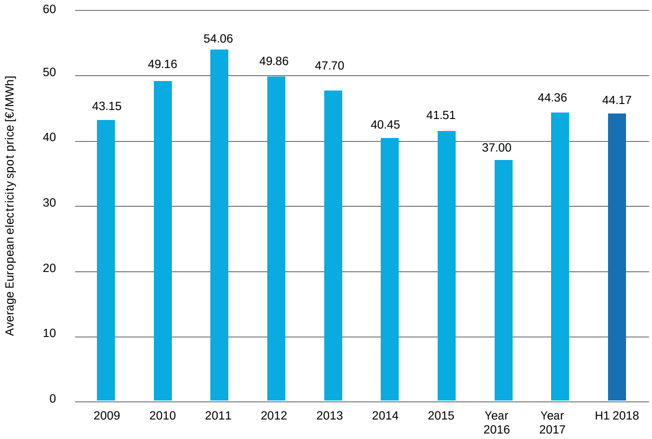
Figure 3.4. Map of electricity flows



Source:

1 https://yearbook.enerdata.net/electricity/electricity-domestic-consumption-data.html
2 https://docstore.entsoe.eu/Documents/Publications/SDC/Winter_Outlook_2017-18.pdf
3 https://www.entsoe.eu/news/2018/03/06/press-release-continuing-frequency-deviation-in-the-continental-european-power-system-originating-in-serbia-kosovo-political-solution-urgently-needed-in-addition-to-technical
4 ENTSO-E Winter Outlook 2017
5 The European Power Sector in 2017, Agora Energiewende

Figure 3.5. Average European electricity spot price (2009 to H1 2018)



Source: Power Exchange websites – Capgemini analysis, WEMO2018

the Nordic market remained stable as it was not affected by this weather.

- After an initial stabilization of price volatility, prices increased in 2017, particularly in Q1, with its harsh weather conditions[1].

Installed capacity forecast

In 2025, low-carbon capacities are expected to represent 68% of the European Union's capacity mix

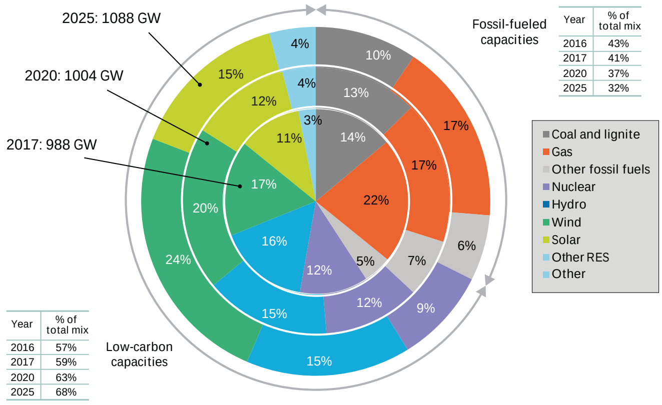
Recent political decisions from Brussels are likely to accelerate the decommissioning of existing coal-fired power plants.

In April 2017, the European Commission voted for tougher environmental performance standards for Large Combustion Plants (LCP), including hard coal and lignite plants [2].
Power generators failing to reduce their emissions in line with the specified targets by mid-2021 will face penalties or closure. According to the European Environmental Bureau [3], 82% of coal capacities expected to be operating at that time will be affected.

The EU is urging countries to invest in Renewable Energy Source (RES) infrastructure for immediate replacement of ageing components, as according to the IEA, investment in the power sector prior to 2020 will be less costly than after that date[4].

The decrease in wind and PV prices along with the generalization of tendering process areas in Europe will be instrumental in the investment in new capacities, and thus to the achievement of a 32% renewables share in the 2030 power mix[5].

Figure 3.6. Current (2017) and future electricity capacity mix (2020, 2025)



Year	% of total mix
2016	43%
2017	41%
2020	37%
2025	32%

Year	% of total mix
2016	57%
2017	59%
2020	63%
2025	68%

Source: ENTSO-E database – Capgemini analysis, WEMO2018

Nuclear share in electricity mix will decrease slightly after 2020.

The German nuclear phase-out plan continues with the decommissioning of Philippsburg 2 at the end of 2019. However, new nuclear capacities will see the light of day with Finland's 1.6 GW Olkiluoto-3 plant, expected to begin regular operation from May 2019.
EDF's Flamanville nuclear plant in France has delayed the start-up of its new third reactor for another year, with full operation starting in 2020. As a consequence the closure of Fessenheim will also be delayed.

Generation & consumption forecast

As the EU capacity mix turns to renewable power investment, the EU objective of 32% RES in the production mix is predicted to be fulfilled.

- After having analyzed past weather patterns in Europe and established various scenarios, a study published in June 2018 went as far as saying that this objective will be outperformed[6].
- Generation from nuclear capacities is likely to increase in 2018 and to stay constant until 2020, when some French nuclear plants should become available for production (30 TWh more in 2018), compensating for the final closure of Germany's Gundremmingen B plant at the end of 2017[7].
- With the increase in both renewables and nuclear generation in 2018, fossil generation is expected to see a

1 European commission, Electricity market quarterly reports
2 http://ec.europa.eu/environment/pdf/31_07_2017_news_en.pdf
3 http://eeb.org/new-rules-hasten-end-for-europes-dirtiest-power-plants/
4 https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2050-energy-strategy
5 http://europa.eu/rapid/press-release_STATEMENT-18-4155_en.htm
6 https://www.sciencedaily.com/releases/2018/07/180726161255.htm
7 The European Power Sector in 2017, Agora Energiewende

sharp decrease in 2018, and a drop of 16% is forecast by 2020 (assuming constant consumption)[1].

Electricity demand is forecast to rise by 0.7% per year between 2017 and 2025.

- Demand continues to increase due to the economic growth forecast[2] coupled with the electrification of usages. These two factors will probably be competing forces with energy efficiency for the downwards vs. upwards evolution of electricity consumption in Europe.
- The target CO_2 emissions reduction is a factor in the electricity demand increase forecast, as it requires moving from conventional fuels to electric power, driving the electrification of daily usages: heating and cooling systems, continuous growth in electric vehicles (both BEVs and PHEVs), and so on[1].
- Finally, the digital revolution is also driving the demand increase. Electricity consumption by Bitcoin mining, for instance, is growing and it is likely to represent 0.5% of the world's electricity by the end of 2018[3].

Adequacy of supply forecast

In the short term, the risk to Europe's security of supply remains under control[4].

According to ENTSO-E, **adequacy of supply will be maintained throughout Europe in the summer of 2018** given the estimated availability of generation, market-based demand-side response and commissioned interconnections.

However, hydro reservoir levels still need to be monitored: 2017 left the Alpine region with hydro levels close to historical lows. Regional Security Coordinators (RSC) will have to assess closely the week-ahead adequacy situation in Austria and Switzerland where hydro generation amounts to more than half the capacity, and ensure that TSOs will be ready in case any risk materializes.

Furthermore, generation curtailment might be needed in case of renewable generation excess and low demand in Ireland and south Italy.

In the mid-term, adequacy of supply will still be secure but some areas should be monitored.

ENTSO-E's base case scenario for the Mid-term Adequacy Forecast (MAF) shows that most countries will be able to secure their adequacy of supply by 2020. But high risks are still observed in some countries like Cyprus, Ireland or Malta, where a Loss Of Load Expectation (LOLE) greater than 10h/y is forecast[5].

For 2025 and with the 2017 MAF base case scenario, adequacy of supply will continue to be under control for most countries. However, the situation could worsen in the Baltic area (due to aging power plants for instance). In contrast, adequacy of supply could improve between 2020 and 2025 in Bulgaria and Northern Ireland, thanks to planned commissioning of CCGT plants and a new interconnector respectively.

Regulation and implementation of European Market integration

Market integration continues to take shape at the European level thanks to the implementation of network codes[6]

All 8 electricity network codes are now published, yet their implementation status differs:

- **Emergency & Restoration:** published in November 2017
- **Electricity Balancing:** published in November 2017
- **System Operations:** published in August 2017
- **Forward Capacity Allocation:** published in September 2016 and implementation ongoing
- **High Voltage Direct Current Connections:** published in August 2016 and implementation ongoing
- **Demand Connection Code:** published in August 2016 and implementation ongoing
- **Requirements for Generators:** published in April 2016 and implementation ongoing
- **Capacity Allocation & Congestion Management:** published in July 2015 and implementation ongoing.

While the newest published codes will be more detailed in order to produce implementation guidelines in the coming years and shape the European electricity landscape, the EU witnessed in June 2018 the go-live for intraday coupling, whereas the Regional Security Coordinators are to be implemented in December 2018.

The evolving European energy landscape is a driving force for regulation and coordination of the EU's system operators.

System operators and the increasing need for flexibility:

- As we saw previously in this chapter, an increase in energy generation from variable renewable energy (VRE) sources is expected in the EU and will lead to more decentralized

1 The European Power Sector in 2017, Agora Energiewende
2 European Economic Forecast, Spring 2018
3 "Bitcoin will use 0.5% of world's electricity by end of 2018, finds study" Independent, May 16th 2018
4 ENTSO-E Summer Outlook 2018
5 ENTSO-E, Mid-Term Adequacy Forecast, 2017 Edition
6 ENTOS-E - Key Recommendations for the Clean Energy Package

and distributed loads while requiring greater flexibility. Consequently, regardless of the voltage level (transmission or distribution), the system will need to handle greater volatility and less predictable generation, as well as less inertia.

- TSOs may become more dependent on the use of flexibility sources and services connected at the distribution level, and will need to obtain and activate such services from DSO clients, potentially causing congestion on the affected distribution network.
- Whereas regulation has made it mandatory for European TSOs to coordinate their actions, the risk of potential problems in DSO networks means that coordination and information exchange between both DSOs and TSOs is also key to managing an overall functioning system and securing adequacy of supply. System operators (TSOs and DSOs) bear responsibility for making decisions and operating their own networks securely and reliably.

Focus on infrastructure interconnexion

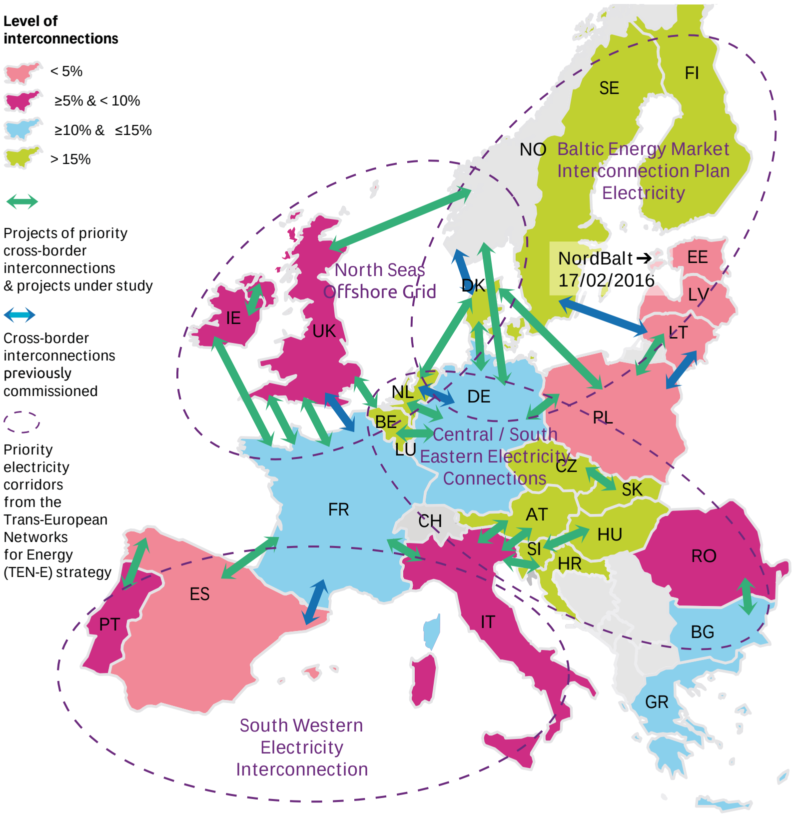
In 2017 the European Commission once again strengthened its commitment to the interconnection infrastructure after the report of the Expert Group on electricity interconnection

The Expert Group launched in 2016 issued its report in November 2017, in which it proposed a new approach for setting interconnection targets, based on five principles[1]:

- **Improve the functioning of the European electricity market** through the implementation of the Third Package network codes and **increase the capacity available to the market** (it is for example proposed that AC interconnectors' net transfer capacity be doubled)
- **Favor new interconnection projects** if any of the following thresholds are triggered: minimizing price differentials between countries or bidding zone (€2/MWh), ensuring that electricity demand can be met in all conditions, enabling export potential of excess renewable production
- Make mandatory a **positive cost-benefit analysis** for each new interconnector
- **Facilitate public involvement** to help address any perceived concerns towards interconnectors
- Regularly **re-evaluate the proposed methodological approach** as the fast pace of technology is likely to influence the network infrastructure.

In the wake of this report, the European Commission issued a "Communication on strengthening Europe's energy networks" where it estimated that about €180 billion would need to be invested by 2030 to upgrade and expand European energy networks (national grids and interconnectors), leading to €40-70 billion annual savings[2].

Figure 3.7. Map of interconnections levels and interconnections projects (2018)



Countries	Projects of cross-border interconnections	Expected date	Capacity increase
AT - DE	Westtirol (AT) - Vöhringen (DE) Pleinting (DE) - St Peter (AT)	2024 2024	1,000 MW > 2,000 MW
AT - IT	Lienz (AT) - Veneto region (IT) Prati (IT) – Steinach (AT)	2024 2019	> 500 MW -
CZ - SK	Otrokovice (CZ) - Ladce (SK) - CZ-SK interconnector	2019	5,907 MW
DE - BE	Lixhe (BE) / Oberzier (DE) – ALEGrO Project	2020	1,000 MW
DE - DK	Audorf (DE) - Kassoe (DK) - DKW-DE	2020	1,000 MW
DE - NL	Doetinchem (NL) -Niederrhein (DE)	2018	1,500 MW
DE - PL	Vierraden (DE) / Krajnik (PL) Gubin (PL)-Eisenhuettenstadt (DE) - GerPol Power Bridge II	2020 2026	> 1,000 MW 700 MW
DK - NL	North Sea Wind Power Hub	2035 - 2040	14,000 MW
ES - PT	Fontefría (ES) – Ponte de Lima (PT)	2021	3,000 MW - 3,200 MW
FR - DE	Vigy (FR) - Uchtelfangen (DE)	2027	1,000 MW
FR - ES	Cubnezais (FR) / Gatica (ES) - Golfe de Gascogne	2025	2,000 MW
FR - IT	Grande-Ile (FR / Piossasco (IT) - Savoie - Pièmont	2019	1,200 MW
FR - UK	Warande (FR) / Kingsnorth (UK) – GridLink Menuel (FR) / Exeter (UK) – FAB Project Lovedean (UK) - Barnabos (FR) - AQUIND Interconnector Mandarins (FR) – Sellindge (UK) ElecLink	2022 2022 2022 2018	1,400 MW 1,000 MW - 1,400 MW 2,000 MW 1,000 MW
IT - SI	Salgareda (IT) - Beričevo (SI)	2022	1,000 MW
NO - DE	Tonstad (NO) / Wilster (DE) – NordLink	2020	1,400 MW
NO - UK	Norway / United Kingdom interconnection – North Sea Link	2021	1,400 MW
PL - DK	Avedøre (DK) - Dunowo (PL)	2030	-
PL - LT	Ostroleka (PL) -Stanislawow (PL) - LitPol Link Stage 2	2023	1,000 MW
RO - BG	Black Sea Corridor	2020	1,339 MW ~3329 MW in 2030
UK - BE	Richborough (UK) / Gezelle (BE) – NEMO link Leiston (UK) - TBD (BE) - Nautilus: 2nd interco UK - BE	2019 2028	1,000 MW 1,400 MW

Note: The European Council requires each country to have a minimum import capacity level equivalent to 10% of its installed capacity
Source: European Commission, ENTSO-E – TYNDP, Enerpresse, various sources – Capgemini analysis, WEMO2018

1 European Commission, Towards a sustainable and integrated Europe, Nov 2017
2 European Commission, Communication on strengthening Europe's energy networks, Nov 2017

Since its beginnings in 2013, the European policy towards interconnection Projects of Common Interest (PCIs) has started to come to fruition and is accelerating:

- Approximately 30 PCIs are or will be in operation by the end of 2018 while 47 more are to be completed around 2020
- In August 2017, the Spain-France power link consultations started[1]. At the very beginning of 2018, the project obtained a €578 million[2] funding commitment from the EU, more than three times the EU CEF support in 2016.
- These numbers have to be tempered as more than half the electricity infrastructure projects are experiencing delays[3].

Focus on market coupling (intraday & day-ahead)

Day-ahead market coupling continued and intraday coupling emerged.

In Europe, 19 countries are coupled in the so-called Multi-Regional Coupling (MRC), covering about 85% of European power consumption and operating with no major incidents according to ENTSO-E.

While day-ahead coupling projects are quite mature (and continue with additional couplings like Croatia and Slovenia to Nord Pool in June 2018), Cross Border Intraday (XBID) went live in June 2018 with the help of 4 partners, EPEX SPOT, GME, Nord Pool and OMIE[4].

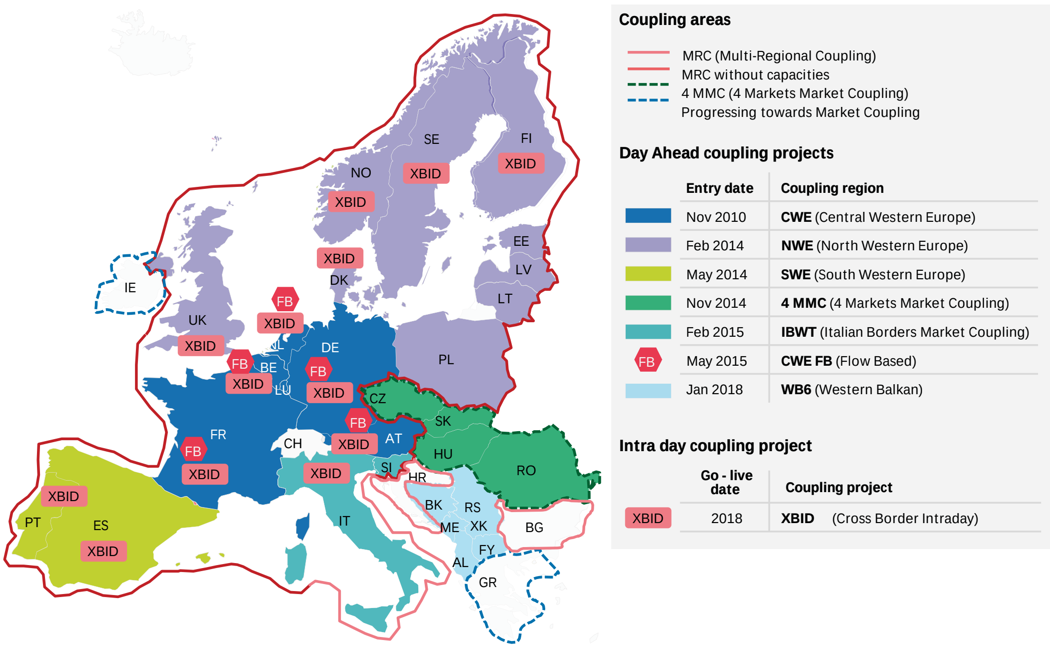
Countries continue to launch their intraday markets (IDM), in order to be able to join XBID. Croatia (CROPEX) successfully launched its IDM in April 2017, and Bulgaria (IBEX) announced the launch of its IDM in April 2018[5], whereas countries like France and the UK continued their growth in volumes traded in IDM (50% and 20% increase y-o-y respectively in July 2018)[6].

The balancing regulation is put into practice with the implementation of cross-borders projects.

To meet the objectives of the European Commission regulation regarding cross-border balancing, many cross-border projects have been launched. For instance, the PICASSO Project was launched by eight TSOs from five countries and has expanded with eight more TSOs as members, with an objective to design, implement and operate a platform for automatic Frequency Restoration Reserves. Other projects worth mentioning include the Frequency Containment Reserves (FCR) project with ten TSOs, the Manually Activated Reserves Initiative (MARI, 25 TSOs), the Trans European Replacement Reserves Exchange (TERRE, six TSOs) and the International Grid Control Cooperation (IGCC, 23 TSOs).

In addition, in June 2018 ENTSO-E submitted the implementation frameworks for imbalance netting and replacement reserves with approval expected by the end of 2018.

Figure 3.8. Market Coupling – WEMO 2018



Source: Power exchanges and various industry sources – Capgemini analysis, EEMO17 & WEMO 2018

1 Inelfe, Electricity Interconnection France-Spain across the Bay of Biscay
2 Reuters, "EU provides record funding for a France-Spain power link", January 25, 2018
3 European Commission, Communication on strengthening Europe's energy networks, November 2017
4 Nord Pool Cross-Border Intraday: Questions & Answers
5 Balkan Green Energy News, "IBEX announces intraday market kick off", April 2, 2018
6 EPEX SPOT and CROPEX press released

Topic Box 3.1: Capacity mechanisms

The difficult harmonization of European capacity mechanisms

On November 30, 2016, the European Commission (EC) submitted the draft package Clean Energy for All Europeans, notably including proposals for a regulation on the internal market for electricity (Proposal for a Regulation of the European Parliament and of the Council on the internal market for electricity *(recast), November 30, 2016, COM (2016) 861 final)*. One of the objectives of the EC is to harmonize the regulation of capacity mechanisms within the European Union (EU), which proves difficult due to the wide diversity of the mechanisms set by several Member States.

Initial lack of regulation in the EU has led to a wide range of European capacity mechanisms.

In several Member States, the "energy only" market does not provide sufficient profitability and incentive to invest in new generation capacities. As a consequence, some Member States' power generation sites may be insufficient to maintain security of supply in the future.

To prevent possible electricity shortages, many Member States have set up capacity mechanisms, which consist of remunerating capacity providers (power generation and demand response operators) for being available to produce during consumption peaks.

The approaches adopted in response to each Member State's electricity systems and national energy policy issues have led to different capacity mechanism designs from one State to another, from more centralized to more market-based designs:

- Germany and Belgium rely on temporary strategic reserves: competitive tendering procedures are organized in order to select capacity generators which are outside the electricity market, and operate only in emergencies.
- Italy and Poland adopted a market-wide capacity mechanism based on competitive auction managed by TSOs where capacity providers can obtain compensation for being available.
- in the French market-wide capacity mechanism, energy suppliers have to possess sufficient capacity certificates to cover the increased demand of their clients as well as a security margin, in order to operate on the market. Capacity certificates are delivered by RTE, the French transmission system operator (TSO), and sold by power generators to suppliers.

Although the designs of capacity mechanisms vary, they all offer capacity providers additional revenue through payments for making electricity capacity available. The existence of this revenue outside of the traditional electricity market has led the EC to suspect the existence of State aid. The EC launched a sector inquiry in April 2015 and made several recommendations in November 2016 *(Final Report of the Sector Inquiry on Capacity Mechanisms, November 30, 2016, COM (2016) 752 final).*

Following the European Commission's initiative, capacity market designs progress towards increasing cooperation between Member States.

According to the 2016 sector inquiry outcome, capacity mechanisms should not be a substitute for market reform failures. Before proposing capacity mechanisms, Member States must make appropriate efforts to address their resource adequacy concerns through market reforms. The EC considers that lack of cost-effectiveness of electricity generators used during consumption peaks may reflect current overcapacity and regulatory failures: the incentives to invest, which would only rely on capacity mechanisms, may prove insufficient to maintain adequate levels of capacity in the medium and long term.

The EC is also concerned that capacity mechanisms often provide subsidies only for national capacity providers, ignoring the value of cross-border imports and distorting investment signals. This means many of the benefits of an open and well-connected internal energy market are lost and costs for consumers increased.

In order to resolve those two major issues, the EC made recommendations in the final report of its sector inquiry, which have been included in the proposal for a regulation on the internal market for electricity *(Articles 22 and 23, proposal for a Regulation of the European Parliament and of the Council on the internal market for electricity (recast), November 30, 2016, COM (2016) 861 final)*, which is being negotiated. The EC wants each Member State to:

- rely on a thorough necessity assessment going beyond national borders
- allocate support through competitive tenders open to all types of capacity providers
- limit competition distortions by appropriate design;
- limit interference with price formation in the energy markets
- limit the impact on cross-border trade by allowing capacity providers in other Member States to participate.

On this last issue, the European dimension for capacity mechanisms is, for now, limited to the objective of cross-border cooperation, with the intention that capacity providers can play a role directly or indirectly in neighboring countries' capacity mechanisms. However, this is only a first step for the EC and in the future, cross-border cooperation should free the way for an integrated capacity market.

Decentralization of the energy system and the evolution of local balancing

Aggregation's new role in the market: grid management and appropriate grid balancing measures must accompany one another at local levels

There are now many varied sources of energy in the power system, ranging from offshore wind farms, EU interconnectors, distributed generation and energy storage in homes and vehicles, and microgeneration connected as part of consumers' electrical installations.

This results in power flows with much greater variations in volume and direction than were foreseen when the network system was originally planned, representing a challenge for power system design. As a result, flexibility and demand response are becoming increasingly important for balancing demand and supply.

In several EU countries aggregators are entering the electricity or reserve markets, though their progress has not been smooth. Regulatory frameworks are undergoing gradual reform in order to better enable their market access.

In European markets, existing aggregators work primarily with industrial or commercial customers. However, it is expected that new technologies will make it possible for residential flexible electricity consumption to become more commercially attractive and play a bigger role in system stability and efficiency.

In Germany, Next Kraftwerke, an aggregator of wind and biogas power plants, achieved a 50% capacity increase in 2017. It hopes to repeat this in 2018 and add more green power producers to its portfolio.

Electric vehicle registration in the EU-28

The increasing integration of electric vehicles (EVs) generates opportunities and challenges for grid management. Vehicle-to-grid technology, for example, enables better balancing of peak demand on the electricity grid by allowing EVs to both draw power from the grid and return it to the network.

2017 saw a 35% increase in the registration of plug-in hybrid electric vehicles (+224,000), compared with 2016. France recorded the largest number of registrations (over 26,110 PHEV), followed by Germany (more than 24,350 PHEV) and the UK (more than 13,580 PHEV)[1].

Evolution of the DSO role

The Clean Energy Package reinforces the "trusted third-party", market facilitator role of the DSO.

Integration of renewables requires flexible and innovative approaches to handle fluctuating loads. The EU energy transition process is accompanied by many new products such as smart appliances, and services at the local distribution level such as smart grids.

- The Clean Energy Package (CEP) therefore proposes that authorities set incentives for DSOs to procure flexibility services from distributed energy resources such as self-generation, small-scale renewable generation, energy storage and power-to-heat services neutrally (rather than owning/operating them) and to integrate innovative solutions in order to manage local congestion and solve technical problems.
- The CEP ensures transparency of market transactions and recommends prohibiting DSOs from owning and operating EVs and storage infrastructure, except in specific cases where they are required in order to ensure the reliable, efficient and secure operation of the distribution system.

Essentially, these regulations and recommendations all contribute to the transition from a Distribution Network Operator to a Distribution System Operator, where DSOs will be responsible of local network balancing in strong collaboration with TSOs. In that respect, the Council of European Energy Regulators also backs Clean Energy proposals for:

- Greater TSO/DSO coordination
- Greater participation of DSOs in the EU institutional framework via a new EU-wide DSO entity
- DSOs to produce network plans that feed into TSO plans, as producers' flows are likely to spill out onto the transportation network.

1 European Environment Agency, Electric vehicles as a proportion of the total fleet, June 2018

The evolutions described above all raise the balancing mesh question. In the future, as the balancing zones will not only depend on the number of points in one geography, DSOs will have to redesign their local modelling by including the Renewable Energy Source (RES) concentration, EV distribution, and the producers' profile within a given zone.

Many EU DSOs have voiced plans to transform their businesses into service-oriented companies, and agreed to collaborate and share their competencies and knowledge. Associations of DSOs and partnerships will contribute towards the development of a regulatory framework to improve the development and exploitation of a more flexible European energy system.

Smart meter deployment

Smart meter deployment progresses in Europe: almost 40% of the target 281 million electricity customers had a smart meter by the end of 2017[1]

As a reminder, in 2009 the European Union set an objective of 80% smart meter deployment by 2020[2]. However, this is not expected to be reached, as revised data in 2017 projected 72% penetration by 2020.

- Several countries have already finished their first wave of smart meter rollouts and are now replacing their first generation, among them Italy (32 million smart meters) and Sweden (5.2 million smart meters)[3].
  - In Italy, Enel's distribution arm e-Distribuzione plans to install 13 million second generation meters by 2019 and another 28 million in the following decade.
  - Sweden is facing a more complex situation with uncertainty around regulations and a greater diversity of DSOs (around 5 million expected to be installed by 2025).
- Other countries currently deploying their first generation include France (12 million smart meters in July 2018 representing 32% of the goal[4]), the UK (12 million smart meters in August 2018, 46%[5]) and Spain.
- Countries who didn't choose mass rollout are now launching selective deployment, starting with large consumers:
  - After approval in 2016, Germany is getting ready for deployment. For example, in 2018 E.ON ordered a first batch of smart meter gateways, preparing for the million smart metering systems they will have to deploy[6].
  - In Belgium, smart metering deployment was approved in 2018, aiming to have smart meters in a third of Belgian homes by 2022[7].

(1) http://www.berginsight.com/ReportPDF/ProductSheet/bi-sm13-ps.pdf
(2) https://www.enedis.fr/sites/default/files/field/documents/Enedis_Dossier_Presse_Linky_2017.pdf
(3) https://www.smart-energy.com/regional-news/europe-uk/second-wave-smart-meter-rollouts-begins-italy-sweden/
(4) https://www.geoplc.com/2018/07/compteurs-linky-un-moyen-de-reduire-sa-consommation-delectricite/
(5) https://www.gov.uk/government/statistics/statistical-release-and-data-smart-meters-great-britain-quarter-2-2018
(6) https://www.eon.com/en/about-us/media/press-release/2018/eon-kickstarts-smart-meter-rollout-by-ordering-16000-smart-meter-gateways.html
(7) https://www.rtbf.be/info/belgique/detail_la-belgique-va-generaliser-les-compteurs-d-electricite-intelligents?id=9937466

Gas market

Gas demand grew for the 3rd year in a row reaching its highest level since 2011.

- The gas consumption increase was mainly for use in power generation.
- Portugal, Greece and Spain experienced a double-digit gas consumption growth.

Europe still benefits from large regasification capacities providing an actionable lever for security of supply.

- Utilization rate of European terminals is 27%.
- Importation capacity is set to increase by 70 bcm in 2023 (+30%).
- LNG terminals are developing new offers to generate alternative revenues.

On the supply side, Europe faces a reduction in indigenous gas production.

- The Dutch government has decided to gradually stop production at the Groningen site.
- European gas production decreased by 3.1%.
- The launch of the Corrib field boosted gas production in Ireland.

Although considered key for EU security of supply, the European storage market remains under pressure.

- Storage capacity remains level at 95 bcm with only 7 bcm under construction.
- Despite this, February and March 2017 saw the lowest stock levels recorded since 2011.

Piped gas remains the main source to meet increasing gas demand.

- Russia is still the largest EU supplier (43% of European imports).
- In 2018, the Netherlands became a net importer for the first time since the 1950s.
- Azeri gas will be an opportunity for diversification, thanks to TANAP.

EU gas spot prices increased considerably by mid-2017.

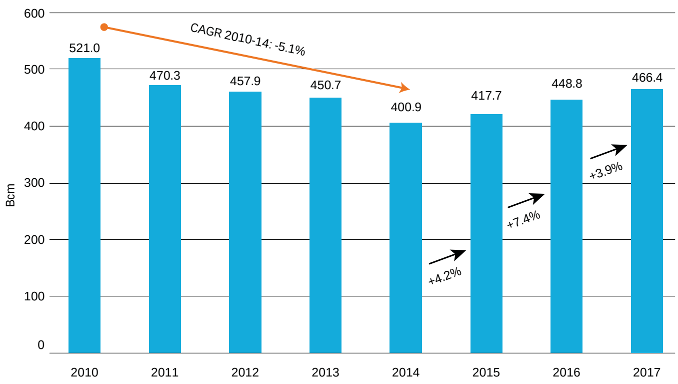
- TTF became the largest European hub, overtaking NBP.
- Low storage levels & weather contributed to an increase in spot prices, in addition to general trends in the oil & gas sector.

Gas demand grew for the 3rd year in a row reaching its highest levels since 2011

EU-28 natural gas demand grew again in 2017 by 3.9% to reach 466 bcm mainly pulled by power generation.

- For the third year in a row, EU gas demand increased by 3.9% over 2016 to reach 466.4 bcm[1].
- Despite this positive trend, after seven consecutive quarters EU gas demand was marked by a decrease of 2%[2] in Q4 2017. This decrease was particularly marked in Denmark, Finland, Latvia and Sweden. Due to mild weather and relatively high temperatures in Northern Europe, gas demand for space heating decreased and took away the growth of gas consumption in the power sector.
- Not all EU members saw the same trend of increased consumption: Portugal showed the biggest growth with 21%[3] more in 2017 than a year earlier. Greece, Croatia and Spain also experienced double-digit growth. The EU's four biggest gas consumers had lower rates; Italy, Germany and France had consumption growth of 6.3%, 3% and 0.4% respectively, while demand fell by 3% in the UK[4].
- Gas-fired power generation led the growth of gas consumption. This market share increased by 11% compared to 2016. This growth rate was highest in Portugal (51.7%), Greece (23.2%), Spain (19.5%), and France (16.5%)[5].
- Maintenance and safety assessments on French nuclear power plants was an important driver for the rising dependence on gas-fuelled generation in Western Europe. Also the low hydro levels and the lack of wind during cold days provided support to gas-powered generation[6].
- In summer 2017, the gas price started to increase. Clean spark spreads reached their lowest level in Q1 2018. The situation of the EU's biggest gas consumers was as follows:

Figure 3.9. Gas consumption in EU-28 (Bcm) 2017



Source: BP Statistical Review 2018, Capgemini Analysis WEMO2018

– In the UK, both wholesale electricity and natural gas prices increased gradually. The clean spark spreads remained stable at around €6/MWh[7] in Q1 2018, helped by slightly increasing carbon prices, securing competitiveness of gas-fired generation against coal.
– In Germany, electricity prices are lower compared to the UK. The clean spark spreads reached their lowest level since Q2 2015, averaging nearly €7/MWh[1] in Q1 2018. With a non-profitable gas-fired generation, the share of gas in the power market was 14.2%.
– Even in the context of Europe's declining energy consumption, the share of natural gas should increase from 24% to 27%[2] by 2040 vs. 2016 levels.

1 BP Statistical Review 2018
2 Eurostat, (data as of 13 June 2018 from data series nrg_103m)
3 Quarterly report on European gas market Vol. 10 and 11
4 Eurostat, (data as of 13 June 2018 from data series nrg_103m)
5 ENTSO-E data
6 Quarterly report on European gas market Vol. 10 and 11
7 Quarterly report on European electricity market Vol. 10 and 11

Europe faces reduction in indigenous gas production

Despite the world global production increase, EU-28 natural gas production continued to fall by 3.1%.

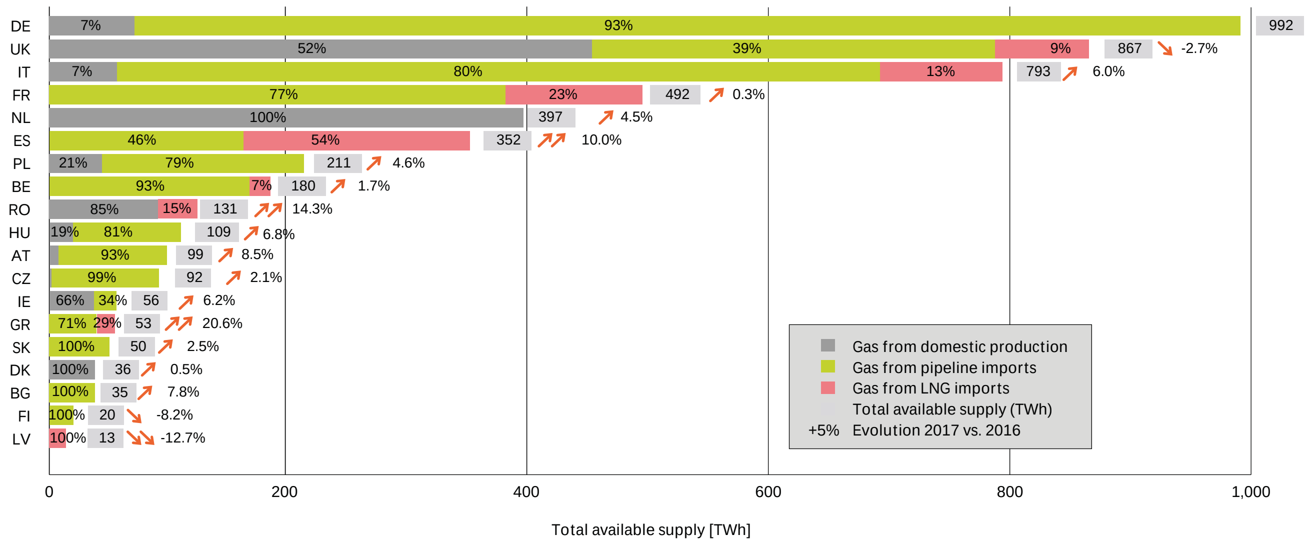
- Global gas production was marked by a significant increase of 4%[1] in 2017, following an average of 1.7% over the five previous years.
- European gas production decreased by 3.1% compared to 2016, to reach 117.8 bcm in 2017[3]. Therefore, the European share of global gas production fell by 0.23% (to reach 3.2%). Several European players reduced gas production; for example in the Netherlands production fell by 9%, and Italy and Germany experienced drops of 4% and 8% respectively[4].
- The Dutch government took the decision (on March 29, 2018) to stop gas production at the Groningen site - one of the largest gas reservoirs in the world – by 2030. This decision came after significant seismic activity in the region. The production shutdown planning consists of reducing production to 12 bcm before 2022 and to stop it by 2030[5].

Indeed, production has been declining since its peak of 53.8 bcm in 2013, reaching 21.6 bcm in 2017[6].

Despite this negative trend, the UK and Ireland proceeded to increase production:

- For the second consecutive year, the UK overtook the Netherlands and remains the largest natural gas producer in Europe. Its gas production grew by 0.6%[7].
- In Ireland, gas production has been boosted since the start of commercial gas production on the Corrib field (late 2015). This new gas field plays a key role in improving energy security of supply in Ireland (in 2014, 96% of Irish gas demand was imported from the UK). Indeed, at peak production, the Corrib field has the potential to supply 60% of Ireland's natural gas needs[8].

Figure 3.10. Domestic gas production versus piped and LNG imports (2017)

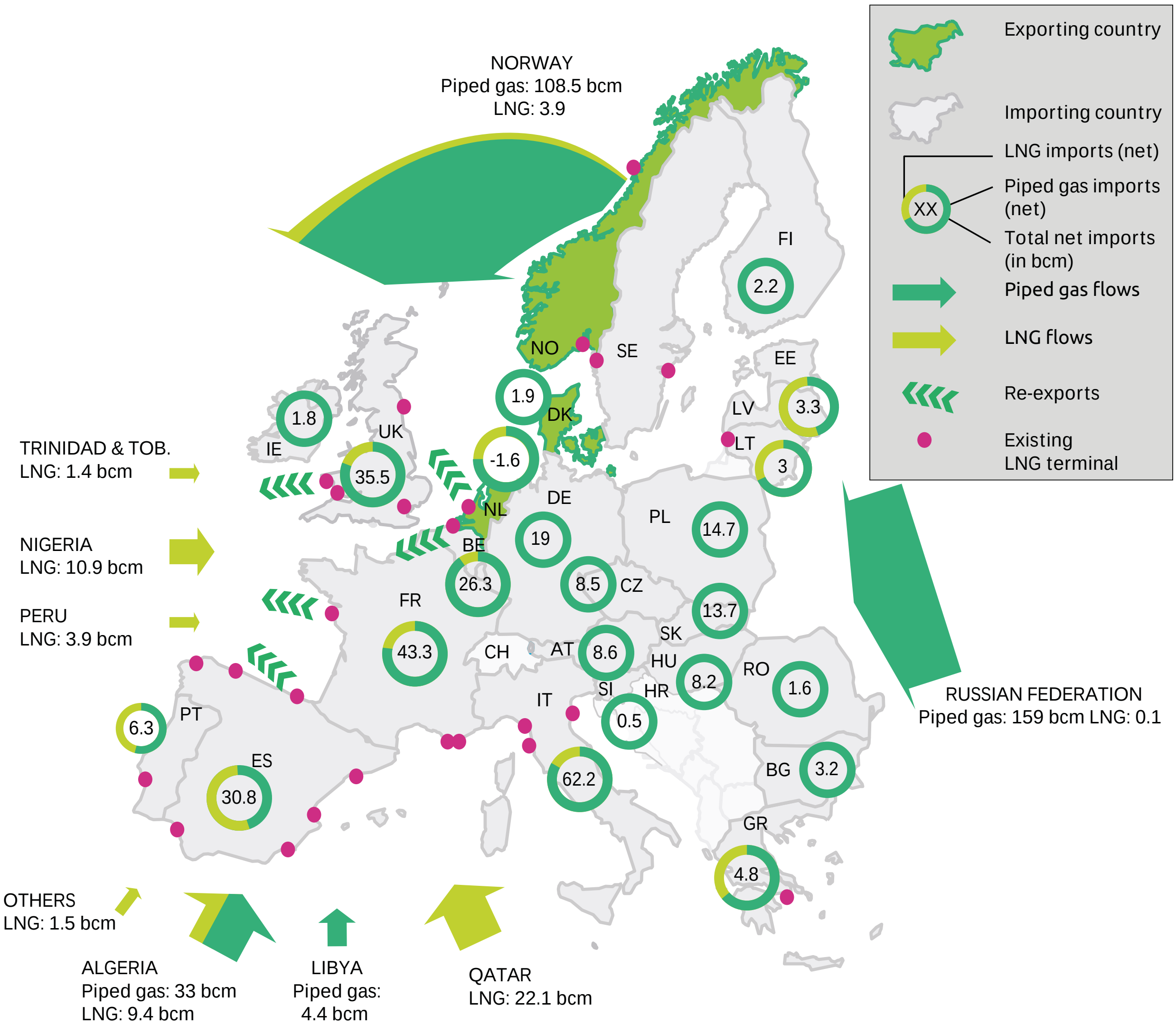


Source: BP Statistical Review 2018, Capgemini Analysis WEMO2018

1 Quarterly report on European electricity market Vol. 10 and 11
2 BP Energy Outlook (https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/energy-outlook/bp-energy-outlook-2018-region-insight-eu.pdf)
3 BP Statistical Review 2018
4 Quarterly report on European gas market Vol. 10 and 11
5 Enerpresse, Article N°12046
6 Reuters, https://www.reuters.com/article/us-netherlands-groningen-gas/netherlands-to-halt-gas-production-at-groningen-by-2030-idUSKBN1H51PN
7 BP Statistical Review 2018
8 Shell Ireland website, https://www.shell.ie/about-us/projects-and-sites/corrib-gas-project/securing-our-energy-future.html

Piped gas remains the main source to meet increasing demand

Figure 3.11. Map of gas imports (2017)



Note: Others = Brazil, Equatorial Guinea, Egypt, Angola, United Arab Emirates
Source: BP statistical review of world energy 2018, GIIGNL – Capgemini analysis, WEMO2018

Pipeline imports cover the major part of EU gas demand.

Piped gas was the major source satisfying increasing demand, in particular during cold days in winter, covering 81.6% of gas demand to reach 372.8 bcm[1]. The gas imports bill was estimated at around €69 billion.

- Imports from Russia increased by 12%[2] and it continues to increase its exports to the EU-28 despite the EU's ambition to reduce this dependency. Germany, the UK and Croatia[3] saw the greatest increases. Russia remained the EU's largest gas supplier, covering 43% of European imports, followed by Norway with 38%. The main Russian supply channels are through Ukraine (44%), Nordstream (30%) and Belarus (24%)[2].
- From April to September 2018, the Netherlands became a net importer for the first time since 1950. Most of this increase was supplied by Norway[4].
- In order to meet the incremental EU gas demand and to improve gas supply channels, several gas pipeline projects are being studied in the design phase or are under construction. For example:

1 GIIGNL
2 Quarterly report on European gas market Vol. 10 and 11
3 PJSC Gazprom Annual Report 2017
4 Reuters, https://www.reuters.com/article/netherlands-gas-imports/dutch-become-net-importer-of-gas-as-groningen-production-cuts-bite-idUSL8N1RW38L

- Despite political tensions, in September 2018 construction finally started on the Nord Stream 2 pipeline, lacking only Denmark's environmental and construction permit[1]. This pipeline will have a huge supply capacity reaching 55 bcm per year.
- The TANAP pipeline opened on June 12, 2018 and will allow the supply of an additional 10 bcm of Azeri gas to western EU. After the TAP inauguration in 2020, transportation capacity should be increased to 24 bcm in 2023 and then 31 bcm in 2026[2] giving the EU a more diversified piped gas supply.

Figure 3.12. Piped Gas imports to Europe (bcm)

Countries	Netherlands	UK	Azerbaijan	Norway	Other Europe	Russia	Algeria	Libya	Total imports 2017	Total imports 2016	% change 2017 vs 2016
Austria	-	-	-	-	-	8.6	-	-	8.6	7.3	18%
Belgium	9.6	7.9	-	0.2	-	-	-	-	17.7	22.2	-20%
CZ	-	-	-	3	-	5.4	-	-	8.4	7.4	14%
Finland	-	-	-	-	-	2.2	-	-	2.2	2.3	-4%
France	4.9	-	-	17.1	0.1	11.5	-	-	33.6	32.35	4%
Germany	20.2	-	-	25.7	0.4	48.5	-	-	94.8	99.2	-4%
Greece	-	-	-	-	0.6	2.7	-	-	3.3	3	10%
Hungary	-	-	-	-	-	8.2	-	-	8.2	7.23	13%
IE	-	1.8	-	-	-	-	-	-	1.8	2.69	-33%
Italy	8.1	-	-	0.8	0.1	22.3	18	4.4	53.7	59.41	-10%
Netherlands	-	1.1	-	22.6	8.6	8.6	-	-	40.9	38	8%
Poland	-	-	-	-	3.5	11.1	-	-	14.6	12.6	16%
Slovakia	-	-	-	-	-	13.7	-	-	13.7	13.4	2%
Spain	-	-	-	2.6	-	-	11.8	-	14.4	15.03	-4%
United Kingdom	-	-	-	35.4	-	4	-	-	39.4	34.1	16%
Other EU	-	-	-	0.9	0.9	12.1	3.2	-	17.1	21.9	-
Rest of Europe	0.5	-	2.1	0.7	1.9	2.7	-	-	7.9		-
Europe 2017	43.3	10.8	0	108.5	14.3	159	33	4.4	372.8		-49%
Europe 2016	52.3	10	0	109.8	24.4	140.9	32.5	4.4	369.6	-	-
% echange 2017 vs 2016	-17%	8%	0%	-1%	-41%	13%	2%	0%	1%	-	-

Source: Capgemini analysis. WEMO2018

Europe still benefits from large regasification capacities providing an actionable lever for security of supply

Figure 3.13. LNG imports to Europe in bcm (2017)

	US	Algeria	Nigeria	Trinidad& Tobago	Norway	Egypt	Equatorial Guinea	Peru	Qatar	Re-exports received	Re-exports loaded	Total net imports	% of total Europe	% ch. 2017/16
Belgium	-	-	-	-	0.03	-	-	-	1.22	0.05	(0.12)	1.2	2.6%	9.4%
France	-	4.42	3.25	0.08	0.79	-	-	0.18	2.00	-	(0.99)	9.7	21.1%	28.8%
Greece	-	1.28	-	-	0.08	-	-	-	0.37	-	-	1.7	3.7%	139.6%
Italy	0.08	0.82	0.10	0.30	0.16	-	-	0.08	6.57	-	-	8.0	17.4%	30.0%
Lithuania	0.18	-	0.10	0.08	0.80	-	-	-	-	-	-	1.0	2.1%	-28.0%
Netherlands	0.08	0.05	0.10	-	0.68	-	-	-	0.78	0.08	(0.73)	1.0	2.1%	89.2%
Portugal	0.53	0.26	2.11	-	0.08	-	-	-	0.61	0.08	-	3.1	6.8%	87.8%
Spain	0.67	2.72	4.37	0.53	0.82	-	-	0.18	3.79	-	(0.99)	11.4	24.8%	-16.4%
Malta	0.03	-	-	0.22	-	0.01	0.07	-	-	-	-	0.3	0.6%	-
Finland	-	-	-	-	0.07	-	-	-	-	0.01	-	0.1	0.2%	200%
Sweden	-	-	-	-	0.19	-	-	-	-	0.24	-	0.4	0.9%	-
Poland	0.10	-	-	-	0.08	-	-	-	1.56	-	-	1.6	3.6%	-
United Kingdom	0.10	0.23	0.10	0.20	0.08	-	-	0.08	5.96	0.04	(0.23)	6.5	14.1%	-36.6%
Europe	1.75	9.78	10.10	1.41	3.86	0.01	0.07	0.52	22.86	0.5	-3.1	46.1	100%	7.4%
% of total Europe	3.8%	21.2%	21.9%	3.1%	8.4%	0.03%	0.1%	1.1%	49.6%	1.1%	-6.7%			
% change 2017 vs. 2016	-	-5.8%	24.2%	42.5%	3.3%	-	-	-74.7%	2.4%	375%	-36.3%			

Source: GIIGNL – Capgemini analysis, WEMO2018

1 https://www.bloomberg.com/news/articles/2018-08-27/why-world-worries-about-russia-s-natural-gas-pipeline-quicktake

2 TANAP website

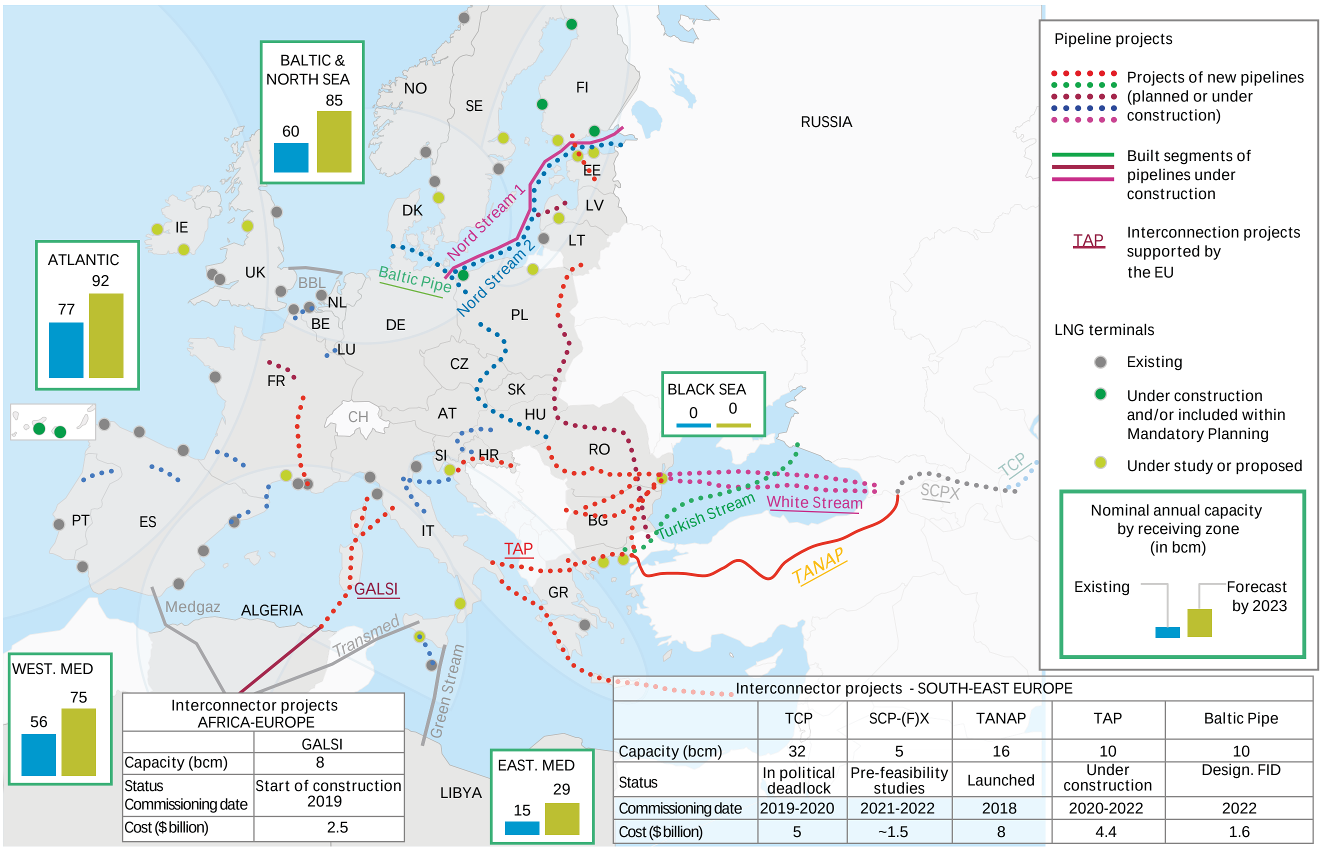
LNG imports continue to increase and reach new markets.

EU-28 LNG imports increased in 2017 by 7.4% reaching 46.1 bcm[1]. This met 9.9%[2] of EU-28 gas need.

The EU-28 utilization rate increased to 27% but remains lower than the 34% global average. In addition, in 2018 Northwest Europe started to increase its reload activity in particular due to shipments from Yamal LNG.

- In 2017, the three countries that increased their LNG imports the most were the "Eastern gas axis" of Spain, Portugal and France, representing 52.3%[3] of the total.
- Poland and Lithuania are using LNG to allow price competition. For instance, in 2017 Lithuania balanced its gas imports (50% LNG and 50% piped gas from Russia) allowing it to negotiate better prices.
- The U.S. is the new source of LNG for the European market, providing 1.75 bcm[3] in 2017 and aiming to secure a greater market share in Europe. However, the market remains driven by price and Asian markets are still more attractive.

Figure 3.14. Map of pipelines and LNG terminals projects (as of June 2017)



Interconnector projects AFRICA-EUROPE

	GALSI
Capacity (bcm)	8
Status	Start of construction
Commissioning date	2019
Cost ($ billion)	2.5

Interconnector projects - SOUTH-EAST EUROPE

	TCP	SCP-(F)X	TANAP	TAP	Baltic Pipe
Capacity (bcm)	32	5	16	10	10
Status	In political deadlock	Pre-feasibility studies	Launched	Under construction	Design. FID
Commissioning date	2019-2020	2021-2022	2018	2020-2022	2022
Cost ($ billion)	5	~1.5	8	4.4	1.6

Source: GIE GLE, European commission projects of common interest – Capgemini analysis, WEMO2018

New customers Albania, Ireland and Estonia will enter the market with LNG terminals planned.

Malta started to import in 2017 (0.3 bcm) to reduce it dependency on heavy oil as a source of energy.

Overall the LNG import terminal annual overall capacity is 210 bcm[4] - way above the 46.1 bcm imported in 2017 - and should be around 280 bcm in 2023 giving flexibility for LNG import increase. The EU-28 are following the upwards trend of global LNG exports with terminal liquefaction capacity at 500 bcm and 125 bcm capacity under construction in March 2018[5].

1 GIIGNL
2 Quarterly report on European gas market Vol. 10 and 11
3 GIIGNL
4 GLE Investment database
5 IGU 2018 World LNG report

Although considered key for EU security of supply, Europe's storage market remains under pressure

European storage hit the lowest level since 2011 during winter 2018.

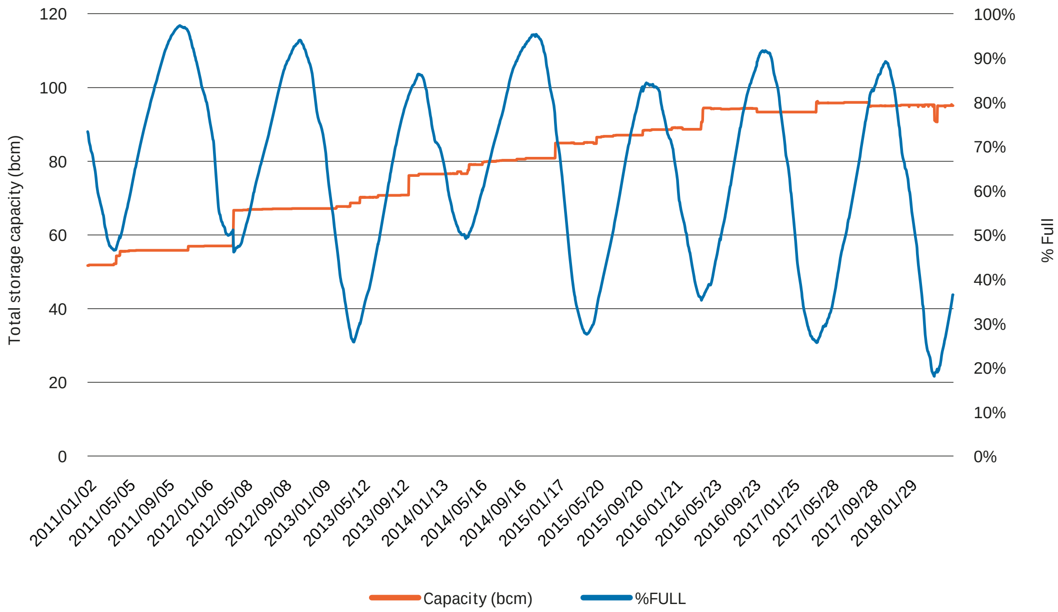
Flexibility offered by gas in electrical power generation relies on high volume quickly accessible that can also be provided by storage. Therefore gas storage capacity remains a key factor for energy security of supply but hit its lowest level since 2011 during winter 2018.

The combination of cold weather in February and March and low import levels led to the lowest stock level recorded since 2011 at 18% of storage capacity. The situation was especially critical for four Member States with a filling rate below 10%: Belgium, the Netherlands, Slovakia and France[1].

Overall EU-28 storage capacity remains unchanged at 95 bcm with no major facility start-ups and only 7 bcm under construction[2]. The low seasonal spread continues to send negative signals to storage operators, except in the UK:

- The UK situation is different from the EU mainland with storage capacity covering only 6% of the UK annual gas demand (20% for France) after the Rough facility closure in 2017. Dependence on the Belgium-UK interconnection pipeline was strong during winter 2018. With a high seasonal spread in the UK, the market is sending a price signal to storage operators incentivizing seasonal storage[2]. The UK accounts for 30% of EU-28[1] planned projects for new storage capacity. However, few of these are under construction making this situation permanent in the short term.
- In France, the storage market is under pressure due to the monopoly of two players. 2018 was a turning point with a new regulation set by the CRE[3]. The objective through open bidding for storage capacity, is to increase the level of stored gas and decrease the cost from €7.5/MWh to €5.2/MWh, thereby avoiding a repeat of the critical situation of a filling rate of only 75% on October 31, 2017 and only 3% on April 1, 2018[3].

Figure 3.15. Gas storage



Source: Capgemini analysis, WEMO2018

1 GIE website https://www.gie.eu
2 European Commission Quartely report on European Gas market
3 CRE website https://www.cre.fr/Gaz-naturel/Reseaux-de-gaz-naturel/Stockage

Following a period of convergence in international gas prices, EU gas spot prices increased considerably by mid-2017

Several factors led to this situation.

International gas prices experienced strong convergence during Q2 2017[1], the greatest since 2011. This situation remained stable until mid-2017, when spot prices at Asian and European hubs grew substantially:

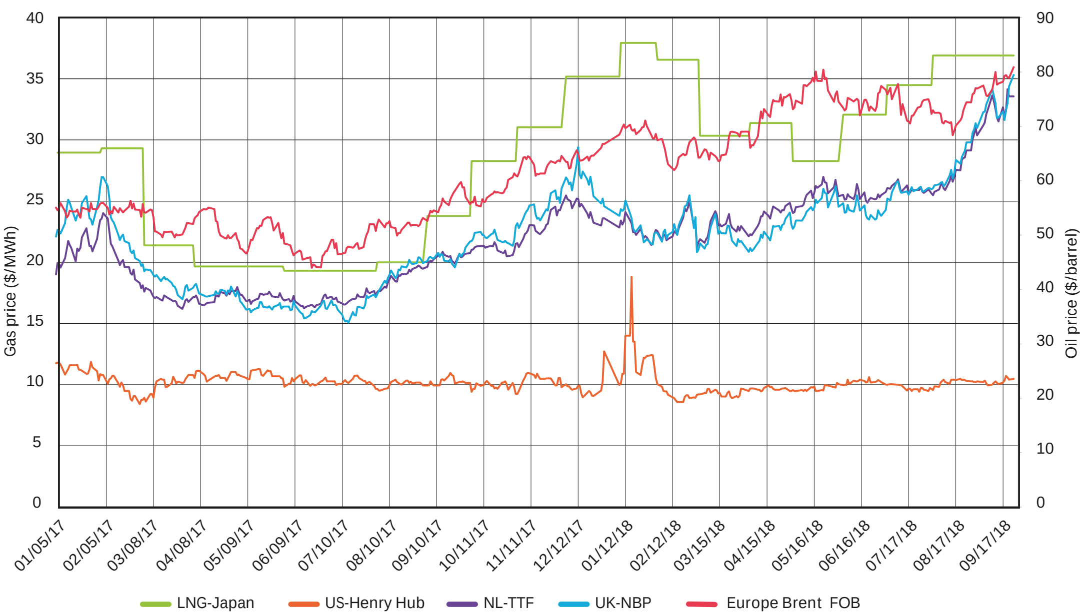
- Japanese LNG price growth was supported by the robust increase in Chinese gas demand as well as strong global seasonal demand.
- In Europe, in August 2017, several factors contributed to a steady rise in gas spot prices:
  - Low storage levels, higher coal and oil prices, continued conversion from coal to gas, Norwegian gas supply outage and concerns about French nuclear power availability.
  - The euro strengthened significantly between January 2017 and March 2018, compared to the U.S. dollar. The exchange rate increased to 1.23 in March 2018, having previously been 1.05 in January 2017[2]. This development has widened the gap between European and American prices.
  - Weather conditions had a major impact on gas prices at European hubs. In January 2018, above-average temperatures lowered gas prices. These prices rose sharply in March, due to late cold weather.

Traded volumes on European gas hubs fell by 4% in 2017 (amounting to 44,500 TWh). After the Brexit referendum, the Dutch Title Transfer Facility (TTF) hub overtook the UK's National Balancing Point (NBP) and became the largest European gas trader. The TTF hub covered 56% of European traded volumes in Q1 2018, while the NBP share decreased to 31%[3].

The French gas market is about to evolve. From November 1, 2018 the two existing hubs will merge into a single one. The French Energy Regulatory Commission (CRE) is insisting on this merger particularly because price differences have widened to the detriment of consumers in southern France[4].

On the other hand, cold weather in North America reduced natural gas stocks and supported the sharp rise in gas prices between December 2017 and January 2018[5].

Figure 3.16. Gas spot prices



Source: Capgemini analysis, WEMO2018

1 European Commission, Quarterly Report, Q1 2018

2 XE Currency Charts, https://www.xe.com/currencycharts/?from=EUR&to=USD&view=2Y

3 European Commission, Quarterly Report, Q1 2018

4 CRE deliberation https://www.cre.fr/content/download/16595/file/171026_2017-246_ZoneDeMarcheUnique.pdf

5 NGI the weekly gas market report http://www.naturalgasintel.com/articles/113294-eias-2018-henry-hub-natural-gas-price-forecast-rebounds-to-320mmbtu

4-Supply & Final Customer

Retail energy prices in Europe

Average retail energy prices decreased in Europe between H2 2016 and H2 2017.

- **Average household electricity and gas prices in Europe remained nearly stable in H2 2017**
  - Gas: -0.5% in H2 2017 compared to H2 2016
  - Electricity: -0.25% in H2 2017 compared to H2 2016.
- **Average industrial gas and electricity prices in Europe decreased in H2 2017 compared to H2 2016**
  - Gas: -9% for very small industries, -5% for small to medium industries and 0% for medium to large industries
  - Electricity: -2% for very small industries, -1.2% for small to medium industries and -3.9% for medium to large industries.

Figure 4.1. Average European gas and electricity prices in 2017

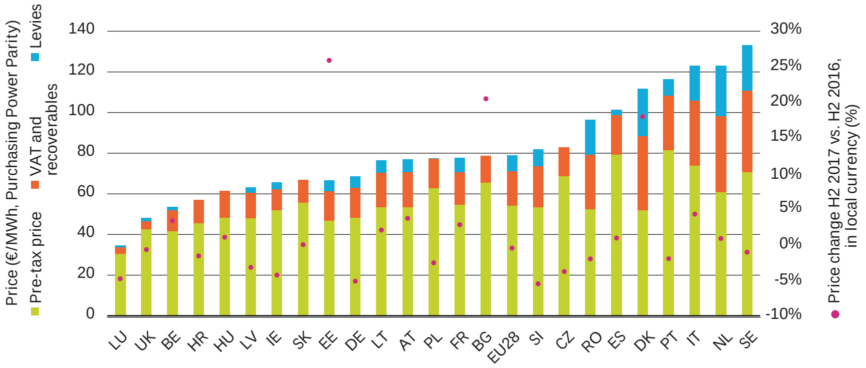
	Residential			Industrial		
	Change in price between H2 2016 and H2 2017	Min (€/MWh)	Max (€/MWh)	Change in price between H2 2016 and H2 2017	Min (€/MWh)	Max (€/MWh)
Gas	-0.5%	34.6	133.1	From -9% to 0%	17.3	66.5
Electricity	-0.25%	133.9	287.6	From -3.9% to -1.2%	39.2	219.9

Source: EUROSTAT – Capgemini analysis, WEMO2018

Residential gas prices remained stable.

- **Across Europe, Household gas prices varied from less than 35€/MWh in Luxembourg to more than 120 €/MWh in Sweden,** resulting in a price differential ratio of ~4 between the cheapest and the highest price.
- **Household gas prices increased significantly between H2 2016 and H2 2017 in Estonia (+26%), Bulgaria (+21%) and Denmark (+18%).**
- **The largest falls in Household gas prices was recorded in Slovenia** (-6%) **and Germany** (-5%).
- **Taxes and levies made up the largest contribution to the price of gas for households in Denmark** (53% of household gas price) **and the Netherlands** (51% of household gas price).

Figure 4.2. Residential gas prices in Europe – all taxes included (H2 2017 compared to H2 2016, in local currency)



Note: Annual gas consumption between 20 GJ (i.e. 5,557 kWh) and 200 GJ (i.e. 55,566 kWh)
Source: EUROSTAT – Capgemini analysis, WEMO2018

Figure 4.3. Industrial & Commercial gas prices in Europe – VAT excluded (H2 2017 compared to H2 2016, in local currency)

Source: Eurostat – Capgemini analysis, WEMO2018

Industrial gas prices decreased in H2 2017 compared to H2 2016.

- **In H2 2017, the most significant fall in industrial gas prices was observed in small to medium industries** with a 30% drop in the Netherlands and the **most significant increase was recorded in very small industries in Lithuania** with a 50% rise compared to H2 2016.
- **The UK had the lowest industrial gas prices** both for medium to large industries (17.3€/MWh) and for small to medium (46.6 €/MWh) industries and **Romania had the lowest industrial gas prices** for very small industries (29€/MWh).
- **Sweden had the highest gas prices** for all industries.

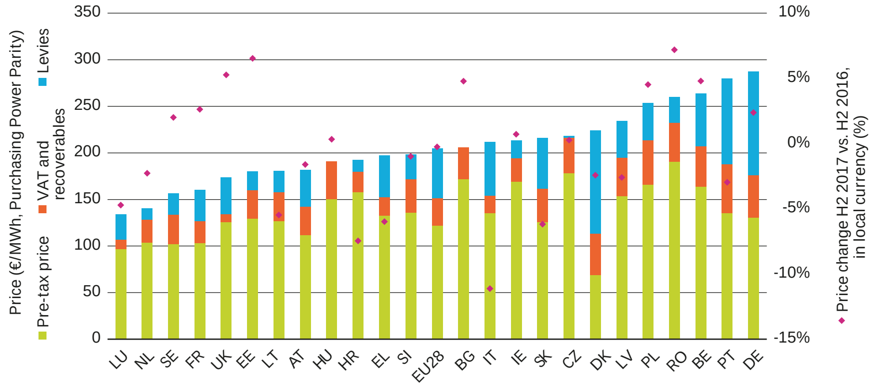
There are still significant differences between residential electricity prices in European countries.

- **Across Europe, the lowest residential electricity price** was observed in **Luxembourg** with 133.9 €/MWh and **the highest in Germany with 287.6 €/MWh. The price differential ratio was 2.14 between the cheapest and the highest price.** In Germany, the renewable energy (EEG Umlage – Support to renewable electricity generators) accounted for more than 23% of the retail electricity bill. This surcharge rose from 6.35 ct/kWh to 6.88 ct/kWh between 2016 and 2017[1].

1 https://www.cleanenergywire.org/factsheets/what-german-households-pay-power

- **Residential electricity prices increased** by 7% in Estonia and Romania and by 5% in the UK, Belgium, Bulgaria and Poland.
- **The increase in electricity prices in Romania was mainly related to the upward trend of coal prices and low hydro situation, combined with a severe winter**[2].
- **The largest fall in electricity prices was recorded in Italy (-11%) followed by Croatia (-7%).**

Figure 4.4. Residential electricity prices in Europe– all taxes included (H2 2017 compared to H2 2016, in local currency)

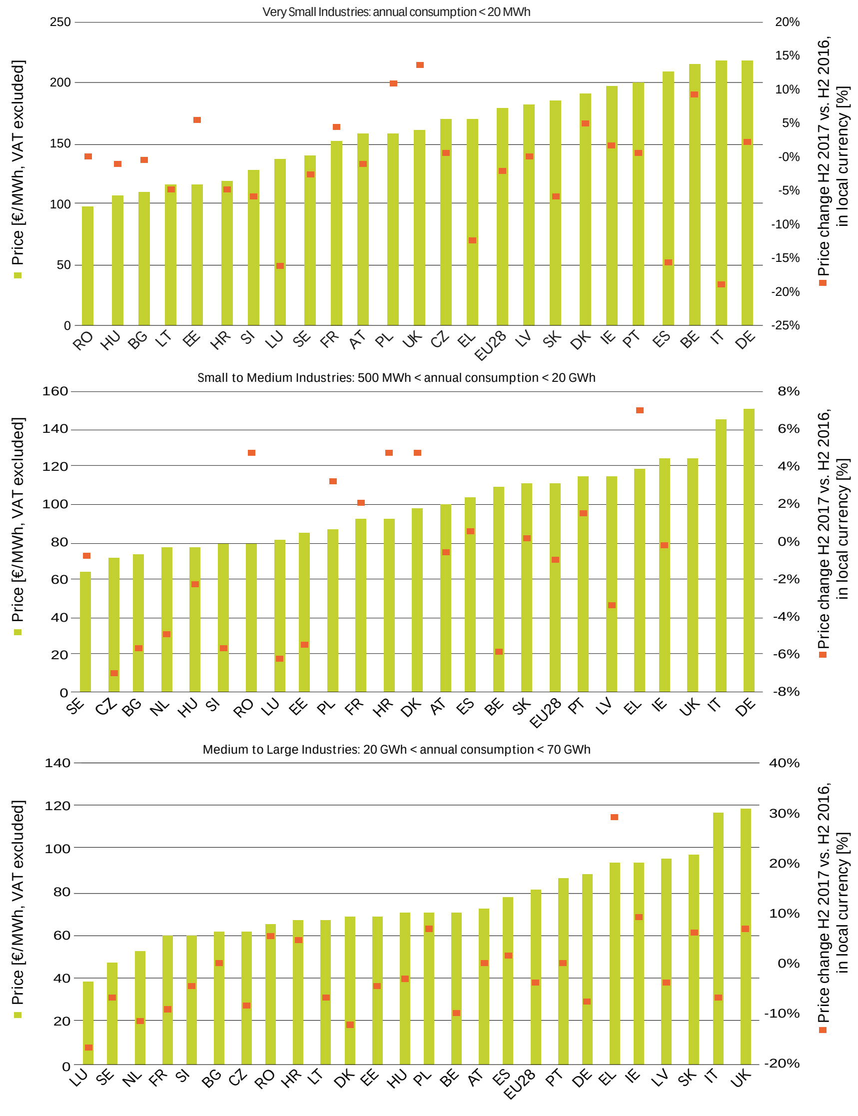


Note: Annual electricity consumption between 2,500 kWh and 5,000 kWh
Source: EUROSTAT – Capgemini analysis, WEMO2018

Industrial electricity prices decreased in H2 2017 compared to H2 2016.

- **Amongst the other EU countries, Germany had the highest electricity prices for both very small industries and small to medium industries,** due to a high level of taxes.
- **The UK had the highest electricity prices** for medium to large industries. High electricity prices in the UK are partially explained by a higher domestic carbon floor price £18/ton (20€/ton) compared to other EU countries (6€/ton for the EU-ETS quotas).
- **Romania, Sweden and Luxembourg had the lowest electricity prices** respectively for very small industries, small to medium industries and medium to large industries.
- **The most significant rise in industrial electricity prices was observed in Greece, up 29% for medium to large industries.**
- **The most significant fall in industrial electricity prices was recorded in Italy, with a drop of 19% for very small industries.**

Figure 4.5. Industrial & Commercial electricity prices in Europe – VAT excluded (H2 2017 compared to H2 2016, in local currency)



Source: Eurostat – Capgemini analysis, WEMO2018

2 https://www.eecc.eu/blog/booming-power-prices-in-romania-and-hungary

Artificial Intelligence (AI) is paving the way for outstanding customer experience

By analyzing huge amounts of data, learning and predicting faster than humans, AI offers a powerful new way to deliver a better customer experience, thus improving customer satisfaction, loyalty and endorsement.

AI encompasses a range of technologies that learn over time as they are exposed to more data. AI commonly includes speech recognition, natural language processing, semantic technology, biometrics, machine and deep learning, swarm intelligence, and chatbots or voice bots.

According to Gartner[1], "through 2020, AI use cases supporting CX are forecasted to deliver the most business value" and by 2021, "15% of all customer service interactions will be completely handled by AI, an increase of 400% from 2017".

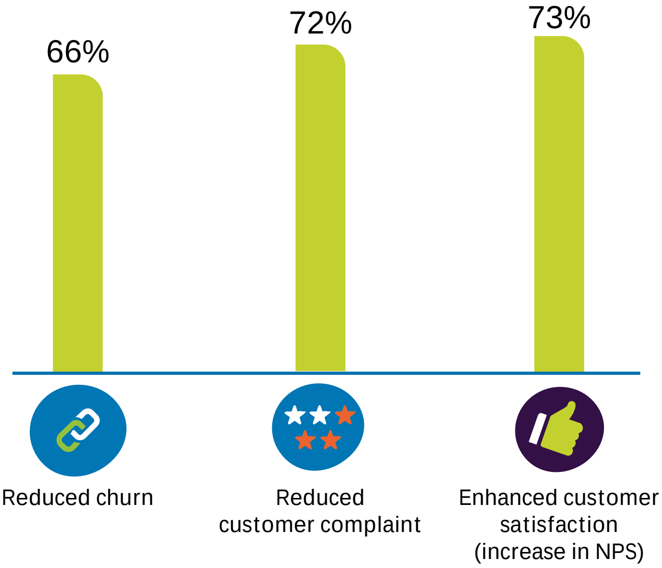
Anticipate customer needs...

...by analyzing high data volumes to provide **proactively personalized recommendations** and advice. Customers now expect providers to anticipate their needs at each stage of their life journey: moving house, billing problems, bill payment, energy use management, outage or emergency, etc.

Offer first-class customer service...

... by providing the most **relevant actions at the right moment:** pause a customer's energy contract while they're living in their secondary residence, adapt the temperature of their home according to their expectation in terms of comfort or cost, supply renovation services, etc. AI technology enabling highly scalable and bespoke experiences gives customers peace of mind.

Figure 4.6. Share of organizations implementing AI that observe more than 10 percentage point gain on the following benefits



Source: Capgemini Digital Transformation Institute, State of the AI Survey, N=993 companies that are implementing AI, June 2017

Simplify interactions with customers...

...by providing speed and efficiency in customer interaction through **conversational interfaces** and augmented analytics. **Virtual Customer Assistants (VCAs)** and **chatbots**, thanks to technologies linked to natural language processing, speech recognition, machine learning, etc., offer a new way to enhance understanding and thereby deliver a really **quick** and **easy** service. VCAs and chatbots are also continuously improving by learning from conversations with customers.

1 Gartner, "Gartner says Global Artificial Intelligence Business Value to reach US$1.2 Trillion in 2018", [online], April 25, 2018, https://www.gartner.com/newsroom/id/3872933

Topic Box 4.1: Beyond energy retail prices

How will energy suppliers/purchasers integrate renewable and decarbonized electricity?

Renewable electricity: accelerating increase in consumer choice

European energy regulation is delivering its promise of strong competition among electricity and gas suppliers, pushing them to supply commodities at the lowest possible price to their customers. However, price is no longer the only criteria prompting consumers to switch supplier: the source of the electricity, and whether it is renewable, are increasingly considered. As far as corporate consumers are concerned, an increased portion of their electricity comes from renewable sources. According to IRENA[1], this portion represented more than 465 TWh in 2017 (3.5% of global commercial and industrial sector consumption). Their choice is not only driven by corporate social responsibility rules and image improvement, but also by pure economics, as renewable electricity production costs are rapidly decreasing and will continue to do so over the next decades. Active renewable sourcing is therefore seen as a natural hedge against increasing electricity prices, especially from fossil fuels.

RE100 initiative: real interest and commitments from corporates

RE100 is a collaborative global initiative of around 140 companies (half of them headquartered in Europe) operating in 120 countries, committed to sourcing 100% of their electricity consumption from renewable sources, at some point in the future. According to RE100's latest report, they represented together an annual consumption of 160 TWh, which would equate to the 24th largest electricity consumption country.
There are several options available to companies making progress towards 100% renewable electricity consumption: unbundled energy attribute certificates (like Guarantees of Origin in Europe), self-generated electricity, purchase from on-site installations owned by a supplier, or direct contracts with producers (corporate Power Purchase Agreements, or PPAs).

Switching to 100% renewables enables firms to deliver on emission reduction goals, improve management of fluctuating energy costs, improve their reputation, provide energy security and, at some point, increase their profits.

Guarantees of Origin (GoOs): a necessary starting point, but not the panacea

Nowadays, most suppliers offer GoOs-based green electricity to all types of customers (B2B and B2C). The European-wide GoOs mechanism was set up by an EU directive to provide a framework to track electricity, especially from renewable sources. This is now considered a legal requirement when providing green electricity offers, but it does not fully meet clients' expectations. Indeed, as GoOs can be traded independently from the power itself, there could be some mismatch between the true origin of the electricity and the positive message the customer believes they are supporting.

Self-consumption: an appealing way to add value to corporate assets

According to IRENA, one third of renewable electricity sourced by corporate consumers comes from self-consumption. It means that renewable production facilities are built on-premise, directly connected to corporates' buildings and facilities. For some companies, this is a clever way to add value to unused property (rooftops, land), either by investing themselves into production facilities (mostly photovoltaic) or by letting a third party invest. In any case, it allows them to offset part of their grid consumption against a local, behind-the-meter production, thus avoiding some of the network charges and associated taxes. Moreover, in regions where networks cannot provide reliable, continuous access to electricity, this can serve as back-up power, in case of rolling blackouts or unexpected power cuts.

Corporate Power Purchase Agreements (PPAs): are they taking off in Europe?

Globally, corporate PPAs account for another third of renewable electricity sourced by corporate consumers, according to IRENA. A corporate PPA is a contract under which a business buys electricity directly from a producer of renewable energy on a long-term basis (generally 15 to 25 years), thus providing a long-term commitment to green energy and also some visibility on the electricity bill. In effect, it allows the alignment of both producers' and consumers' interests: price visibility (the price is based on production costs: Leverage Cost Of Electricity or LCOE) and stability (the price is not subject to wholesale power price volatility).
Over the past five years, PPAs have been increasingly used by IT companies to supply their data centers (Google, Apple, Facebook, Amazon, Microsoft, etc.), initially mainly in the US (from 3.1 GW registered in 2015 to 5.4 GW worldwide in 2017, according to Bloomberg New Energy Finance), then in Northern Europe. In H1 2018, Norway and Sweden saw corporate wind PPAs signed totaling almost 1.4 GW – a figure equal to all corporate PPAs signed in Europe in the whole of 2017.
Eneco has been a leader in the Netherlands, signing corporate PPAs with Dutch Railways and Google a few years ago. Now, PPAs are spreading to other industrial segments: the French railway company SNCF is in the process of contracting corporate PPAs, as well as the airport operator Aéroport de Paris. ENGIE has signed the first corporate PPA in Italy, supplying a brick and tile provider, Weinerberger, with PV electricity. In the Netherlands, Vattenfall has announced it will purchase power from three solar PV farms, totaling 38 MW, to supply power to the residents of the city of Uden.

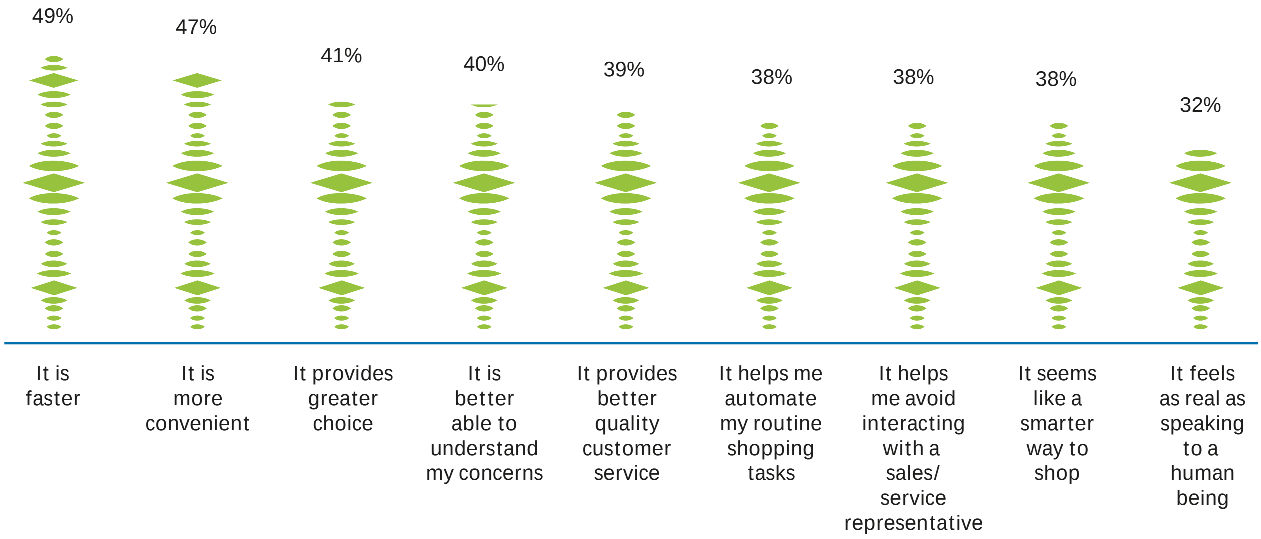
1 http://www.irena.org/publications/2018/May/Corporate-Sourcing-of-Renewable-Energy

AI will create richer, more engaging customer experiences across all channels through disrupting use cases

Energy Broker

Based on the analysis of energy production (whether from the national or local grid, or produced or stored by the customer themselves, such as PV, home or car battery, etc.), the customer's current and future estimated consumption, and the energy price, the broker automatically makes the best decision in order to reduce the customer's energy bill. The broker can thereby make sell or buy decisions, activate the appropriate energy source, change energy provider, etc. This gives customers peace of mind by proposing the most relevant action at the right time.

Figure 4.7. Speed and convenience top the list of reasons for preferring voice assistants over human interactions



Source: Capgemini Digital Transformation Institute, Conversational Commerce Survey, October-November 2017, N=5,041 consumers in the U.S., UK, France, and Germany.

Europe

Virtual Customer Assistant

One of the biggest changes that AI will bring to everyday customer experiences is in the human-machine interface. Indeed, one of the benefits that AI can bring is a much more natural form of interaction through a Virtual Customer Assistant (VCA). Based on a cognitive system, it can do a better job than humans in answering customer questions and concerns, faster and more efficiently, by finding the right information and making the most relevant decision. In that way and thanks to emotion detection, the VCA gives instant support to the customer in an interactive and natural way (voice and speech recognition).

The VCA can also assist customers in evaluating the energy performance of their home, suggesting whether or not to install solar PV, replace the windows, insulate the loft, etc.

Overall churn rates increased across Europe, with some specific changes in selected countries for electricity (France, Northern Ireland) and gas (Northern Ireland, Estonia, Czech Republic)

Switching rates are a key indicator of competition maturity on energy retail markets

By definition, switching suppliers is "the action through which a customer changes supplier". More specifically: a switch is essentially seen as the free (by choice) movement of a customer from one supplier to another. Switching activity is defined as the number of switches in a given period of time.

Customer switching is one of the factors that are used for measuring the level and success of competition in retail energy markets; in principal the higher the number of customers changing their supplier, the more there are opportunities for competitive suppliers and new entrants. VaasaETT divides levels of switching into six categories: super hot markets, hot markets, warm active markets, active markets, cool active markets and dormant markets. The category into which a market fits depends essentially upon its switching rate, but also upon its behavioural characteristics.

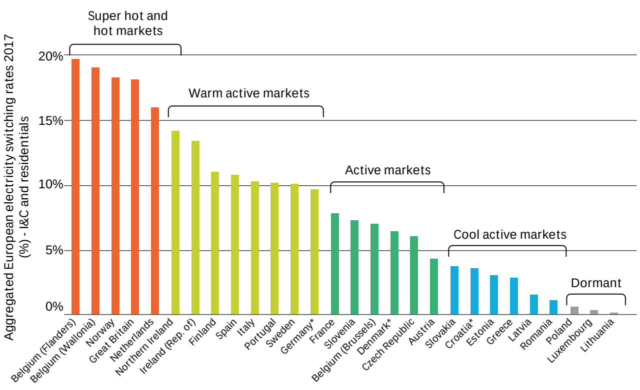
Electricity: slight increase overall in churn rates, no big change since last year

For electricity, although switching rates have overall increased by around 0.5% on average, there were only movement within each switching activity cluster. As in previous year, Flanders, Norway, Netherlands and Great Britain are still the most active markets in Europe. Only Northern Ireland has faced a slight decrease from 15.4% in 2016 to 14.2% in 2017. However, customers' growing interest in taking advantage of the competitive market and its opportunities can be seen in Latvia and Romania which have both developed into a Cool active markets from being a Dormant markets with less than 0.5% switching. Within the Active markets, France came from the 3rd place last year to the number one spot, with a 2% increase switching rates, which shows the increased competition driven by many new entrants to that market.

Gas: increase in churn rates in Eastern Europe, Western Europe stays the same

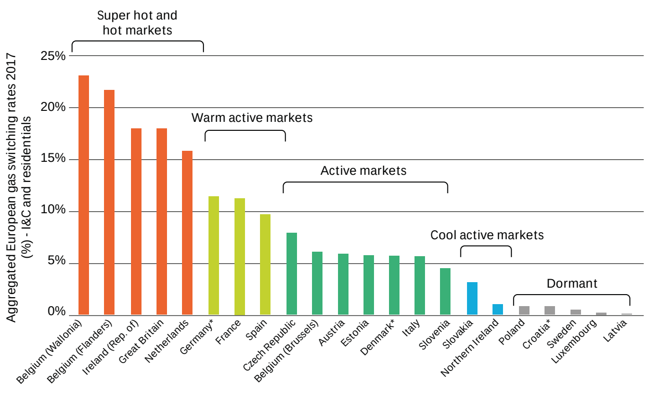
Two markets have faced by far the largest changes in recent years. In Estonia in 2015, the annual switching rate was 6.1%, which leapt to 11.7% the following year, only to drop back down again in 2017 to around 6%. In Ireland, gas customers' eagerness to switch supplier fluctuated from 16.3% down to 13.9% and back up to an impressive 18.2% during 2015-2017.

Figure 4.8. Aggregated European electricity switching rates (2017)



** 2016 data*
Source: VaasaETT Utility Customer Switching Research Project

Figure 4.9. Aggregated European gas switching rates (2017)



** 2016 data*
Source: VaasaETT Utility Customer Switching Research Project

Topic Box 4.2: Will regulated energy tariffs disappear?

Despite opening up gas and electricity supply markets to competition, many Member States have decided to maintain tariff regulation in order to protect consumers against price volatility.

Tariff regulation has made it possible, as the historic monopolies imposed by Directive 2003/55/EC gradually come to an end, to maintain price stability to protect consumers[1]. In 2016, according to a report by the Council of European Energy Regulators (CEER)[2], nine countries still had regulated electricity and gas tariffs. These were Bulgaria, Denmark, France, Hungary, Lithuania, Poland, Portugal, Romania, and Spain. Some, such as Cyprus and Malta, were applying regulated tariffs only for electricity, while others such as Croatia, Latvia and Greece were doing so for natural gas.

In general, Member States index regulated tariffs on the wholesale market. Regulated tariffs can take the form of a rate of return, a price cap, a discretionary regulation, or other ceilings.

In the field of electricity, all 11 countries entrusted the application of regulated tariffs to historical operators. Despite these regulated sales tariffs, it is still possible for suppliers to offer competitive deals. In most cases where this duality exists, regulated prices are available to all domestic consumers, who also have the choice to opt for offers on the open market.

However, although competition now exists in the supply markets, European institutions are pushing to end regulated tariffs.

The European Court of Justice (ECJ) has stated in two decisions[3] that a public intervention measure on the selling price of natural gas is, by its very nature, an obstacle to the achievement of an internal market for natural gas.

However, the ECJ admits, by way of derogation, State intervention on the basis of Article 3.2 of Directive 2009/73/EC, if three cumulative conditions[4] are met.

As for the European Commission, on November 30, 2016, it presented a new set of measures in a fourth energy package entitled Clean Energy for all Europeans where it pursues the goal of fully opening the energy market, in order to strengthen free competition. To do this, the Commission advocates the abolition of regulated tariffs. This is one of the objectives pursued by the draft directive on the electricity market.

In this context, Member States are progressively adapting their regulations to reduce the scope of regulated tariffs.

Consequently, some Member States, such as Germany, the United Kingdom, Norway, Sweden, Finland, Austria, Estonia, Slovenia and the Czech Republic, have chosen to completely eliminate regulated tariffs in all market segments. Others, such as France, Italy, Lithuania, Poland, Portugal, Romania and Spain, have decided to maintain, at least on a temporary basis, tariffs for the most vulnerable consumers.

Specifically concerning France, after two major decisions by the French Council of State[5], the future of regulated tariffs will not be the same in the electricity sector as in gas. Concerning gas, the French Council of State ruled that regulated tariffs did not comply with European law. Their abolishment is expected in the following months. However, concerning electricity, the administrative jurisdiction has taken a more comprehensive view: it admits that regulated tariffs for residential consumers are in the general interest as they enable price stability to be maintained.

1 Compared with 2008, the total number of household consumers supplied at regulated prices for end-users in the EU in 2015 increased from 54% to 35% and from 49% to 25% respectively in the electricity and gaz markets (Council of European energy regulators, “Retail Markets Monitoring Report”, November 21, 2017).

2 CEER, Retail Markets Monitoring Report, mentioned above.

3 ECJ, Grand Chamber, April 20, 2010, *Federutility*, C-265/08, and September 7, 2016, ANODE, C-121/15.

4 The intervention must fulfill an objective of general economic interest, respect the principle of proportionality and include clearly defined, transparent, non-discriminatory and controllable public service obligations.

5 CS, July 19, 2017, ANODE, req. n°370321 and CS, May 18, 2018, ENGIE, req. n°413688.

5-New Business Models & Services

Downstream energy new business models and services

New business models and new players are shaking up the downstream energy market. Digital levers and innovations such as self-consumption, storage, energy management platforms, and peer-to-peer marketplaces have been growing dynamically. New energy products and services are expected to represent up to 20% of a company's total revenue.

- Downstream energy transformation ventures gravitate around four smart areas: smart homes, smart buildings and factories, smart mobility, and smart cities and communities. We analyze the evolution of each area in this chapter.
- The centralized model is not dead yet and major Utilities are still leading the market, but there is a strong evolution (if not revolution) and a growing transformation trend enabled by new technologies. All the traditional Utilities have now launched new business models to create new revenue streams and competitive differentiation. Most of them have set up dedicated organizations to incubate, launch and scale those new business models and services, be it in dedicated business units (e.g. Enel-X or Centrica), in digital business incubators (e.g. EDF Pulse Studio, ENGIE Digital) or by getting closer with their energy services activities.
- Customers have also been evolving and are now willing to "manage energy their way": developing their capability to generate and self-consume energy, entering new forms of energy sourcing to increase the share of renewables in their supply contracts, or aiming for more convenience at home. And when decentralized generation sources are coupled with storage solutions and digital energy management platforms, it impacts on the whole downstream power industry. Combined with the development of e-mobility, this adds a level of complexity that some industrial customers want to manage directly by setting up smart grids in their own facilities.

As-a-Service business models are becoming mainstream.

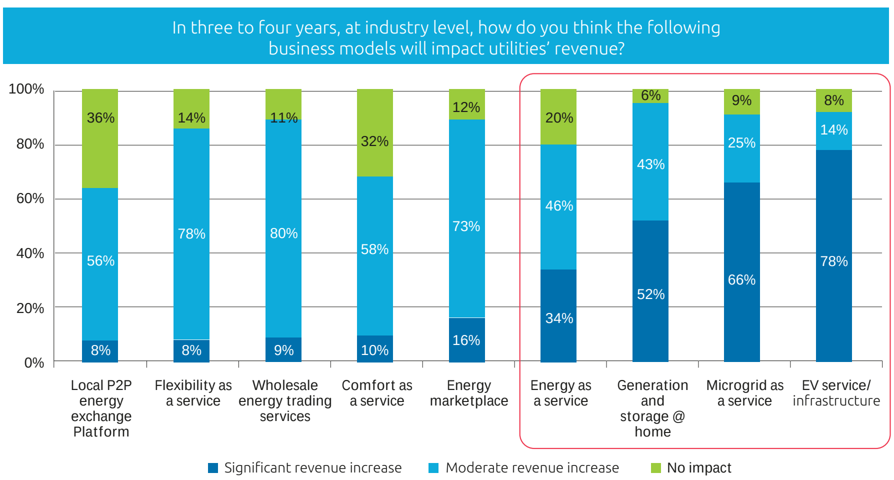
- According to Utilities executives in a Capgemini-IDC survey, energy as a service and comfort as a service are, or are planned to be, widely deployed, along with flexibility as a service. Those new business models, along with others, will represent 5-10% of revenue in 3-4 years; the ones having the most significant impact on revenues are EV services/ infrastructure, microgrid as a service, and generation and storage by households. Nevertheless, high revenues do not necessarily imply high margins. The services and business models having the most impact on gross margins are forecasted to be comfort as a service and energy as a service.
- This of course puts traditional downstream Utilities' business models under pressure and explains why we are seeing a proliferation of innovative business models. Furthermore, beyond traditional Utilities, energy service companies (ESCOs), and electrical equipment providers, several players are entering the market or moving their value chains to develop and benefit from these new business models. EU executives predict that in the next three to four years competition will come from non-traditional players such as GAFAMs (Google, Apple, Facebook, Amazon, Microsoft); energy equipment manufacturers (ABB, Alstom, GE, Siemens, etc.), telcos and electric car manufacturers.

New business models will represent 5-10% of the revenues in 3-4 years

The most significant impact on revenues will come from electric vehicle (EV) services, generation and storage at home, and microgrid as a service. However, energy as a service and comfort as a service will be the top margin contributors.

Microgrid as a service is viewed as a low-margin business model, with a third of organizations saying less than 5% of their company's gross margins will be derived from it in three to four years, while an additional 38% of organizations estimate 5-9%.

Figure 5.1. Impact of the following business models on utilities' revenue in three to four years

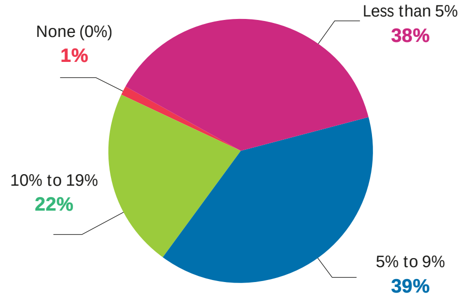


Source: IDC – Utilities New business models

New energy products and services expected to represent from 5% to 19% of a company's total revenue

Almost four out of ten EU executives believe that within the next three to four years, the impact of new products and services will range from 5% to 9% of their total revenues.

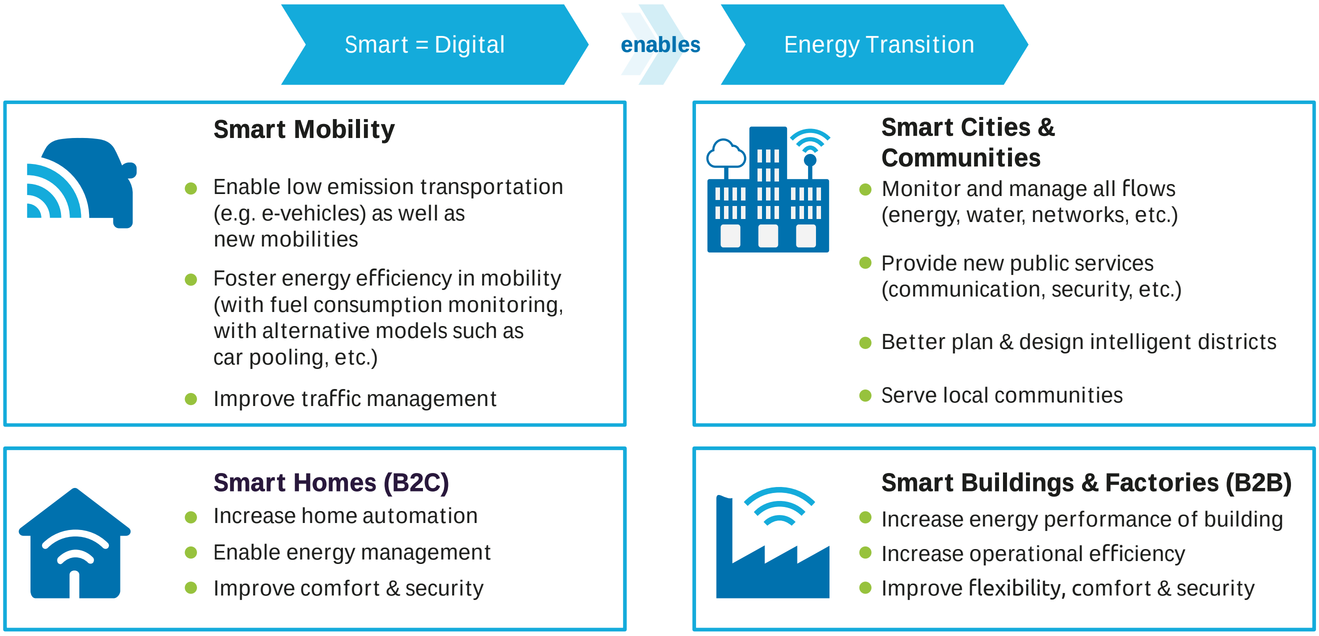
Figure 5.2. Percentage of the total company's revenue that will come in the next three or four years from the sale of new energy products and services



Source: IDC – Utilities New business models

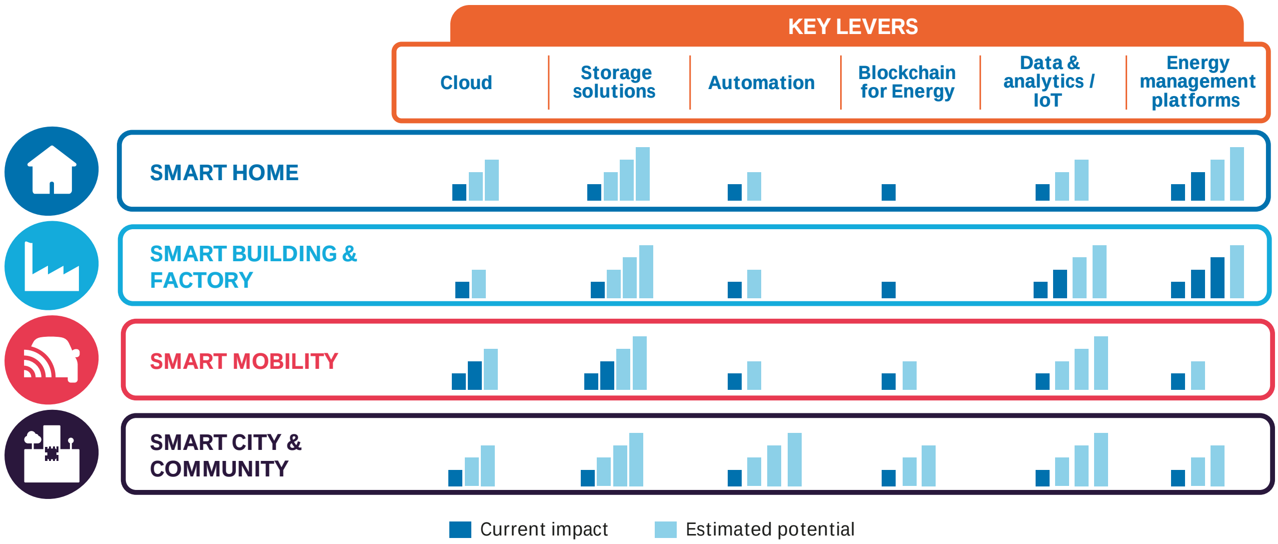
Downstream energy transformation and value proposition development gravitate around four smart areas

Figure 5.3. The SMART4 approach – the four smart areas of the energy transition downstream



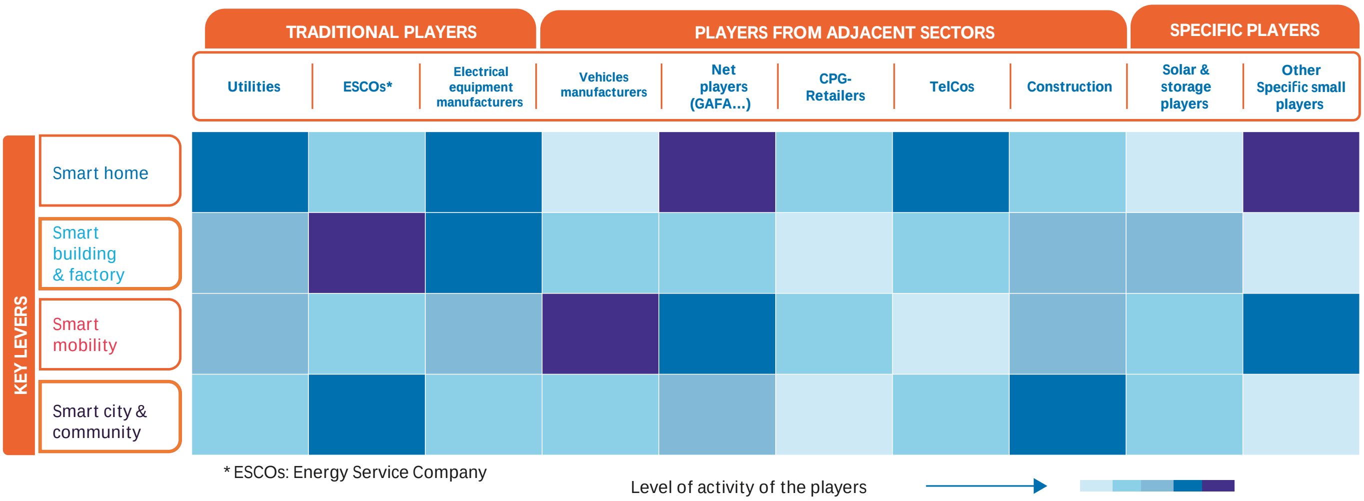
Source: Capgemini analysis, WEMO2018

Figure 5.4. Contribution of key levers to the four Smart areas



Source: Capgemini analysis, WEMO2018

Figure 5.5. Heatmap of types of players on key levers



Source: Capgemini analysis, WEMO2018

Smart buildings: digital technologies are promoting a rapid growth in the smart building market

Data issue

In traditional construction and real estate (CRE) markets there are data issues that need to be addressed, such as When is data created? Who owns and controls it? How can high volumes of data be managed? Without answering these questions, the transformation of this sector is not realizing its full potential. But new players are coming to the market, in particular from the digital world.

Silicon valley is looking at the sector

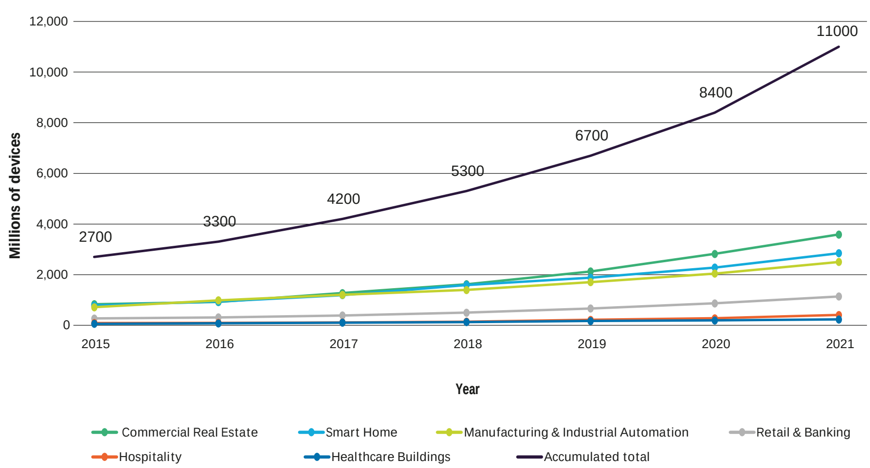
Venture capital and strategic funding are flooding this new market (US$ billion) thanks to the attractiveness of the transformation of this traditional market.

A report identified 25 VC funds, strategic funds, and accelerators actively targeting AEC.
For example, new player in the market, Katerra, has just received a loan of US$865 million from Softbank.

IoT is coming of age with rapid growth and maturing solutions

Thanks to the fall in the cost of sensors, data storage, and connectivity, more CRE should move toward an IoT application strategy.
Revenue from IoT-enabled smart buildings technology is forecast to exceed US$8 billion in 2020.

Figure 5.6. Growth in Smart Building Connected Devices over time



Source: Capgemini analysis, WEMO2018

IoT sensor deployment in smart buildings is likely to grow from 2.7 billion in 2015 to nearly 11 billion in 2021. The main sectors seeing this growth are commercial real estate, smart home and manufacturing & industrial automation according to the Memoori report "The IoT in Smart Commercial Buildings 2016-2021".

Standards remain a key issue: there is a lack of interoperability for currently used protocols.

Data analytics are increasingly used to create value within commercial real estate building operations.

- Air quality monitoring is becoming mainstream and brings a new value-adding dimension to smart buildings.

Decentralized systems promise lots of added value but remain to be scaled up.

- Blockchain primer

Energy efficiency drives smart building efforts

The economic opportunity is massive.

According to a study by the American Council for an Energy Efficient Economy (ACEEE), an investment effort of 1-4% in energy efficiency for commercial buildings could generate up to US$60 billion.

The drivers of green efficiency in smart buildings

Smart buildings rely on smart equipment and appliances that can communicate with each other: the coordinated operation of all building systems can achieve savings of up to 35% or more.

For example in La Défense, in Paris, the Ampere building owned by SOGEPROM, behaves in accordance with these principles:

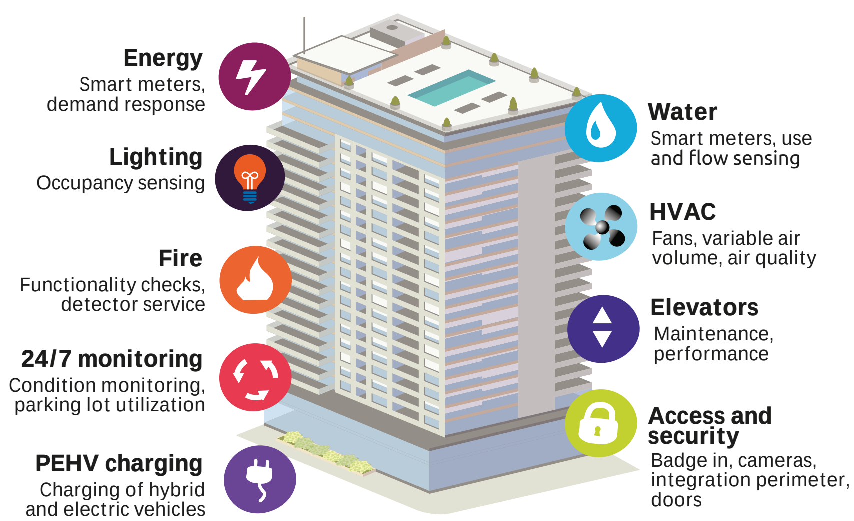
- Employees can use an app to control lighting and temperature in their workplace.
- Air flow exceeds regulation standards, with micro-organisms cleaning the air.
- Elevators incorporate the Otis ReGen Drive device, generating electricity while braking. In addition, the building is one of six European sites selected to test the recycled batteries for the Energy Local Storage Advanced system (ELSA) program. This research project aims to use second-hand EV batteries to store electricity in buildings. The Ampere building already houses two batteries with a capacity of 12 kWh which supply, when needed, energy from the elevators braking and PV solar panels on the roof.

EU policies on energy efficiency in buildings: the Energy Performance of Buildings Directive.

The EU estimates that Europe's buildings are responsible for 40% of energy consumption and 36% of CO_2 emissions. Thirty-five percent of EU buildings are over 50 years old and 75% of building stock is energy inefficient. To cope with that situation the EU is creating incentives to foster this new market along four lines:

- The EU Building Stock Observatory monitors energy performance of buildings across Europe.
- The EU has set a target for all new buildings to be nearly zero-energy by 2020.
- Energy performance certificates provide information on the energy efficiency of buildings and recommended improvements.
- Financial support mechanisms in EU countries can help pay for energy efficient renovations.

Figure 5.7. Building Energies



Source: Capgemini Consulting analysis

Advanced building energy management systems can save from 13% to 66% on energy with a continuously optimizing system.
Smart HVAC can result in cost savings of 24-32% depending on the building type.
Other smart building components, like smart windows, can lead to savings of 19-26% 19-26% on cooling and 48-67% on lighting

Europe

Smart building: Improving construction

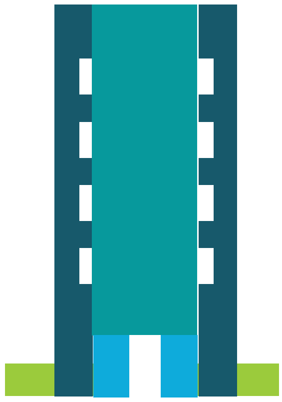
Offsite construction

- Enables and stimulates the reuse of construction components
- Reduces waste
- Addresses sustainability issues

Leading companies are Saint-Gobain, Smartglass International, Ravenbrick, Sage Electronics, Hitachi Chemical, Asahi Corporation and Dupont

AI

- Used to create construction plans
- Manages the project and controls tasks.
- Informs engineer on how the project should be constructed



BIM

- Creates and manages information on a construction project across the project lifecycle
- Manages smart equipment after the end of construction
- Allows collaboration between all the stakeholders of a project

Recent BIM projects in Europe: Mayfield School, East Wing (Geneva) airport and l' Ilot Fontenoy Segur (Paris)

New technologies: Smart glasses, RFID exploitation

- Alters light transmission properties when voltage, light or heat is applied
- Shorter assembly time
- Offsets rising cost

Leaders are Katerra, Blu Homes and Project Frog

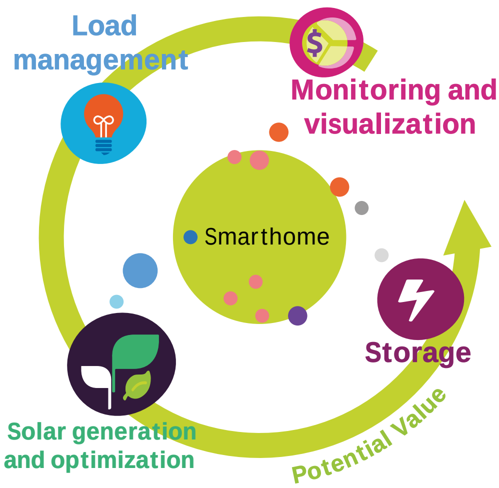
Home energy management systems focus mainly on load management

Smart home energy solutions are mainly related to load management. This consists of the following services:

- Smart meters that allow consumers to visualize and analyze their energy consumption. The objective is that once consumers understand the impact of appliances on the overall load, they will change their behavior and use less energy. An additional service is information about price signals from energy providers to reduce energy costs. Such services are typically offered by Smappee or Schneider Electric's Wiser Link.
- An energy management system (EMS) can automatically process price signals and follow settings chosen by consumers in order to optimize the load by turning off certain appliances.
- Smart appliances such as smart thermostats for hot water and heating or smart air-conditioners can be monitored remotely in order to increase comfort (right temperature at the right time) and energy efficiency (no heating or cooling when not needed). Smart appliances connected to the EMS, which processes price signals and can manage the load curve according to consumers' settings, can thus reach a new level of optimization. Beyond heating and cooling appliances, this load management is particularly relevant for electric vehicles charging. There are many offers available: Honeywell (US), Nest by Google (US), Tado (GER) and Netatmo (FRA) are key players in the European market. In 2018, Rexel launched Energeasy Connect, a platform that can support many smart home services (comfort, security, thermostat).

The global smart meter market represented ~US$30 billion in 2016 and is forecast to grow by 6% CAGR until 2023, thanks to government regulation. The global smart thermostat market, valued at ~US$1 billion in 2017, will continue to boom in the years to come with 50% CAGR forecast. One key benefit for utilities with such services is the churn reduction.

Figure 5.8. Smarthome



Source: Capgemini Consulting analysis

With the rise of distributed generation and storage, new solutions emerge to optimize energy generation and consumption as a whole

According to IDC Capgemini, 56% of utility companies have already deployed or will deploy in the next 2 years residential generation and storage offers.

Residential PV installations, small wind turbines, and residential storage solutions, with significant incentives, regulatory schemes, environmental awareness, distributed generation, and storage in houses and buildings, are booming. And while support mechanisms are moving from a Feed-in-Tariff (FiT) incentives to a self-consumption schemes, optimization of the generated power usage is becoming a crucial challenge.

- With a single battery, many services can be offered in order to decrease energy bills. The choice of services depends mainly on the power tariff structure. For instance:
  - Arbitrage: with peak and off-peak tariffs, the battery can charge during off-peak hours (usually during the night) and be used during peak hours.
  - Peak shaving: in certain cases, the electricity bill depends a lot on the peak electricity demand of a consumer e.g. the maximum demand seen by the grid. The battery can be used to reduce the demand seen by the grid by providing power momentarily.

Interestingly, different types of players invest in this market: pure players (Sonnen), utilities (CrowdNett by Eneco) or even car manufacturers (Nissan + Eaton, Renault Powervault, Tesla Powerwall) that are moving along the value chain with electrification of their vehicles. Contrary to this, Mercedes announced in 2018 it will stop manufacturing residential batteries; and storage pure player Senec was acquired by EnBW.

- Regarding distributed generation systems, two main business models exist.
  - the most common one, mainly used to trigger the market, is based on a FiT. Solar panels can be installed on a roof and the power produced sold to the grid. The FiT, which is fixed for years, ensures the profitability of the investment for the individual. In such cases, all the generation is valorized and the only challenge for the owner is to maintain the system properly. Therefore, no smart home services are needed.
  - The self-consumption model is a pure behind the meter model: the generated power is consumed directly by the individual appliances. In some cases, the excess of power can be injected into the grid, but the profitability of a self-consumption installation relies on the ability to consume and thus valorize all the generated power.

Beyond pure equipment providers and installers, basically all power suppliers are developing a self-consumption offer such as EDP, EDF, E.ON or ENGIE.

The solar generation peak (middle of the day) and the demand peak (in the evening) are not synchronized. This has two main solutions: the PV installation can be sized small enough to valorize all the energy or the generated power is consumed in a smarter way. For instance, an additional battery can store excess power in the day and supply power in the evening; smart appliances can then be activated to use this power (for air cooling, heating, EV and so on).

Again, various types of players have entered this market. Car manufacturer Nissan launched a combined offer with solar and coupled storage system in the UK. Huawei also launched the FusionHome offer combining solar, load management and battery interface.

- Generation by residential consumers is already a huge global market, mainly developed by equipment providers. Residential storage is a smaller market but with huge CAGR of 40-45% forecast until 2020 (see chapter 2). For instance, Italy installed about 8,000 home units in 2017 – twice the expected number – while Germany deployed 37,000 rather than the 31,000 forecast[1].

Electrification is one of the four megatrends reshaping the future of mobility

The future of mobility is Connected, Autonomous, Shared & Electric.

With more concerns and opportunities in security, comfort and environment, mobility is reshaping to become smart mobility. Four major trends are changing mobility: Connectivity, Autonomous driving, Shared & Services and Electric, often summarized in the acronym CASE.

E-mobility participates in transforming the whole automotive industry.

Four dynamic market drivers have been identified: consumers, technology, regulatory framework, OEMS & equipment services providers.

- The median range for EVs has extended by 56%: certain models can now drive well over 480 km on a single charge

1 PV Tech - EMMES

- 35% of consumers say they would drive cars with a range of 400km.

EV annual sales have grown rapidly.

- EV annual sales are expected to reach 1.5 million units by the end of 2018, with an Europe's market growth around 35% from 2016 to 2017.
- Electrification opportunities are particularly high for light-duty vehicles fleets: electric buses are expected to make up over half of the global bus fleet by 2025.

Charging infrastructure and value chain are critical for the mass adoption of EVs.

- Batteries prices are still decreasing:
  - From 2014 to 2016, battery costs fell by more than 50% due to process improvements and economies of scale.
  - Li-ion battery (with the highest energy density) prices decreased by 77% between 2010 and 2016, from US$1,000/kWh to US$227/kWh.
- EV charging infrastructure is the only critical factor that needs to be addressed to unlock the potential of e-mobility.
- There are now as many public charging points as there are gas stations in Europe.
- Reduced charging times are about to be rolled out, taking just 15 minutes instead of 30 for fast charging.

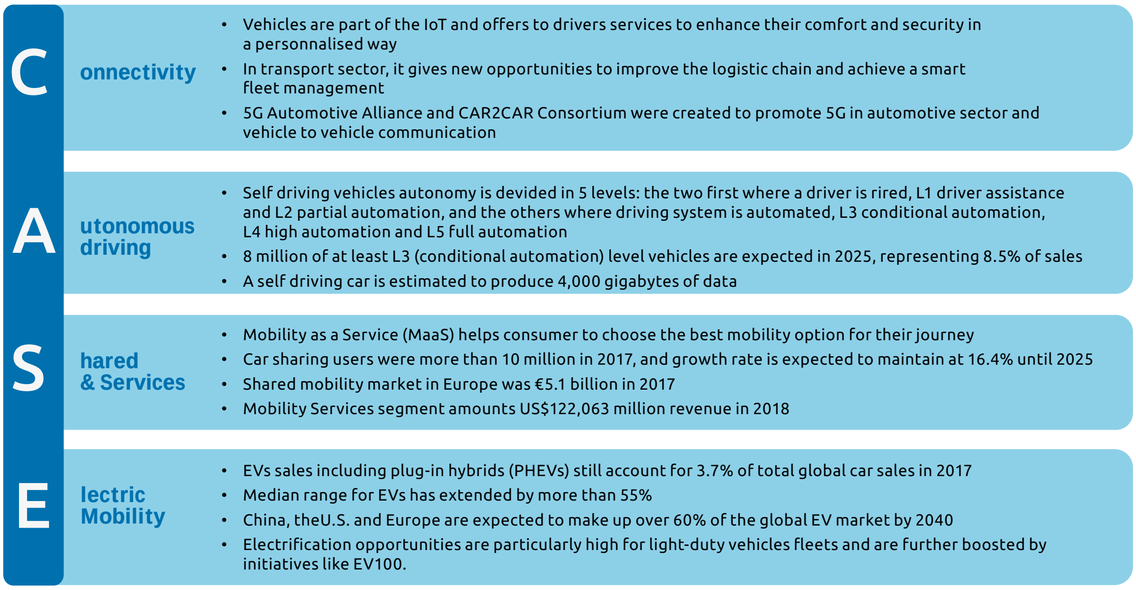
Rapid expansion of EVs is having a significant impact on companies' business.

An increasing number of vehicle manufacturers have disclosed plans to add more EVs to their product portfolio.
More than US$90 billion has been invested by vehicle manufacturers globally in the battery and EV markets.

Utilities and power companies are scaling up their activities through mergers & acquisitions in the EV charging space:

- They are mainly targeting investment areas which they can use to leverage their know-how.
- Critical parts of the electrification value chain are strongly linked to other industrial value chains.
- Vehicle-to-grid (V2G) charging services could be used during peak times when demand for power is at its peak, saving the grid from overload.

Figure 5.9. CASE



Source: Capgemini analysis, WEMO2018

The EV charging business can be split into ten new business models impacting on the energy and mobility of tomorrow

Interviews show key trends about the future of mobility.

Customer preferences are influenced by range- anxiety, price competitiveness, and charging infrastructure:

- 35% of consumers are happy to drive cars with a range of 400km (which is now the norm)
- Fast charging (30 minutes) satisfies 25% of consumers, increasing to 37% with 15 minute charging.

Charging accessibility is fundamental to improve the general acceptance of EVs.

- The EV charging value chain is a combination of energy supply, charging infrastructure and add-on services.

- 80% of experts interviewed believe that the length of charging is the most crucial element that should be considered at public charging points.

The EV charging ecosystem can be split into ten business models focusing on value proposition, customer segments served, revenue streams, cost structure and key activities.

Considering the maturity of these business models, defined by the stability of their value proposition and revenue streams, four of them stand out: direct billing for charge point operation, smart platform development, PPP with potential delegation, and manufacturing:

- Manufacturing and PPP are the most stable as they were the first to appear on the market.
- Bundled vehicle and charging is at the other end of the spectrum as, until now, few OEMs have managed to generate sustainable value through bundled offerings.

Two business models appear to be the most profitable for the future:

- Bundled vehicle and charging, if players seize the opportunities it offers as a built-in mobility service offering
- Smart charging development (B2B).

EV charging infrastructure development is likely to match one of three scenarios:

- In the best case, EV charging infrastructure will develop quickly with varied and sustainable business models, and could lead to the disappearance of Internal Combustion Engines (ICEs) in 2040.
- In the worst case, by 2050 electric infrastructure fails to be realized, most business models collapse and the effects of climate change have worsened as of 2050.
- The BAU scenario could lead to decreased car ownership as new generations favour new mobility models, and ICEs remain after 2050.

Figure 5.10. A classification of the EV charging ecosystem in ten business models

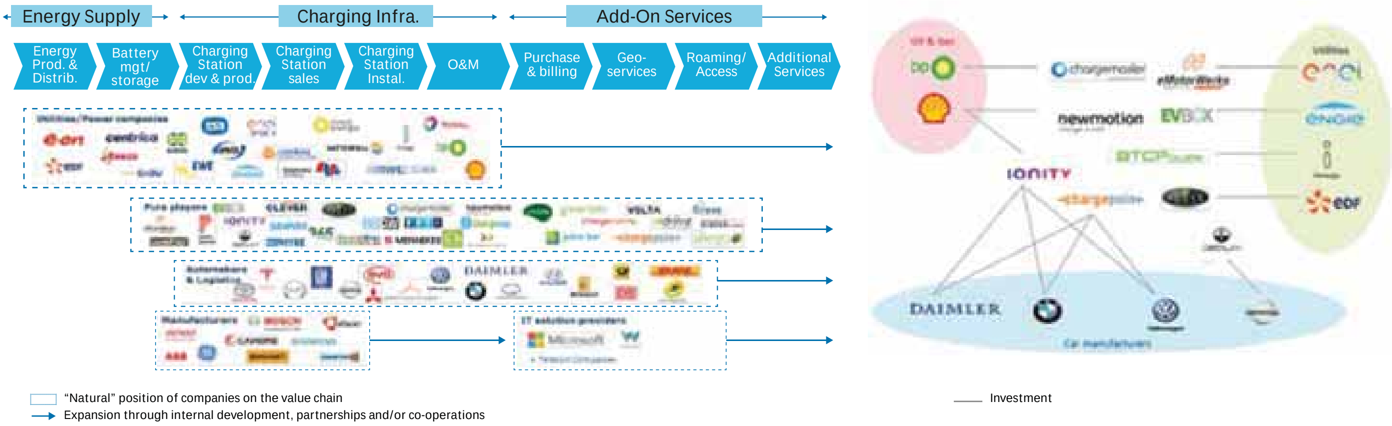
Source: Capgemini analysis, WEMO2018

The overall mobility shift is pushing players to be active on the electrification value chain, to review their investment strategies and to transform their business models through mergers and acquisitions or internal developments. The transformation imperative becomes even more salient as the ecosystem's complexity increases. A recent Capgemini study on the key factors defining the mobility of tomorrow with a focus on the EV charging ecosystem sheds some light on the EV charging infrastructure's evolving value chain, on opportunities for value-creation, and on development pathways.

There is an opportunity to create new business models along the EV charging value chain

Utilities/power companies are expanding on the electrification value chain for EVs

Figure 5.11. companies



Source: Capgemini Consulting analysis

While e-mobility is promising, challenges remain.

Four key issues have been raised by EV charging ecosystem players and they need to be considered to identity the winning business models:

- **From "range anxiety" to "experience anxiety":** although the range of new EVs reaches beyond the 400-500 km barrier, purchasing an EV remains a radical move. The charging experience remains complicated due to heterogeneity of standards, unclear pricing schemes, and lack of interoperability among most markets. This is one of the most critical challenges for the EV market if it is to really take off.
- **Digital and data mastery are critical to win in the EV charging market:** digital brings opportunities for companies to adapt their business model. For backend systems, owning the operation brings opportunities for specific customization, high flexibility and the possibility of marketing IT solutions. On the other hand, EV charging as a service or partnering provides fast setting up with high professionalism and low implementation costs.
- **Client relationships will be key to winning in the new e-mobility world:** while several business models emerges, those who develop excellent client relationships will succeed in sales of mobility and energy services.
- **No clear leader stands out yet:** while everyone agrees e-mobility business models are required to manage an ecosystem, no clear leaders stands out yet among vehicle OEMs, Utilities, start-ups or mobility companies.

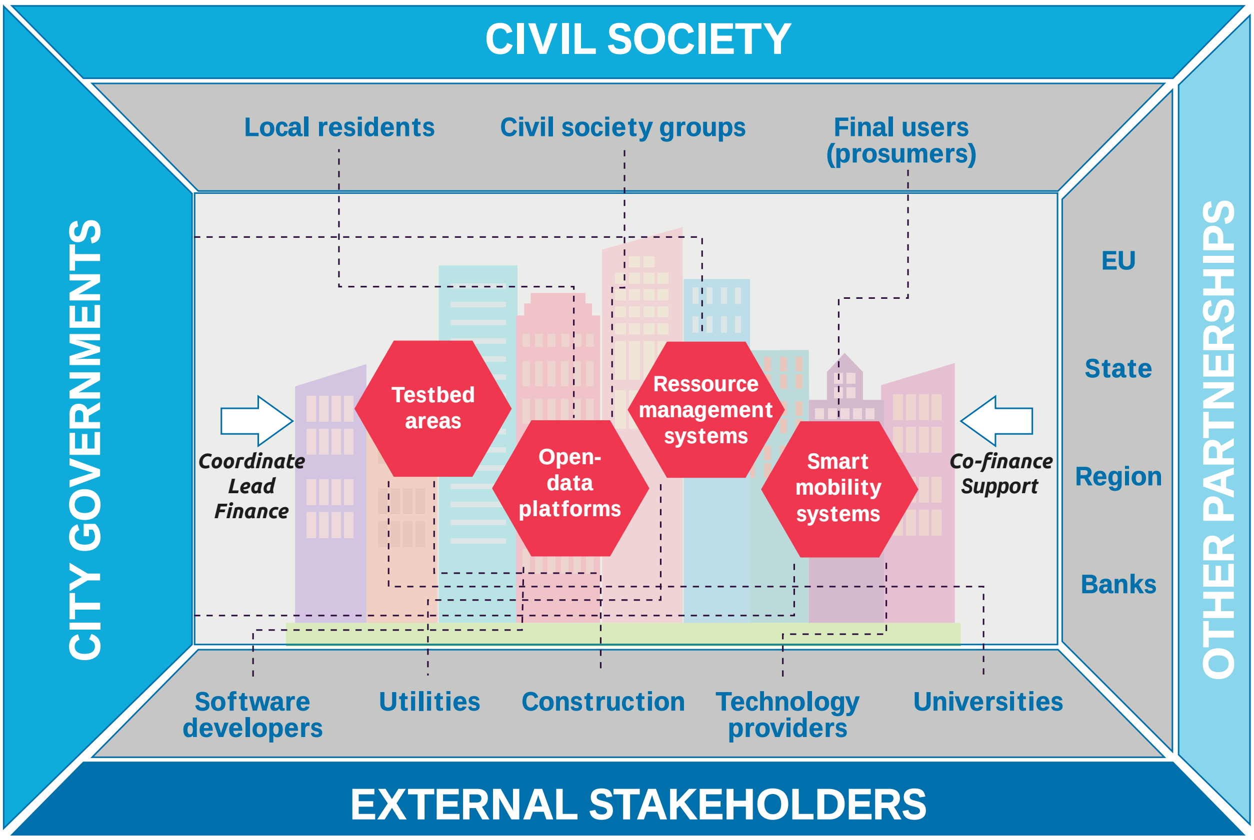
The main players are clustered in five segments: Utilities/power companies, pure players, OEMs & logistics, manufacturers, and IT solutions providers.

- The rapid expansion of EVs will have a significant impact on Utilities/power companies. They are increasing their presence in the current EV ecosystem by investigating and developing new business models along the various parts of the value chain.
- Pure players are involved in upward activities, like EV charging points manufacturing, or downward ones, like additional services.
- Critical parts of the value chain are strongly linked to other industrial value chains as well, from manufacturing to IT/ telecom provision.

OEMs, Utilities and O&G are scaling up their mergers and acquisitions (M&A) activity in the EV charging space:

- Utilities & power companies continue to reshape their investment strategies and to transform their business models through M&A in this crowded EV ecosystem. They are mainly targeting investment areas which they can use to leverage their know-how.

Smart cities



In response to the city's contemporary challenges, horizontal and multi-stakeholder governance models are developing and digital is playing an increasingly central role.

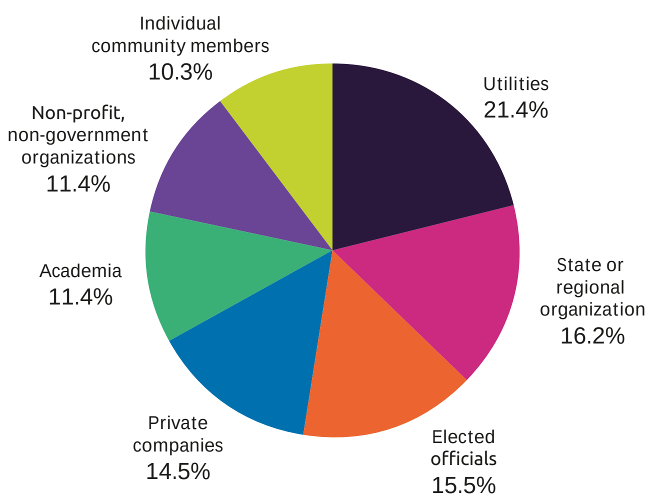
- Two-thirds of the EU's population live in cities, and smart solutions (efficient and sustainable while generating economic prosperity) are found in cities in all countries. Examining EU cities with at least 100,000 residents, 240 (51%) have implemented or proposed smart city initiatives.
- In a nutshell, a smart city can be defined as an innovative way to handle urbanization while minimizing its impacts on the environment. It is meant to be inclusive, efficient and collaborative, mainly by using technical innovations to optimize urban flows (traffic, energy consumption, etc.).
- But in recent years, smart- cities have appeared to be first and foremost networks of players capable of leading decentralized initiatives: platforms, start-ups and citizens invest in the city independently and overlap each other, which ultimately results in a collective urban intelligence.

Utilities are a major driver of smart city initiatives.

Knowing that local governments cannot develop citywide initiatives on their own, smart city projects are an opportunity for Utilities to develop new business models. Centered around complex systems (EV charging stations, network automation, and advanced communication systems), those projects use operations and infrastructures mainly owned by Utilities, such as electricity grids, water and sewage networks, and parking.

- The global market potential of smart cities is estimated to reach US$400-1,600 billion by 2020. Nonetheless, Utilities appear to be unequally eager for smart city domains: for instance, waste management is a domain in which almost four out of five (79%) Utilities claim to have already invested, while the corresponding figure for water and sanitation solutions is 27%.

Figure 5.12. Main partners for «smart city» initatives*



* From municipality/administration point of view, Black & Veatch's 2018 Smart Cities & Utilities Report survey.
Source: 2018, Black & Veatch: "2018 Strategic directions: smart cities & utilities report"

Europe

Digitized and connected cities are supported by smart grids, platforms and the Internet of Things.

- With renewables, energy sources are more diverse and less controllable, which creates difficulties in maintaining network stability. By providing flexibility in both production and consumption, a smart grid enables new services and creates business opportunities for new and established players. Emerging stakeholders include:
  - Providers of solutions and organizations related to energy services, which are addressing the energy market in a different way from traditional players (utilities, retailers etc). Their purpose is to facilitate customer participation (e.g. peer-to-peer trading, smart appliances).
  - Smaller organizations, such as energy cooperatives, that are implementing solutions at a local level. These players are focusing on citizens' engagement and energy communities.
- Given its potential benefits (improvement of transmission and production capacity while reducing losses), smart grid initiatives are growing rapidly in Europe, totaling 950 projects for €5 billion of investment in 2017:
  - Amsterdam has launched a virtual power plant initiative in the Ecuplein district, which incorporates solar PV, load and home battery systems of 35 households.
  - Electron, a UK energy tech company, plans to leverage blockchain technology to launch a trading platform, supported by National Grid and Siemens, allowing electricity consumers to be paid for adjusting their energy consumption.
- Digital platforms and big data can allow city authorities to aggregate the increasingly large and varied amount of data generated from cities, in order to harness value from it. Currently being tested in Copenhagen, Cisco Kinetic for Cities (a smart connected digital platform) manages the data from lighting, parking, traffic, waste management and Wi-Fi.
- Transforming devices from isolated systems into an integrated one, IoT technology can have numerous applications in a smart city project, from traffic sensors to rubbish bins. For instance, in 2015, the city council of Bristol, in the UK, launched its project Bristol is Open. Based on IoT initiatives, an open data portal is sharing information about energy, air quality and traffic flow, collected by various IoT devices, such as willing participants' smartphones

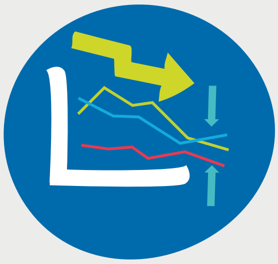
In 2018, the biggest challenge facing Europe's smart cities is cybersecurity and privacy.

- In numerous smart city initiatives, information is made more accessible to citizens thanks to open data, which refers to all freely available data. For example, Copenhagen Solutions Lab is pioneering sustainability efforts with an open data portal. Its latest project, EnergyBlock, will use sensors to monitor energy production levels in rooftop greenhouses and gardens across Copenhagen's Nordvest area. The data from these sensors will be shared via Copenhagen's open data portal in an attempt to showcase renewable energy sources available within the area.
- In the meantime, privacy has become a major concern in Europe with the implementation of GDPR (EU regulation on data protection and privacy) in May 2018. With this regulation, smart cities now need to guarantee the safety of data. To face this issue, Dijon imposed strict rules concerning the use of collected data. The city authority put in place an innovative legal set-up where it has full legal responsibility for all the data produced by the city sensors and networks.

6-Financials

Main trends observed in 2017-18

A noticeable improvement in revenue levels in 2017 supported by the increase of wholesale market prices and a stronger economy

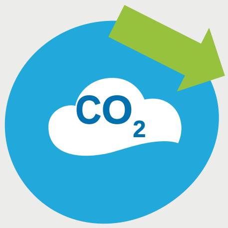


Despite high gross energy prices and the development of new services, the intensification of the competition between existing players and newcomers is tending to lower the EBITDA margins, which is also tending to converge

Due to important CAPEX requirements, Utilities are increasing debt level and leverage ratio as well as lowering the dividends per share

After a few years of uncertainties, the successful transformation of Utilities has reassured the financial markets, leading to an outstanding 2017 stock performance and an overall credit rating improvement

German companies have regained a better financial situation after having suffered from constraints linked to the forecast decommissioning of nuclear assets in past years; they have also started to reap the rewards of their transformation plans



CO_2 intensity continues to decrease pushed by heavier EU taxation on CO_2 emissions, the implementation of more efficient production technologies, and investors' pushback

2017 showed an increase of revenues, inversing the downward trend of the last years

After several years of decreased revenues (4-year negative CAGR), 11 out of 16 companies improved their revenues in 2017. This can be primarily attributed to the general increase in wholesale market prices compared to 2016 (see Fig. 6.1). In addition, Utilities' revenues depend for a large part on other companies' (mainly industrial) electricity consumption. The fact that the economic situation wasn't good for Utilities in past years but got better in 2017 contributed to an increase in the volume of electricity consumed.

△ companies'+ Q4 revenues 2017/2016	DE-EPEX	ES-OMEL	FR-EPEX	IT-IPEX	NORDIC - Nord Pool	UK-EPEX
△ wholesale market prices	18.20%	31.82%	22.53%	26.19%	9.45%	9.05%
△ companies' revenues 2017/2016	1.40%	7.70%	-1.02%	5.92%	2.00%	-0.52%

Source: Gestore Mercati Energitici, Capgemini Consulting analysis. Evolution for the companies of our sample grouped by country / region

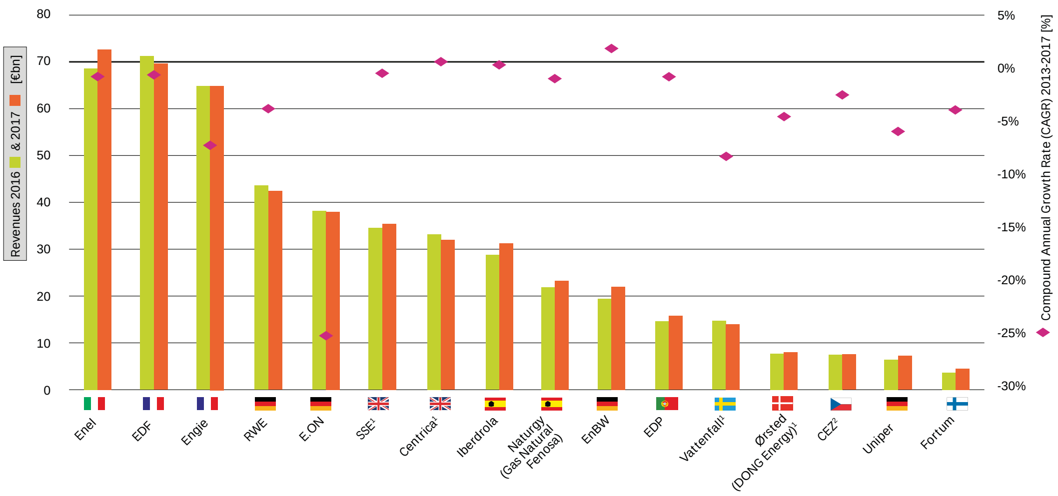
It's noticeable that the increase in revenues is slightly less than the rise in electricity prices. This may be explained by an intensification of competition between players, leading to attrition of main Utilities' customers' portfolios.

Fortum shows the highest revenue increase in 2017 – nearly 25%. In addition to favorable wholesale prices, the increase was mainly due to electricity demand growth in Northern countries, as well as the strengthening of Russian ruble and the integration of Ekokem, Hafslund and DUON.

Germany's **EnBW** also succeeded in increasing its revenue, by 13.5%. It is also the only company showing a positive 2013-2017 CAGR. This is mainly due to the successful implementation of its 2020 growth strategy: expansion of renewable energies, restructuring of grids, and broadening of services.

E.ON's low CAGR is the consequence of a change of scope, the company having transferred its conventional energy sources to Uniper in 2016.

Figure 6.1. 2016 & 2017 revenues in € billion and CAGR 2013-2017



Sources: Tomson Reuters EIKON data ("Total revenue"), Capgemini Consulting analysis
1 SSE, Centrica, Vattenfall, Ørsted (DONG Energy) and CEZ revenues are calculated using Thomson Reuters EIKON fixed exchanges rates
2 Uniper figures correspond only to European generation revenues

EBITDA margin: an overall downward and converging trend

The average Utilities' EBITDA margin has been falling year after year: from 20.7% in 2013 to 17.8% in 2017 (see table below). Over the last five years, 2015 was the best year overall for the companies in our sample and 2017 the worst.

EBITDA margin's evolution					
	2013	2014	2015	2016	2017
Utilities average	20.5%	20.0%	21.1%	18.4%	17.8%
Trend	-	↓	↑	↓	↓

Despite a convergence tendency, the studied sample can be divided into three main groups:

Leading: CEZ, Fortum, Iberdrola, Orsted (ex-DONG Energy)

Leading companies have a the highest EBITDA margin. The margin does decline for most of them, but they still manage to keep it at a very high level. All these companies – Iberdrola excepted – **are facing less competition in their native market** (whereas German, British or French companies are, potentially, leading to a higher client churn rate).

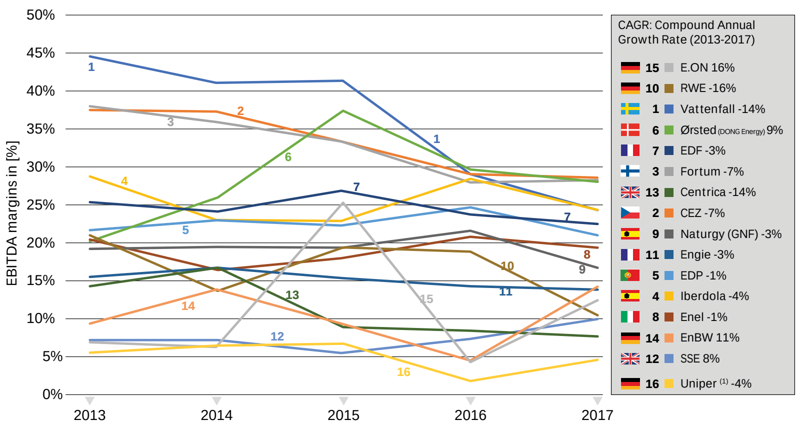
Stable: French companies (EDF, ENGIE), Naturgy (ex-GNF), EDP, Enel

Stable companies have an EBITDA margin that remains around the sector's average. Despite their decreased margins, they are in control of their OPEX and the changing environments. Note that some companies (such as EDF) have to comply with regulated energy prices, which reduces their ability to enhance their margin since they are among Europe's cheapest energy providers.

Lagging: German companies (E.ON, EnBW, RWE, Uniper), British companies (SSE, Centrica)

Lagging companies have an EBITDA margin below the Utilities' average. However, they have tended to increase their margin and thus reduce the gap between them and the stable companies. This is especially the case for the German companies (except RWE), highlighting the success of the transformation programs implemented.

Figure 6.2. EBITDA margins (2013-2017) and associated CAGR



Sources: Tomson Reuters EIKON data ("Normalized EBITDA"), Capgemini Consulting analysis
1 Uniper figures correspond to electricity generation only

Notes on EBITDA margin variations

- EBITDA is a key indicator since it is not affected by the way the company finances its activities.
- As a ratio between EBITDA and total revenues, the EBITDA margin allows investors to evaluate the effectiveness of a firm's cost-cutting efforts. Many factors can impact on the evolution of a company's EBITDA margin (production capabilities, local economic situation, local and international regulations, inflation (deflation), market prices movement, consumer preferences, competition between players, company's core performance, etc.) but a high EBITDA margin means that the company's OPEX is well managed.

Net debt

Net debt and leverage ratios are increasing

Thanks to a period of low interest, companies benefited from favourable conditions to borrow and maximize their investments. However, using too much debt is risky: companies must be able to pay financial fees related to this level of debt. The level of debt must therefore be analyzed regarding the leverage ratio of the company (i.e. net debt / EBITDA), which reflects the capacity of the company to pay back its debt.

Currently, both net debt and leverage ratio have increased:

- **Average net debt increase (2017 vs 2016): +5%**
- **Average leverage ratio (2017 vs 2016): 2.85x vs 2.77x**

The three companies having the highest increase in net debt levels are German

EnBW and **E.ON** have faced challenges in recent years resulting in low EBIDTA for 2016: the multiple changes in regulation and laws are strongly impacting on these companies, as well as digital transformation. The tremendous growth of their EBITDA (2016-2017) should be considered as a return to normal situation. 2017 can be considered as a good year: EBITDA grew more than net debt (in %), their leverage ratio is divided by two and goes below the average of our sample. Significantly lower interest rates for nuclear provisions could explain a part of this phenomenon. It allows these companies to invest more, thus becoming more competitive.

RWE is facing more difficulties since, in addition to issues mentioned above, it prepared itself to sell its share in Innogy (US$17 billion) to enter E.ON's capital (17%). To finance this investment, RWE raised its debt level (from 0.9x to 2.7x) but still remains under the sector's average.

Top companies decreasing their net debt levels

Some companies have divided their debt by more than two. Following its acquisition by Fortum (46.67% of the capital), **Uniper** drastically reduced its debt level. **Orsted** reduced its debt divesting from its fossil fuel assets. The company wants to focus on renewable energies and plans to massively invest in wind farms in the coming years.

A special case with Fortum

Fortum's net debt level has been rising steadily since the company entered Uniper's capital. Nevertheless, its leverage ratio remains one of the lowest.

Figure 6.3. Net debt and EBITDA in € million and leverage ratios for 2016 and 2017

	2017 Net Debt [€m] (2016-2017 evolution)		2017 EBITDA [€m] (2016-2017 evolution)		Leverage ratio 2017	Leverage ratio 2016
Ørsted (DONG Energy)	633	(-57.0%)	2,246	(-22.0%)	0.3x	0.8x
Fortum	1,227	(3,406.0%)[1]	1,273	(25.0%)	1.0x	0.0x
EnBW	3,836	(93.0%)	3,124	(265.0%)	1.2x	2.3x
Centrica	4,774	(-13.0%)	2,428	(-13.0%)	2.0x	1.8x
Vattenfall	7,674	(7.0%)	3,389	(-21.0%)	2.3x	1.7x
EDF	38,569	(-10.0%)	15,656	(-8.0%)	2.5x	2.5x
E.ON	12,344	(40.0%)	4,742	(195.0%)	2.6x	5.5x
CEZ	5,506	(4.0%)	2,160	(0.0%)	2.6x	3.0x
RWE	11,753	(68.0%)	4,415	(-46.0%)	2.7x	0.9x
Engie	28,231	(-10.0%)	9,005	(-3.0%)	3.1x	3.2x
SSE	9,530	(22.0%)	2,773	(-19.0%)	3.4x	2.8x
Enel	57,106	(-2.0%)	14,082	(-2.0%)	4.1x	4.1x
Iberdrola	38,202	(18.0%)	7,604	(-7.0%)	5.0x	4.3x
Naturgy (Gas Natural Fenosa)	19,687	(-3.0%)	3,892	(-18.0%)	5.1x	4.3x
EDP	18,972	(-11.0%)	3,303	(-8.0%)	5.7x	5.9x

Sources: Thomson Reuters EIKON data ("Normalized EBITDA" & "Net Debt Incl. Pref. Stock & Min.Interest STND"), Capgemini Consulting analysis

[1] *2016-2017 Net Debt evolution is listed as 3406% for Fortum as in 2016 the net debt was €35 following a negative debt in 2015 of €-2,126 million*

Companies with leverage ratios above 5x are from Spain and Portugal

These companies' leverage ratios reach almost twice the mean leverage ratio of the others. It is interesting to note that they are in countries facing difficult financial situations.

In the case of **Iberdrola**, the company's increase in net debt (+18%) is mainly due to the integration of the Brazilian company Neoenergía (€2.817 million contribution to Iberdrola's consolidated debt) and the investments undertaken in 2017. **EDP**'s situation is getting slightly better because the decrease of its EBITDA was more than compensated for by a debt reduction.

Dividends Per Share (DPS)

The dividends per share are globally stable or decreasing.

In 2017, all the companies in our study paid stable or lower DPS for 2016, except Enel (+33% vs 2016), E.ON (+43% vs 2016), EnBW and RWE (these two companies didn't pay any dividends in 2016). As already mentioned, the energy sector is facing plenty of new challenges (digitalization, climate risk, competition), most of them requiring important investments.

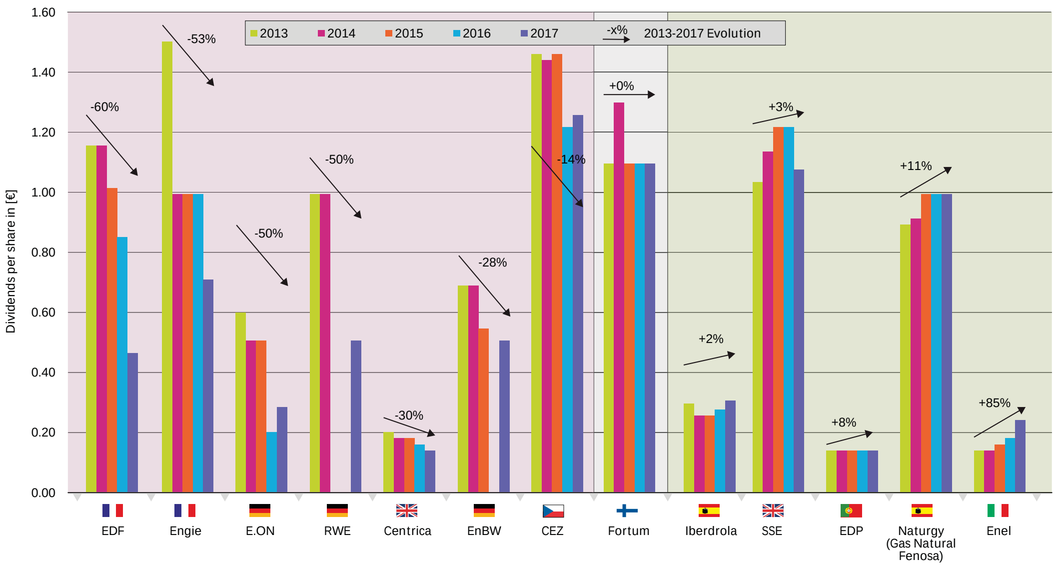
Enel is the only company having significantly increased its DPS (+85%) over the 2013-2017 time period. This growth rate is mainly due to a systemic augmentation of Enel's Free Cash Flow (FCF): CAPEX is stabilizing, and financing cash-flows are improving (i.e there are fewer financial fees). However, we can see that **Enel's DPS is still one of the lowest** in our sample group.

E.ON seems to have had a huge increase in its DPS compared to 2016. However, we can see that its DPS decreased from 0.60 in 2013 to 0.21 in 2016 before reaching 0.30 in 2017. Indeed, in the 2013-2016 period, E.ON lost money every year but continued to pay (decreasing) dividends. The US$1.5 billion paid by RWE for the buyout of E.ON's renewable energy assets possibly gave E.ON the capacity to increase its DPS for 2017.

French companies (EDF & Engie) are paying fewer dividends year after year. EDF is facing huge investments (e.g. Hinkley Point C in the UK) leading to an increase in its investing and financing cash flow. The French state, which is major stakeholder, might have impacted on the dividend strategy.

RWE and EnBW paid dividends in 2017. This has to be noted since these companies didn't pay any in 2016 and 2015 (for RWE). RWE is selling its participation in Innogy to E.ON (for around €17 billion). In parallel, RWE is taking around 17% of E.ON's capital and will focus on renewable energies (RWE took over assets involved in renewable energy production).

Figure 6.4. Dividends per share in € and 2013-2017 evolution



Sources: Thomson Reuters EIKON data ("Dividend per Share DPS"), Capgemini Consulting analysis

About Dividends Per Share (DPS) evolution

DPS (Total dividends paid / ordinary shares outstanding) reflects the financial strategy of the company more than its economic health.
Some companies invest their liquidity in R&D, new infrastructures or external growth instead of paying dividends: stockholders are making money through stock price increases.
Some companies pay high dividends, irrespective of investments and their liquidity. This can be a strategy aimed at protecting the company from a take-over bid.
Investments are made mainly using debts: from financial markets (negative impact on DPS since the number of ordinary shares outstanding is increasing) or from banks (potential impact on DPS as an increase in the global level of debt is going to increase the financial fees and thus decrease the company's FCF).
In the end, the total amount of dividends paid depends on a company's free cash flow (FCF) and the way it wants to use its cash: investing is decreasing companies' liquidity since the company is not leveraging at 100%.

Stock performance

Stock is performing well globally

The companies' share prices show a significant performance compared to EURO STOXX 50: Utilities' efforts are paying back, investors are regaining trust.

Despite overall uncertainty (regulatory changes, competition from new players, low economic conjuncture), Utilities have managed to turn around the downward trend of previous years. But in general, current share prices remain very low compared to 2013 figures.

Utilities have been forced to adapt and restructure themselves in a post-Fukushima era, with several constraints such as overcapacities (particularly in gas), deflating electricity prices (spot + term), the need for C02 reduction, renewables acceleration, and political defiance towards nuclear power (Germany, Italy).

To go further...

Beside savings plans and assets rationalization, **German Utilities** (particularly E.ON and RWE, +57.2% and +68.8%) are implementing new strategies with a clearer separation of activities (production and retail for RWE, networks and services for E.ON – through the Innogy transfer to E.ON, among others initiatives)

Enel (+46%) has been rewarded by its financial performance (EBITDA exceeding forecasts, +6% turnover in 2017), as well as by its focus on mature markets (Italy, Spain, USA) and ongoing group digital transformation (e.g. creation of Enel X)

In France, 2017 was a complicated year. Nevertheless, **EDF** benefitted from a strong carbon price increase, as its production mix is one of the lowest CO_2 emitters in Europe. Despite technical and financial doubts (huge refit costs

– “Grand Carénage”, slipping new nuclear schedules and multiple technical difficulties), the persistent rumours of potential group activities separation decisions by the French Government had a positive effect on the share price.

ENGIE continued its shift towards zero-emissions energies, by selling or decommissioning coal and oil assets and massively investing in renewables and biogas, power-to-gas; the fact that ENGIE appears strongly engaged in digital transformation is also probably well perceived by the markets.

In the UK, **Centrica** made progress on cost-cutting and balance sheet improvement in 2017. However, strong competition and increasing prices accelerated customer churn (>10% of British Gas customers in 2017) despite the tremendous efforts made in innovation.

Figure 6.5. Utilities’ stock performance (July 2018)[1]

	Share price year-to-year ratio (2018/2017)	Share price ratio (2018/2013)	Share price / EURO STOXX 50 ratio (2018/2017)	Share price / EURO STOXX 50 ratio (2018/2013)
Uniper	125.9%	-	-31.3%	-63.1%
RWE	68.8%	-47.9%	72.1%	-59.8%
EnBW	61.0%	-15.0%	64.2%	-34.5%
E.ON	57.2%	-32.2%	60.3%	-47.7%
Enel	46.0%	54.5%	49.9%	19.1%
CEZ	46.0%	-28.8%	48.9%	-45.1%
Ørsted (DONG Energy)	61.0%	-	61.0%	-15.0%
EDF	41.4%	-20.9%	44.2%	-39.0%
Engie	36.5%	-14.5%	39.2%	-34.1%
Naturgy (Gas Natural Fenosa)	33.6%	35.2%	36.2%	4.3%
Fortum	30.7%	7.5%	33.3%	-17.1%
Iberdrola	30.4%	85.7%	33.0%	43.1%
EDP	24.1%	19.2%	26.6%	-8.1%
Vattenfall	11.1%	-20.4%	13.3%	-38.6%
SSE	-5.3%	-23.8%	-3.5%	-41.2%
Centrica	-31.3%	-63.1%	-29.9%	-71.6%
EURO STOXX 50	**-1.9%**	**29.7%**	**0.0%**	**0.0%**

Sources: Thomson Reuters EIKON data (stock prices and index values from July 1, 2013,2014,2015, 2016, 2017, 2018), Capgemini Consulting analysis
[1] Uniper and Ørsted stocks started trading on September 12, 2016.

Credit ratings

Overview: from stabilization to improvement

Rating trends remain mostly stable, and even tending toward an improvement. Transformation and cost cuttings plans have been successfully implemented. Companies have taken advantage of low interest rates and have stable operating conditions (some are recovering from sharp regulatory changes in the nuclear sector). The stabilization is reinforced by investments in regulated businesses and relatively high wholesale market prices.

Fortum downrated following Uniper acquisition

The long-term corporate credit rating of Fortum was downgraded following its announcement of the acquisition of 47% of Uniper in January 2018 for €3.7 billion (€1.95 billion from existing cash resources, the rest from committed credit facilities). S&P justifies the downrating – accompanied by a negative outlook – by the combination of the following factors:

- Expected weakened credit metrics with possible decrease of funds from operations to debt to below 25% in 2018 (vs. 56.1% in 2016) and forecasted increase of net debt to EBITDA ratio to 3.4x (duration in financial years for EBITDA to cover long-term debts);
- Doubts on Fortum’s capacity to conduct a coherent industrial strategy and financial policy in the future. Indeed, if Fortum’s stake remains around 50%, it would not have the formal power to influence Uniper’s strategic decisions until Uniper’s supervisory board renewal in 2022;
- A lack of measures announced by Fortum to significantly strengthen its balance sheet at the date of the rating.

Figure 6.6. Standard & Poor’s credit ratings

Company	31/12/2011	31/12 2012	31/12/2013	31/12/2014	31/12/2015	31/12/2016	27/07/2017	27/07/2018	Rating evolution 2017/2018	Outlook
EDF	AA-	A+	A+	A+	A+	A-	A-	A-	→	From stable to negative
Engie	A	A	A	A	A	A-	A-	A-	→	Stable
SSE	N/A	A-	A-	A-	A-	A-	A-	A-	→	Stable
EnBW	A-	A-	A-	A-	A-	A-	A-	A-	→	Stable
CEZ	A-	A-	A-	A-	A-	A-	A-	A-	→	Stable
Centrica	N/A	A-	A-	A-	BBB+	BBB+	BBB+	BBB+	→	From stable to negative
Vattenfall	A-	A-	A-	A-	BBB+	BBB+	BBB+	BBB+	→	From negative to stable
Ørsted (Dong Energy)	A-	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	→	Stable
Iberdrola	A-	BBB	BBB	BBB	BBB	BBB+	BBB+	BBB+	→	Stable
Enel	A-	BBB+	BBB	BBB	BBB	BBB+	BBB	BBB+	↗	Stable
E.ON	A	A-	A-	A-	BBB+	BBB+	BBB	BBB	→	Stable
Fortum	A	A-	A-	A-	BBB+	BBB+	BBB+	BBB	↘	From stable to negative
Naturgy (Gas Natural Fenosa)	BBB	BBB	BBB	BBB	BBB	BBB	BBB	BBB	→	Stable
Uniper	N/A	N/A	N/A	N/A	N/A	BBB-	BBB-	BBB	↗	Stable
EDP	BBB	BB+	BB+	BB+	BB+	BB+	BB+	BBB-	↗	Stable
RWE (1)	A-	BBB+	BBB+	BBB+	BBB	BBB-	BBB-			

(1) As requested by the company in 2018, S&P is no longer rating RWE’s profile.
Sources: Companies’ websites, S&P long-term issuer rating data, Capgemini Consulting analysis

Three companies saw their ratings improved

S&P assigned BBB+ to Enel, recognizing the group’s increase in EBITDA and the stabilization of its debt. The revaluation followed the publication of the 2018-2020 Strategic Plan which has been well received by markets for its focus on operational efficiency, growth and investment in regulated and contracted businesses.

Uniper’s rating was increased to BBB in April 2018, emphasizing the successful sale of the Russian gas field Yuzhno Russkoye, renegotiations of gas contracts and costs savings. S&P also justified the new rating by a reduced risk linked to the outcome of the takeover by Fortum, which is considered to have limited impact on the risk profile and independence of the company.

EDP’s rating has been reviewed in view of successful debt reduction thanks to well-valued disposals (€2.5 billion for Naturgas and €532 million for Portgas) and improvements in operating performance. Sales of minority interests were also favorably received, as well as the takeover bid of China Three Gorges.

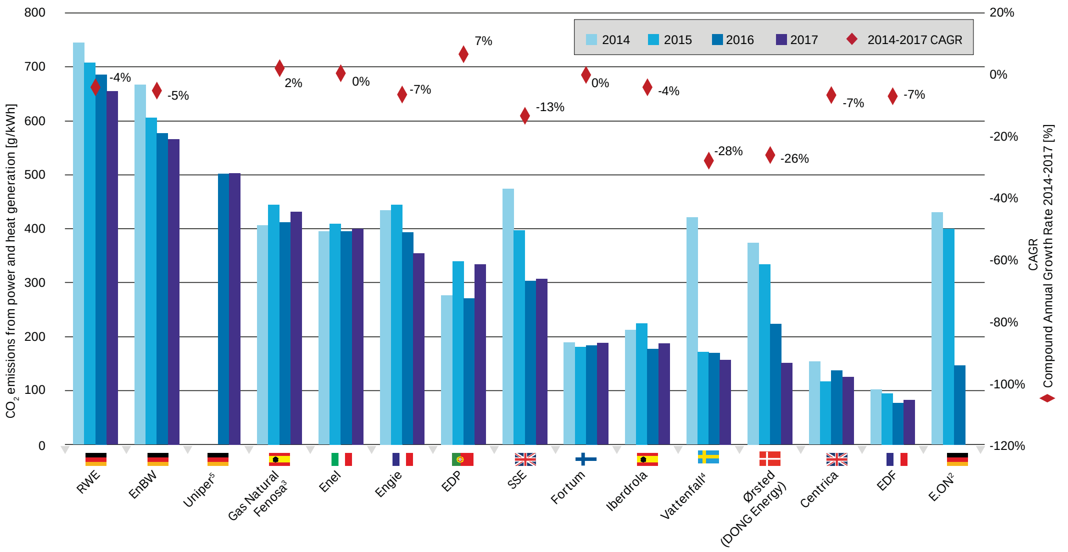
CO_2

The evolving context is reducing carbon intensity

Thanks to a shift towards new ways of production and modernization of existing facilities, Utilities' overall carbon intensity has been decreasing since 2013, except for Naturgy (ex-GNF) and EDP.

The EU leverages carbon taxation to decrease the use of polluting fuels and reach the goals set out in the 2015 Paris Agreement. However, carbon prices still remain too low to trigger high investments in low carbon energy: it increased from €5/t in early 2017 to €14/t in June 2018, but some experts say that investments of US$40-80/t by 2020 and US$50-100/t by 2030 will be needed to reach the goals of the Paris Agreement[1]. In addition to this regulatory constraint, investors are pushing for cleaner energy production, thus impacting on strategic business decisions.

Figure 6.7. CO_2 emissions from power and heat generation[1]



Sources: companies 2017 and 2018 annual reports.
1 The chart displays CO_2 scope 1 emissions (meaning from in-house sources - gas transmission and electricity generation and excluding other Greenhouse gases).
2 2017 indicators calculated from CO_2 emissions and generation reported in the annual report as companies don't communicate anymore on the CO_2 intensity.
3 Gas Natural Fenosa has excluded generation from nuclear sector in its average CO_2 emission calculation. Nuclear representing 10% of the company mix for power generation, the total 2016 average CO_2 emissions figure might be slightly lower.
4 Vattenfall has reported its figures exluding lignite operations starting from 2015 despite divestments happened early 2016.
5 No CAGR Calculated for Uniper for which only 2 years of data have been considered.

Short-term strategies differ depending on countries' tax policies: e.g. in France, carbon tax is expected to rise from around €30 today to €86 in 2022, whereas in Germany the government rejected the additional carbon taxation. However, Utilities' long-term strategy is very likely to follow the EU's low carbon intensity policy.

Three groups of Utilities can be distinguished

1. *Effective shift towards low carbon intensity:* **Vattenfall** and **Orsted** have been seeing a significant decrease in their carbon intensity levels during 2014-2017, by 28% and 26% respectively. They are converting their high CO_2 intensity power plants: Vattenfall started the phase out by converting a lignite power station to natural gas and Orsted by biomass conversion of CHP plants. Vattenfall has observed the highest decline thanks to its dedicated goal of becoming free from fossil fuels within one generation by 2030, and Orsted is currently having higher output from wind power and significant cutbacks in its use of natural gas. These two companies are also influenced by the pushing strategy of their countries. E.ON showed a carbon intensity of less than 146 gCO_2/kWh in 2017 (a steep decline from 2014), thanks to the closure of older coal-fired power plants and heavy investment in green energy sources. Even though, they have been focusing on this question progressively.
2. *Historically low-emission activities:* **EDF** can reach the lowest carbon intensity level in Europe thanks to its nuclear production capabilities. **Fortum**'s carbon intensity has been around 181 gCO_2/kWh for the last three years and it has been investing in keeping this level low. Fortum's energy mix is derived from low carbon energy sources such as nuclear energy, hydropower and biomass.
3. *Gradual phase-out strategy:* Some Utilities have been focusing on this subject for many years but with a less aggressive strategy. Despite extensive communication about its move towards low carbon emission since 2012, **ENGIE** is progressing at a slightly lower speed than its competitors (around 16% reduction since 2014) and remains at a relatively high level of emissions (350g/KWh in 2017). Despite a continuous decrease since 2014, **RWE** and **EnBW** CO_2 emissions remain at a very high level due to coal and lignite usage.

1 Source: http://www.worldbank.org/en/results/2017/12/01/carbon-pricing

Topic Box 6.1: In a more challenging environment, Utilities are implementing new investment strategies towards services and low carbon energy

In 2017-2018, European power companies continued to review their investment strategies and to transform their business models through mergers and acquisitions (M&A). Indeed, these companies continue to evolve in a more and more complex environment. Their benefits and EBITDA are impacted by:

- **Limited economic growth** in most European countries, leading companies to improve their operational performance via restructuring and to propose new services;
- **More competitive markets** (emphasized by the entry of new players), forcing companies to constantly innovate and to focus on more profitable segments;
- **Increasing regulatory constraints** regarding CO_2 prices, pushing companies towards low-carbon technologies.

Oil and gas companies position themselves as serious challengers

Thanks to more revenues (following higher oil prices and cost-cutting policies), **oil and gas companies are increasing their investment** towards cleaner production and energy distribution. European oil and gas companies are now deploying aggressive investment strategies, going beyond their traditional business. This **might position them as major players in the coming years:**

- **Total** has proven its interest in green energy and renewables with the acquisition of the energy efficiency company Greenflex and the solar and wind energy producer EREN RE. Total is also expanding its activity along the entire gas-electricity value chain while developing low-carbon energies thanks to its Direct Energie acquisition. Total is repositioning itself on the French and Belgian electricity supply markets as a leading alternative supplier by combining its 1.5 million clients portfolio with Direct Energie's 2.6 million clients portfolio (Reference: Total).
- In late 2017, **Shell** acquired NewMotion, one of Europe's largest electric vehicle charging providers. This highlights Shell's intention to maximize the services and flexibility for its customers by providing access to a range of refueling choices over the coming years. This will enable new technologies to co-exist with traditional transport fuels. Following its First Utility acquisition, Shell is also moving from a pure industrial and commercial energy provider to residentials.
- **BP** is also offering EV charging capabilities with the acquisition of Chargemaster, having the largest EV charging network in the UK.

One can also mention the growing appetite of non-European companies: Chinese state-controlled company China Three Gorges (CTG) unsuccessfully attempted to take over EDP for €9.1 billion (which was rejected due to the price being considered too low). This operation showed the increasing interest of Chinese investors in European energy assets (China has even become one of the major investors in Portugal).

Reacting to this evolution in their environment, companies are implementing two major strategies:

Utilities are shifting towards renewables

Some companies are splitting future energy sources from their conventional businesses, with an increased interest on distributed energy. **Low carbon energy** and **renewable assets** (separating from or decreasing exposure to conventional generation) are remaining at the top of acquisitions agendas, not only for reputational reasons but mainly due to **changing business strategies around clean energy.**

- **Two major German Utilities, RWE and E.ON,** were among the first ones to make this move. In 2016, E.ON formed Uniper, which took the conventional assets (e.g. gas and coal generation) while E.ON focused on renewables and energy networks. RWE put its green and retail businesses in a subsidiary called Innogy, which went public in 2016. Recently, RWE and E.ON agreed to **break up RWE's subsidiary Innogy** and divide its assets between them in a €5.2 billion deal, making this one of the most high profile deals in the market.
- **Fortum** expects the **deal with Uniper** to deliver an attractive payback that will support Fortum in accelerating the development and implementation of sustainable energy technologies, without sacrificing a competitive dividend.

Utilities are entering new markets, developing new services

Some companies are entering new markets via acquisitions and external growth where they can leverage their know-how.

Enel, E.ON and ENGIE continue to make important acquisitions of companies with different activities helping them to get access to **new markets** such as **e-mobility,** or profit from new technological development such as **energy storage**. As an example, ENGIE fought its way into the fast-growing EV market, with its acquisition of Netherlands-based **EV-BoX,** one of the leading EV vehicle charging service providers.

Southeast Asia

WEMO 2018 Southeast Asia Editorial

Gaurav Modi & Kiran Keshav

South East Asia (SEA) is on the cusp of change

The increasing population and urbanization, resulting in multiple development and infrastructure initiatives, has led to a rising energy demand. However, there is still high reliance on fossil fuels with coal leading the mix. All 6 SEA countries considered for the purpose of this report have signed up to the Paris agreement, and are therefore required to reduce this reliance on fossil fuels and increase the renewables in the energy mix. The big challenge is to meet this increasing energy demand in an environmentally friendly manner.

Equally important to note is the fact that, according to the Global Climate Risk Index, four of the world's 10 countries most affected by climate change are located in Southeast Asia: Myanmar, the Philippines, Thailand and Vietnam. Therefore, the impact of GHG emissions and global warming resulting in climate change has direct ramifications in these countries and the need for action is more urgent than elsewhere.

There are hurdles, however. Investment in renewable energy in SEA is only about 1.2% of the global figure, although the region accounted for 3.7% of the world's emissions in 2017. This modest investment is attributable to policy uncertainty in most of the countries. Projects in the Philippines and Vietnam, for example, have been slow to proceed due to a lack of clear government policies and bankability concerns.

Nevertheless, progress has been made in the last couple of years, and most countries in the region have shown clear intent in embracing a greener energy mix. Singapore has been leading the way with solar photovoltaic panels and its Open Electricity Market that enables consumers to opt for green energy. Malaysia and the Philippines have also been considering deregulation and are at different stages in terms of opening up their markets to competition.

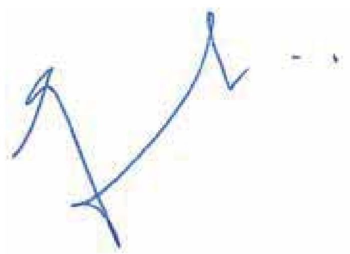
The region is also expected to significantly increase investments in building LNG terminals as it is set to become one of the largest importers of global LNG. Singapore is also being developed as a regional gas hub to focus on gas trading. Such hub-based trading has become a key feature of gas markets in Europe and North America and allows for better transparency as well as enhancing security of supply and affordability. Singapore has made important moves towards liberalizing its gas market, providing the basis for more competitive price setting, and this should eventually enable development of such a hub-style market.

From a consumer perspective, the increase in energy demand is due to rising income levels, leading to higher ownership of appliances and a growing demand for cooling. Considering the fact that power prices in the region are significantly high due to lack of subsidies and reliance on expensive imports, the increase in energy demand results in a very price-sensitive consumer market. Deregulation of the electricity market in Singapore is a step in the right direction to enable competitive pricing and give consumers the option of choosing the plan that best suits them.

Digital technologies such as big data, analytics, cloud and blockchain are also playing a key role in addressing some of these energy-sector challenges in SEA. A deeper understanding of energy data distribution and consumption analytics has helped energy companies in the region to become more efficient across the energy lifecycle. Investment in smart grids, smart buildings, and smart meters has risen significantly in the region and is expected to increase in the coming years, which will further improve data-driven analytical capabilities to better predict energy supply and demand.

South East Asia is poised for change – changing consumer demographics, changing energy demand, changing regulatory frameworks, and changing technology options. All of these are expected to play a major role in transforming the SEA energy market into a vibrant, eco-friendly, secure and efficient market in the next five years.

October 01, 2018



Gaurav Modi

Chief Executive Officer
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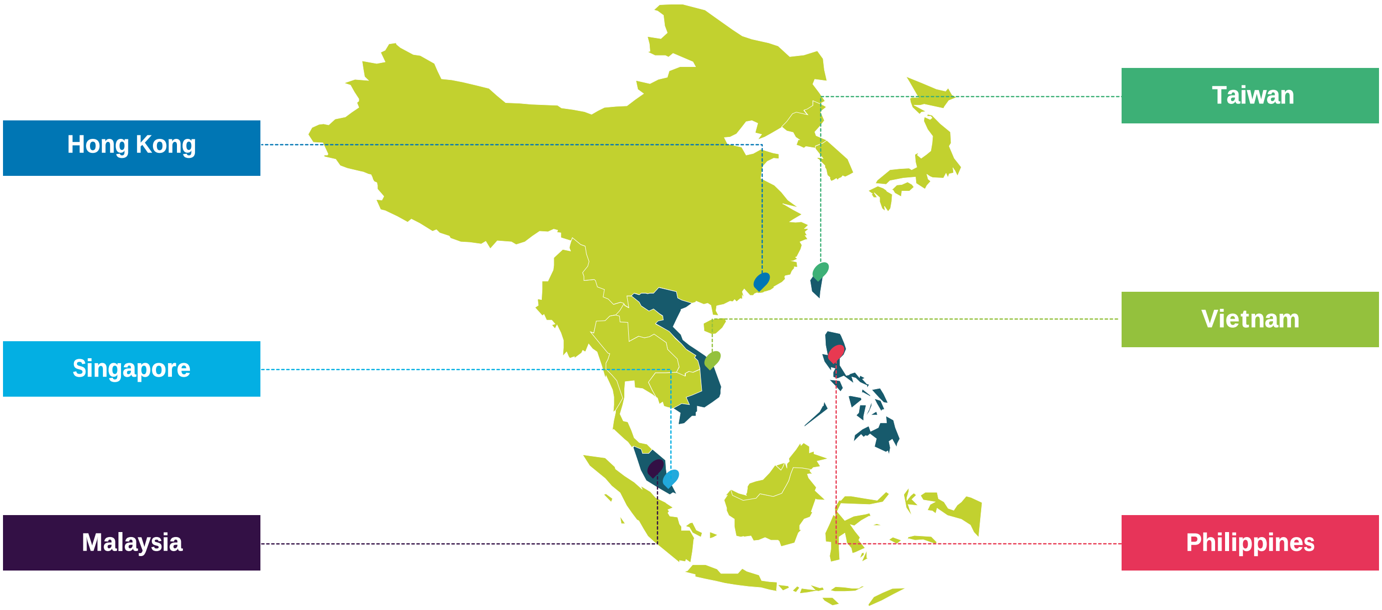
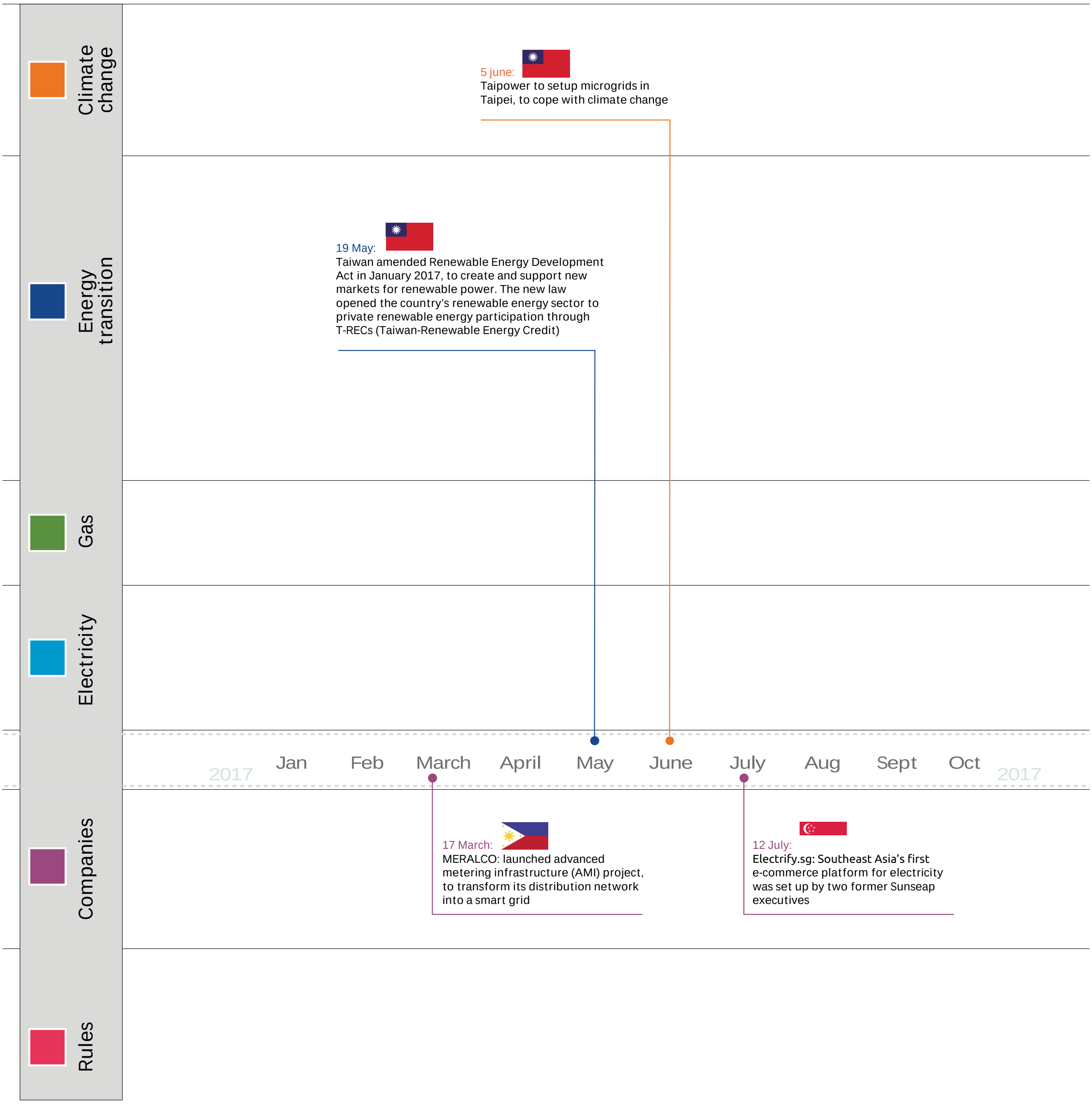
Kiran Keshav

Group Sales Officer

In this Observatory, Southeast Asia (SEA) refers to a region covering the following six countries only



Major energy events (2017 and H1 2018)



Source: Various industry sources - Capgemini analysis, WEMO2018

20 February:
Singapore: Carbon tax set at S$5 per tonne of greenhouse gases generated from next year to 2023

24 May:
Siemens and TNB team up to transform Malaysia's digitalization in its power generation services and energy management

2017 Nov Dec Jan 2018 Feb March April May June July 2018

Southeast Asia

1-Climate Challenges & Regulatory Policies

Southeast Asia is moving towards a clean energy system, but high energy demand and cost pressures are the two key factors behind its slow progress.

- Vietnam witnessed its highest ever energy consumption during the past five years at a CAGR of 7.1%.
- Oil continues to be the leading source of energy, though its share in the total primary energy demand has declined by around six percentage points, to 34%, since 2000.

Growth in energy demand will be highest in the power sector followed by industry, transport and buildings.

- Singapore's imports of energy products grew by 2% from 172.8 Mtoe in 2015 to 176.3 Mtoe in 2016.
- Power generation in Malaysia is primarily dominated by gas and coal, accounting for 78% of the country's energy mix (2017), and in the last five years, renewable energy (RE) has emerged, adding 22% to the country's energy mix.

Renewables and high-efficiency coal, followed by gas, are expected to lead the future of energy production.

- By 2040, renewables are expected to account for the largest share of installed capacity (nearly 40%), but coal is likely to take the most prominent role in the generation mix (40%), and 70% of the new coal-fired capacity will use high efficiency supercritical or ultra-supercritical technologies.
- Concerns about air pollution in several of the region's largest cities continue to rise as the urban population and demand for mobility increase.

Lowering Carbon Emissions to meet the Target

Rising CO_2 emissions are contrary to the objectives of the Paris Climate Change Agreement, which has been ratified by all the countries in the region.
There is strong growth in low-carbon energy, but increased energy needs have led to rising consumption of all fuels. Coal alone accounts for almost 40% of the growth, and overtakes natural gas in the electricity mix (2040).
Southeast Asia's major six countries accounted for 3.7% of total global greenhouse gas (GHG) emissions in 2017.
Hong Kong's emissions will peak by 2020, at a time when it will have more electricity generation from natural gas in its fuel mix.

Climate Challenges in Southeast Asia - An Overview

Southeast Asia is witnessing rapid economic growth and development across all sectors, combined with a growing population and urbanization, as well as improving access to basic services. However, this impressive growth curve creates staggering energy challenges and raises acute concerns about environmental sustainability.

Energy demand is growing fast, driven by increasing industrial activities, rapidly growing populations and rising income levels. The region's heavy reliance on fossil fuels for power generation and other needs is contributing to rising GHG emissions, a trend that presents a major policy challenge in the context of global climate targets.

- Energy consumption in the region is estimated to increase by up to 140% by 2040. One of the major challenges is to meet the rapidly growing energy demand in a timely manner while also chasing other crucial socio-economic and environmental objectives. These include enhancing energy security, reducing the environmental and health impacts of energy supply and achieving universal access to modern energy services. This has prompted a number of countries in the region to evaluate the structures of their energy sector, including power market design, and identify opportunities for augmenting government investments towards environmental sustainability.
- The region is facing the additional challenge of significantly scaling up renewable energy investment and deployment while simultaneously focusing on other barriers that impede investment, such as a country's financial state or regulatory environment.
- Coal is projected to become the largest energy source from 2040 onward, and failure to move away from fossil fuels like coal may damage the international stature of ASEAN countries and also lead to failure in meeting their Paris Agreement targets. Reducing fossil-fuel subsidies and increasing the share of renewables in the energy mix could counteract fossil fuel dependence and achieve the NDCs.
- Food, health, energy; almost everything is at risk as the temperature rises along with ever increasing GHG emissions, and there will probably be more intense typhoons and cyclones as global temperatures increase, but the region also has the opportunity to lead in green technologies.

Consequences

According to the Global Climate Risk Index, four of the world's ten countries most affected by climate change are located in Southeast Asia: Myanmar, the Philippines, Thailand and Vietnam. In these countries and others, climate change is likely to have major implications.

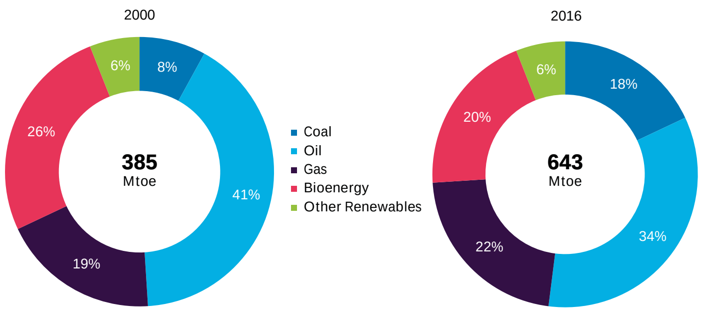
- Extreme weather events are also expected to worsen; events in the past, such as the 2013 Typhoon Haiyan in the Philippines, caused high death tolls and a rise in cross-border migration.
- Transboundary haze pollution[1] originating from fires has already caused pressures between countries across SEA, as it affects air quality and human health across borders. While haze can cause diplomatic rifts, it also provides an opportunity for countries to work together.
- Food security is another major concern, because a large proportion of Southeast Asia's workforce is engaged in agriculture, forestry and fisheries, sectors that are especially vulnerable to climate change. Rice yields and Gross Domestic Product (GDP) in ASEAN countries are projected to decline by 50% and 6.7% by 2100, respectively.

Primary Energy Demand evolving at a noteworthy pace

Primary energy demand grew by around 70% between 2000 and 2016, rising to 643 Mtoe, while the GDP more than doubled over the same period.

- Over the past 25 years, according to the International Energy Agency (IEA), energy demand in Southeast Asia has increased by over 150%. The IEA also forecast that the growth for energy demand in the region would increase another 80% from the current consumption, or reach 1,070 Mtoe by 2040 while electricity generation is expected to reach 1,104 TWh by 2040.
- Oil continues to be the leading source of energy, though its share of total primary energy demand has declined by around six percentage points, to 34%, since 2000.
- Coal demand has more than doubled since 2000, with an annual average growth rate of 8.8%.
  - In 2016, coal demand of around 110 Mtoe accounted for 17% of the total primary energy demand, of which the largest portion was for power generation
- Solid biomass plays a major role in Southeast Asia's primary energy mix, accounting for 20% of total demand in 2016.
- Among the modern sources of renewable energy, hydropower has grown rapidly with expanded use.

Figure 1.1. Primary Energy Demand Evolution, 2000-2016 (million tons oil equivalent)



Source: IEA, Southeast Asia Energy Outlook, 2017

Southeast Asian nations should focus more on energy security and energy efficiency issues in order for ASEAN to achieve sustainable economic growth and market integration, and mitigate the adverse impacts of climate change as a unified body.

Sectoral Demand

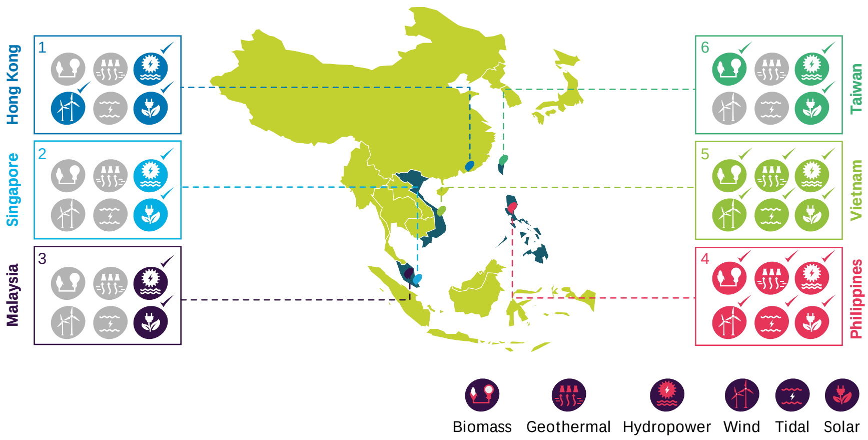
- Rapid economic development has stimulated demand in a range of energy-intensive industries including steel, petrochemicals, paper, cement and aluminium. Growth in energy demand will be highest in the power sector followed by industry, transport and buildings.
- Among end-use sectors, energy demand in transport grew most rapidly, almost doubling between 2000 and 2016. Natural gas and biofuels constitute around 6% of transport energy demand, reflecting efforts made by some Southeast Asian countries, such as Malaysia, to increase the use of alternative fuels.
- Bioenergy is the dominant fuel in the buildings sector, meeting around 60% of energy demand. Since 2000, a 180% increase in electricity consumption (the fastest growing energy source in buildings over the period) has helped slow the growth in biomass use, doubling the share of electricity in the buildings energy mix.

[1] Transboundary haze: In Southeast Asia, haze generally originates from peat and forest fires, mostly in Indonesia. The haze travels across national boundaries and affects the six countries with differing levels of severity. This is the 'transboundary' effect of the fires, and has caused increased awareness and concern in various countries beyond Indonesian shores.

Southeast Asia's growing energy demand

- **Hong Kong** has no indigenous fuels and has to import fossil fuels (mainly coal and oil products) to meet energy demands for electricity generation, transport, industry, etc.
  - Energy consumption in 2015 was 39.5 GJ per capita. For the period from 2005-2015, energy consumption per capita reduced by 4.1% (decreasing at an average annual rate of 0.4%).
- **Singapore**'s imports of energy products grew by 2% from 172.8 Mtoe in 2015 to 176.3 Mtoe in 2016, whereas exports of energy products witnessed an 8% increase, growing from 92.0 Mtoe in 2015 to 99.3 Mtoe in 2016. Imports of natural gas increased by 2.4% from 9.5 Mtoe in 2015 to 9.7 Mtoe in 2016, with Liquefied Natural Gas (LNG) accounting for 23.4% of these imports. Electricity generation increased by 2.6% from 50.3 TWh in 2015 to 51.6 TWh in 2016.

Figure 1.2. Energy Potential by Country and by Technology



Source: The ASEAN Post, September 2017

- Power generation in **Malaysia** is mainly dominated by gas and coal, accounting for 78% of the country's energy mix (2017), and in the last five years, renewable energy (RE) has emerged, adding 22% to the country's energy mix. In 2005, power generation was a little above 80,000GWh. This figure is expected to balloon to 180,000GWh by 2035.
- The **Philippines** can indigenously satisfy energy needs. The total production of all electricity producing facilities is 91 bn kWh, which is 122% of its own requirements. Electricity consumption grew considerably from 82,413,213 MWh (2015) to 90,797,891 MWh (2016). This increase was mainly driven by the growth of residential consumption at 12.7% from 22,747,049 MWh (2015) to 25,631,254 MWh (2016), due to high requirements for cooling systems.
- In **Vietnam**, electricity demand is expected to grow by 8% per annum on average until 2035, corresponding to a need for an additional 93 GW of power generation capacity during the period. Almost half of the new capacity is intended to be coal fired, while almost 25% will be renewable energy.
- In 2016, **Taiwan**'s total supply of primary energy amounted to 146,590.0 103 Kilos Of Oil Equivalent (KLOEs), marking an increase of 0.34% over 146,095.7 103 KLOEs in 2015. In 2016, the per capita energy requirement was 4,998.36 liters of oil equivalent, representing an increase of 0.05% over 4,996.08 liters of oil equivalent in 2015.

Electricity is the main source of growth in final energy use

Electricity accounts for the largest share of the increase in final consumption, as rising opportunities and incomes in the region lead to higher ownership of appliances and increasing demand for cooling. Two-thirds of the increase in Southeast Asia's electricity demand comes from the residential and services sectors, largely due to a rising urban population.

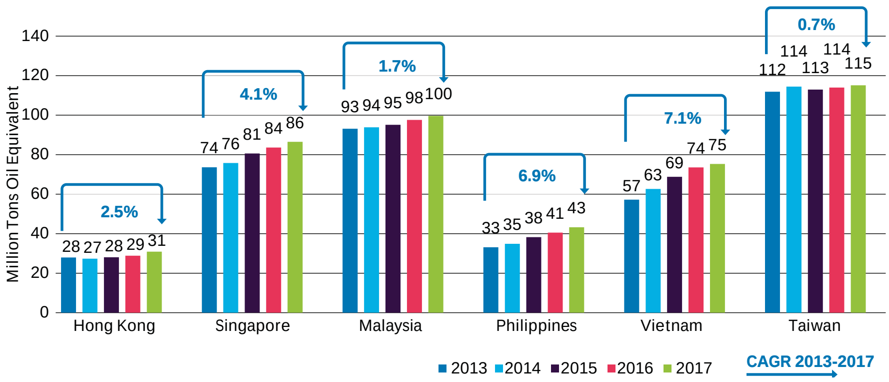
Energy usage in the transport sector remains dominated by oil products, with policy efforts to diversify the mix focusing on biofuels. Biofuels can bring energy security and environmental benefits, although that would require that palm oil production is managed sustainably.

Energy Consumption: primary energy consumption and the underlying impact - current scenario

Primary Energy Consumption - Vietnam witnessed its highest ever energy consumption during the past five years, at a CAGR of 7.1%.

- Southeast Asia continues to witness increasing challenges in ensuring regional cooperation in dealing with climate change issues after the U.S. decision to withdraw from the 2015 Paris Agreement.
  - For example, Vietnam's delta river region, the rice producing section of the nation, is threatened by rising sea levels affecting rice production and insect infestations.
  - Following talks between U.S. President Donald J. Trump and Vietnamese Prime Minister Nguyen Xuan Phuc, the US said it would continue to work together with Hanoi to address global challenges, including environmental protection.

Figure 1.3. Primary Energy Consumption, 2013-2017 (million tons oil equivalent)



Source: BP Statistical Review of World Energy, 2018

- Southeast Asia aims to shift towards a clean energy system, but high energy demand and cost pressures are the two key factors behind its slow progress.
- Despite ambitious green energy targets set by several Southeast Asian nations in the past years, the region's battle against climate change could be a difficult one.
- Strong economic growth and poor regional coordination have been mentioned by experts as basic causes for the persistently low share of renewables in the region's energy mix.

The prevailing scenario

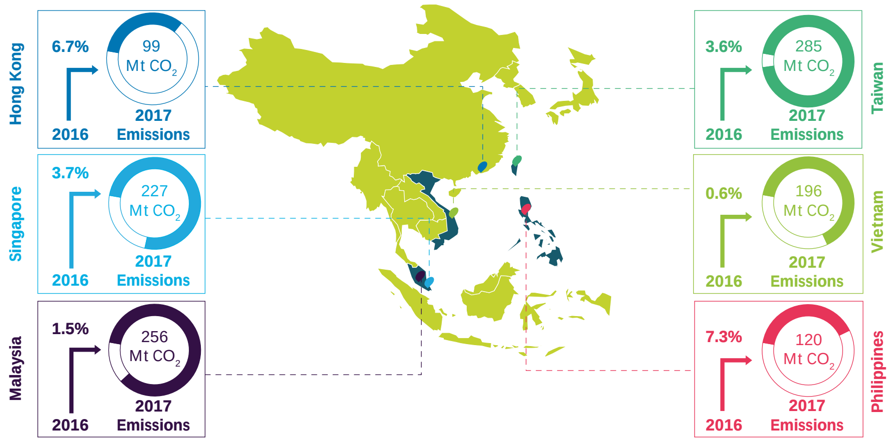
- With Southeast Asian energy demand likely to escalate by more than 80% between 2015 and 2040, as projected by the International Energy Agency (IEA), the government is facing the daunting task of producing large amounts of sustainable energy to meet the ever increasing demand for electricity. The cost of failing to curb GHG emissions will be high, as the region's long coastlines are home to tens of millions of people, susceptible to sea level rises and severe typhoons aggravated by climate change.
- Renewables and high-efficiency coal, followed by gas, lead the race for new power generation: Fulfilling the ever increasing electricity demand requires a huge expansion in the region's power system, with coal and renewables accounting for almost 70% of new capacity.
- Concerns about air pollution in several of the region's largest cities is intensifying as population and demand for mobility increase. Strong growth in fossil-fuel consumption has led to a 75% increase in energy-related CO_2 emissions. Efficiency and increased renewables deployment are vital for a more sustainable energy future.

Energy Consumption: what does the future hold?

The road ahead for Southeast Asia is well defined with clear emission reduction goals.

- Southeast Asia remains an important producer of oil, gas and coal, but also faces several challenges, especially in the short term.
- There is strong growth in low-carbon energy, but increased energy needs have led to rising consumption of all fuels.
- Coal alone accounts for almost 40% of the growth, and has overtaken gas in the electricity mix.
- The region's power system has expanded to meet energy demand, with major components such as coal and renewables accounting for ~70% of the extended capacity.
- The mix of fuels and technologies varies country-by-country but, overall, reflects an emerging preference for a combination of high efficiency coal plants and increased deployment of renewables.
- Concerns about air pollution in several of the region's largest cities are intensifying as the urban population and demand for mobility increase.
- Strong growth in fossil-fuel consumption has led to a 75% increase in energy-related CO_2 emissions.

Figure 1.4. Energy-related CO_2 Emissions Growth, 2017 (million metric tons)



Source: BP Statistical Review of World Energy, 2018

Renewables and high-efficiency coal, followed by gas, are expected to lead the future of energy production

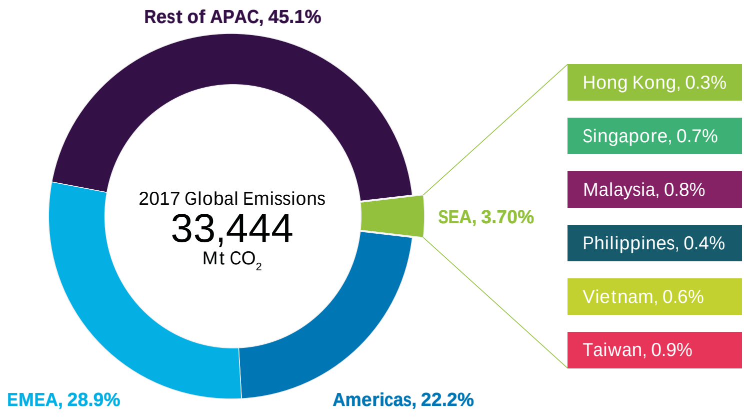
- By 2040, renewable energy is expected to account for the largest share of installed capacity (nearly 40%), but coal takes the most prominent role in the generation mix (40%) and 70% of the new coal-fired capacity uses high efficiency supercritical or ultra-supercritical technologies.
- Demand for natural gas growth is also expected to intensify, by around 60% to 2040, due to rising consumption in power generation and industry. The share of renewables (excluding solid biomass), including hydro, solar photovoltaic (PV) and wind power, will almost double as their deployment helps to meet rising electricity demand and to extend energy access.

Southeast Asia's emissions overview

Southeast Asia's major six countries accounted for 3.7% of total global emissions in 2017.

- Southeast Asia is a growing source of GHG emissions. The region has experienced rapid economic growth in recent years, and regional GHG emissions have rapidly increased, at nearly 5% per year over the last two decades.
- Deforestation and land use account for a majority of emissions. Energy efficiency in most of Southeast Asia is improving more slowly than in other areas of developing Asia or the world as a whole, while coal and oil have been rapidly rising as sources of primary energy.
- Climate mitigation requires a global energy transition, which has implications for regional relationships. Coal is projected to become the largest energy source from 2040 onward, which completely negates the respective NDCs.
- Taiwan had the majority of carbon emissions (0.9%) among other countries. "While carbon reduction is important, having sufficient electricity is even more so stated the Taiwan's Bureau of Energy. High electricity demand throughout 2017 has encouraged the increased usage of coal-burning power plants in Taiwan"[1].

Figure 1.5. Southeast Asia's Share in Global Emissions, 2017 (million tons CO_2)



Source: BP Statistical Review of World Energy, 2018

1 Taiwan News, 2018

Hong Kong: Lowering Carbon Emissions

- In Hong Kong, local electricity generation is the biggest contributor to carbon emissions making up about 70%. Despite a rising population and economy, emissions levels have remained at around 40-45 million tons of CO_2e in recent years. Hong Kong's emissions will peak by 2020 when it will have more electricity generation from natural gas in its fuel mix.
- The country's current decarbonization route will help to reduce carbon intensity by around 50% by 2020 using 2005 as the base. This reduction would be equivalent to about 20% in absolute terms, which is substantial. Hong Kong's 2030 target would take it to a 65-70% carbon intensity reduction from the 2005 level, which equates to about 26-36% in absolute terms.

Southeast Asia GHG Challenges - Regional Outlook

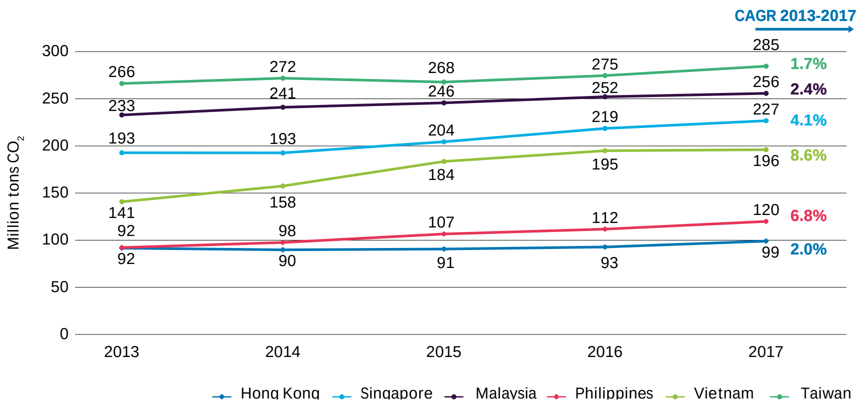
The continuous rise in temperature leads to various other problems, such as more frequent heatwaves, a reduction in agricultural production, sea level rise, scarcity of water resources, etc.

- **Hong Kong** has been warming up due to the effect of GHG emissions from the last century. Apart from rising temperature, Hong Kong is experiencing heavy rain more frequently than before. The sea level is rising in Victoria Harbour. Hong Kong will continue to phase out coal for electricity generation, use more natural gas, and increase non-fossil fuel sources, which will enable Hong Kong to reduce carbon emissions significantly.
- Energy consumption is one of the main sources of carbon in Singapore. Its household appliances, transport systems, and industrial and commercial activities all run on electricity and fossil fuel. A vibrant **Singapore** relies on consuming electricity. Singapore accounts for less than 0.2% of global emissions.
- In **Malaysia**, the mean surface temperatures have increased from 0.6°C to 1.2°C over 50 years (1969-2009) and are projected to increase from 1.5 to 2°C by 2050. While there is no significant difference in the rainfall amount from the observed data, this is projected to change in both Peninsular Malaysia and Sabah and Sarawak.
- Due to its geographical location, climate and topography, the **Philippines** is ranked third on the World Risk Index 2018 for highest disaster risk and exposure to natural disasters. In the Philippines, the transportation sector accounts for the largest average of CO_2 emissions at 36.43%, followed by other industries at 20.22% in the same period of 1990 to 2014.
- **Vietnam** is considered one of the most damage prone regions in terms of climate challenges. Extreme climate events have become more frequent and more intense; its average temperature has increased by about 0.5°C; and its sea level has risen by approximately 20 centimeters, which is particularly disconcerting because of its 2,000 miles of coastline. These impacts present clear challenges for the Vietnamese – especially in the Mekong River Delta region, a crucial hub for food production. In 2016, **Vietnam** ratified the Paris Agreement on Climate Change to mark its commitment to reducing global GHG emissions and pursuing adaptation efforts.
- Although **Taiwan** is not a participant of the Kyoto Protocol, it is part of the global village and has the responsibility of reducing CO_2 emissions. In Taiwan's industrial sector, the petrochemical industry is the largest emitter of GHG.

GHG emissions evolution

- **Hong Kong** has set an ambitious carbon intensity target of 65% to 70% by 2030 using 2005 as the base, which is equivalent to 26% to 36% absolute reduction and a reduction to 3.3-3.8 tons on a per capita basis. It is also predicted that carbon emissions will peak before 2020.
  - Hong Kong has acceded to the Paris Agreement and will follow its reporting timeline. It has based its operational framework on the 4Ts[1] and is using cleaner fuel and renewable energy to reduce GHG emissions.
- **Singapore** contributes around 0.11% of global emissions. The region's NDC emissions target of a 36% reduction in emissions intensity below 2005 levels by 2030 is very weak compared to currently

Figure 1.6. Emissions Evolution, 2013-2017 (million tons CO_2)



Source: BP Statistical Review of World Energy, 2018

Southeast Asia

implemented policies, which will lead to emissions in 2030 of 60 $MtCO_2e$, or a 123% increase above 1994 levels.

- In 2011, **Malaysia**'s total GHG emissions were 290.23 Mt CO_2e. Taking into consideration the drop in emissions from land use, land-use change and forestry (LULUCF), the net GHG emissions were 27.28 Mt CO_2e.
  – Malaysia has undertaken a number of mitigation (emissions reduction) and adaptation (to reduce the impacts and risks or exploit beneficial opportunities) strategies to tackle climate change.
- Proactive mitigation measures need to be implemented in the Philippines to avoid a major rise in GHG emissions. Sectors such as transportation, power generation and household electricity may contribute to a six-fold emissions increase between 2015 and 2050.

- The GHG Act in **Taiwan** calls for GHG reductions based on 2005 GHG emissions levels. It aims for emissions to decline 5% by 2020, 10% by 2025, 20% by 2030, and 50% by 2050.
- The GHG Act targets six major sectors for GHG emissions reductions: energy, manufacturing, transportation, residential and commercial, agriculture and environmental management.

Regional energy targets and subsequent sectoral mapping

Country	Sector	Key Targets & Policies
Hong Kong	Efficiency	Make new gas plants as energy efficient as possible. Existing gas plants can achieve about 45% efficiency but the latest technology can achieve around 60% thermal efficiency
	Renewables	Continue to phase out coal for electricity generation, use more natural gas, and increase non-fossil fuel sources, enabling significant reductions in carbon emissions inthe medium term
	Climate change	Reduce carbon intensity from 65% to 70% by 2030 using 2005 as the base
Singapore	Efficiency	Improve energy intensity by 36% by 2030 from 2005 levels
	Renewables	Increase solar PV capacity to 350 MW by 2020
	Climate change	Reduce GHG emissions by 16% below BAU level by 2020; stabilize emissions with the aim of peaking around 2030
Malaysia	Efficiency	Promote energy efficiency in industry, building and the domestic sector by setting standards, labelling, energy audits and building design
	Renewables	Increase capacity of renewables to 2,080 MW by 2020 and 4,000 MW by 2030
	Transport	Introduce 100,000 electric vehicles by 2020 with 125,000 charging stations
	Climate change	Reduce GHG intensity of GDP by 35% by 2030 from 2005 level, aiming for a 45% reduction with enhanced international support
Philippines	Electrification	Achieve 100% electrification by 2022
	Efficiency	Improve energy intensity by 40% by 2030 from 2010 level. Decrease energy consumption by 1.6% per year against baseline forecasts by 2030
	Renewables	Triple the installed capacity of renewables-based power generation from 2010 level to 15 GW by 2030
	Climate change	Reduce GHG emissions by 70% from BAU level by 2030 conditional on international support
Vietnam	Electrification	Ensure most rural households have access to electricity by 2020
	Efficiency	Increase commercial electricity savings to more than 10% of total power consumption by 2020 relative to BAU
	Renewables	Increase the share of non-hydro renewables-based power generation capacity to 12.5% by 2025 and 21% by 2030
	Climate change	Reduce GHG emissions from BAU level by 8% by 2030 and by 25% with international support
Taiwan	Renewables	Achieve a 20%-by-2025 renewable energy target
	Climate change	Implement an economy-wide target, through domestic abatement efforts, to reduce GHG emissions (214 $MtCO_2e$) by 50% from BAU (428 $MtCO_2e$) by 2030

[1] 4Ts framework, namely target, timeline, transparency and together, under which the 4Ts partners are encouraged to set their energy saving targets and timelines and to share their existing and planned energy saving measures

Topic Box 1.1: Government and private sector initiatives to reduce emissions challenges

Hong Kong

- Hong Kong has incidentally developed very few policy and economic incentives to promote and support green technologies. For example, the World Wildlife Fund (WWF) is distributing photovoltaic panels in Tai O, a village in Hong Kong. To prevent the grid from burning out, the supplier (CLP), has to control the energy input and thus manage its tariff system by implementing a feed-in tariff.

Singapore

- With Singapore's Smart Nation initiative, energy companies are adopting intelligent remote sensors, demand prediction through data analytics and fulfilling the need of end users and customers through value-added applications:
  - ENGIE has partnered with Schneider Electric and Nanyang Technological University in Singapore to build a test site for a 2.8 MW microgrid (expected to come online in 2018). Renewable Energy Integration Demonstrator in Singapore (REIDS), the Semakau project aims to develop a microgrid demonstrator that could improve energy access in off-grid areas and islands.

Malaysia

- Green Technology Master Plan 2017-2030 - To transform Malaysia into a low carbon and resource efficient economy through the implementation of Green Catalyst Projects that would reduce carbon intensity by 40% by 2020.
- Energy Efficiency Action Plan - Aims to reduce emissions by 13.113 million tons CO_2e by 2030.
- Transportation Sector - The launch of the Mass Rapid Transit (MRT) phase one successfully removed 9.9 million cars in 2017 and is estimated to remove an additional 62-89 million cars between 2020-2030.
- Low Carbon Cities Framework – To introduce a carbon reduction blueprint for local authorities and developers when making decisions on greener solutions.

Philippines

- The Philippines' GHG emissions are currently a minor contributor to global warming (in comparison to Vietnam and Malaysia). The following market-based instruments have been employed till date:
  - Feed-in Tariff (FiT) and net metering under the Renewable Energy Act of 2008
  - Received 119 Clean Development Mechanism (CDM) project applications (out of which 70 have been registered)
  - Also signed the Joint Crediting Mechanism (JCM) with Japan.

Vietnam

- The government of Vietnam committed a significant amount of spending toward climate change activities, green growth strategies and action plans. However, the program has not realized fully due to various bottlenecks, and some important activities remain underfunded or not funded at all.

Taiwan

- In 2014, the U.S. Environmental Protection Agency (EPA) and the Environmental Protection Administration Taiwan (EPAT) officially launched the International Environmental Partnership (IEP), a global network of experts working towards addressing environmental challenges. Other priorities such as climate change, electronic waste management, environmental education, mercury monitoring, air pollution, contaminated soil and groundwater are also addressed by EPA and EPAT.

Energy Transition towards Renewables

- In recent years, the region has embarked on a plan to develop an increasingly diversified portfolio of renewable energy sources to achieve benefits in energy security, energy access, economic competitiveness and social and environmental sustainability.
- The majority of countries have their own set of renewable energy national policies (laws) or official strategies, most often for specific renewable energy power sources. However, despite the dominance of laws geared toward renewable energy-based power, most countries still lack comprehensive legal frameworks or mandates for renewable energy-based transport or heating and cooling.

2-Energy Transition

Renewable energy and energy efficiency projects can immensely help countries to making up shortfalls in the Paris climate pledges.

- Most SEA countries are facing high energy demand growth, along with other challenges such as energy security, economic and environmental concerns.
- Improving energy efficiency across the various end-use sectors would complement renewable energy development in efforts to reconcile the objectives of energy sector expansion with sustainable development.

To achieve the set targets, countries have made efforts to develop policy frameworks and robust institutions.

- To support the deployment of renewables in government and community buildings, the Hong Kong authorities aim to increase funding from US$25 million to US$127 billion
- Taiwan amended Renewable Energy Development Act in January 2017, to create and support new markets for renewable power.
  - The new law opened the country's renewable energy sector to private renewable energy participation, and made it possible for nonutility buyers to procure T-RECs directly from projects.

Renewable energy investment in the power sector exceeded US$3.5 billion in 2017.

- Total investment by SEA in renewable energy represented about 1.2% of global investment in renewable energy.
- The modest renewable energy investment figures for the populous Southeast Asian economies with fast-growing electricity demand resulted mainly from policy uncertainty (eg. Bankability of Power Purchase Agreements (PPAs) for solar PV in Vietnam).
- While Hong Kong owed its position to public market activity (eg. Initial Public Offerings or IPOs), rather than to increased renewable energy capacity, the rise in investments in Singapore is the result of a strong focus on solar rooftop deployment (and novel applications such as floating solar).

Countries are taking concerted steps to address non-conducive conditions for renewable power generation.

- Countries such as Hong Kong, lack sufficient flow for large-scale hydroelectric generation.
  - However, in October 2017, Prosperity International of Hong Kong agreed a deal to develop a hydro power plant in Aceh with installed capacity of 1,000 MW and a total estimated investment of US$3 billion.
- In October 2017, Singapore installed its first long-span wind turbine at Semakau Landfill, producing enough energy to power 45 four-room HDB units a year.

Rising energy needs and changing supply-demand dynamics are creating tough challenges for Southeast Asia's policy-makers, but energy transition is also opening up new affordable policy and technology options

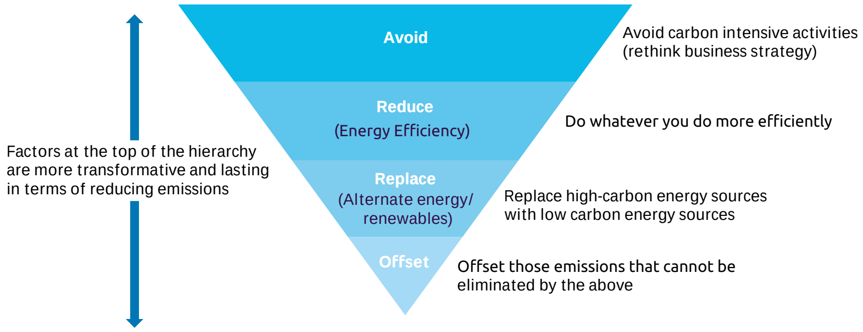
During past decades, SEA has experienced rapid economic growth, boosting energy demand, hasty urbanization leading to growing environmental pressures and heavy reliance on costly fossil fuels. The logical solution for the region that is well endowed with wind and solar resources and with a high density of potential customers, is development of renewable energy.

Transformation of the global energy system forms the backbone of climate action

Renewable energy and energy efficiency projects can go a long way to making up shortfalls in Paris climate pledges, while delivering huge human health and economic benefits.

- With the majority of countries in the region facing high energy demand growth, supply-side interventions alone will be insufficient to meet energy needs while also addressing broader energy security, economic and environmental objectives.
- Improving energy efficiency across the various end-use sectors would complement renewable energy development in efforts to reconcile the objectives of energy sector expansion with sustainable development.
- Most countries in the region have set energy-efficiency targets, although they vary greatly in scope, time frame and objectives.
  - Some target the absolute reduction of energy consumption (e.g. Vietnam), some aim to reduce energy intensity at the level of the economy or in specific end-use sectors (e.g., Malaysia, Singapore).

Figure 2.1. Carbon Management Hierarchy



Source: Capgemini Analysis

Buildings

- Tools that benchmark the energy performance of buildings have been used to reduce energy use in hotels in Vietnam and the Philippines.
- In Malaysia, building codes have been introduced to guide energy-efficient design.
- Malaysia's strategy to promote demand-side management explicitly focuses on education and training to increase the number of registered electrical engineer managers and on promoting ISO 50001 for buildings and industries.
- As ownership increases, domestic appliances are expected to account for a major share of electricity consumption;
  - Efficiency measures, such as mandatory labelling systems, could help reduce the increase in demand.
- Currently, the protocol and methodology adopted differ by country, but efforts are underway to harmonize standards across the region for appliances such as air conditioners, refrigerators and electric motors, in order to contribute to a stronger regional market.

Key enablers for development of energy-efficiency measures

Dedicated policies, action plans and institutions focusing on energy efficiency; targeted financing and business model structures; flexible regulations to allow innovation; robust data gathering, reporting and accessing frameworks; and awareness and capacity building programmes emerge as some of the key enabling factors. Innovative business models, such as energy service companies and public-private partnerships, are also being tried and tested in the region to deploy energy-efficiency measures particularly in buildings and industry.

Government guarantees are crucial to the bankability of projects that are considered high risk due to either their size or where the new technology is used

Transport

- Singapore has a fuel-labelling and emissions scheme (including CO_2 emission limits) that includes providing rebates or imposing surcharges on vehicle purchases.
- Singapore was the first to launch a voluntary Fuel Economy Labeling Scheme in 2003 and has since made it much more stringent.
- The Philippines is currently discussing plans to introduce fuel-economy standards:
  - Besides promoting the energy efficiency of the transport fleet, fuel-switching efforts are also being undertaken, using liquid biofuels as an alternative to fossil-fuel-based products.
- A global shift toward low-emissions mobility has already started and its pace is accelerating.

– This offers major opportunities for car manufacturers to modernize, embrace new technologies, drive global standards and export their products.

- The adoption of electric vehicle (EV) technology and increased use of biofuels in the transportation sector both have their fair share of implementation challenges.
  – For liquid biofuels, clear incentive structures are needed to increase investments, as well as regulatory and policy frameworks to ensure a sustainable supply chain for feedstock.
- Necessary safeguards are also needed to ensure that these investments are sustainable and address indigenous concerns alongside largescale land conversion and agri-business projects.
  – Regarding the electrification of the transport fleet, challenges associated with infrastructure development and the provision of low-carbon electricity will need to be addressed.

Industries

- Several measures to increase energy efficiency have been implemented in the region, including energy audits, energy management/ISO 50001, time-of-use tariffs, smart grids and meters, energy standards and labelling.
- In Singapore, for instance, large industrial emitters will need to improve how they measure and report greenhouse gas emissions, in order for them to better understand and manage emissions.
  – The Energy Conservation Act prescribes mandatory energy management practices, including appointing an energy manager, monitoring and reporting energy use and emissions and submitting energy efficiency improvement plans.
  – Recent enhancements in the Act call for Minimum Energy Performance Standards to be applied to industrial equipment and systems, and the establishment of an energy management system for existing facilities.

Scaling up energy-efficiency measures

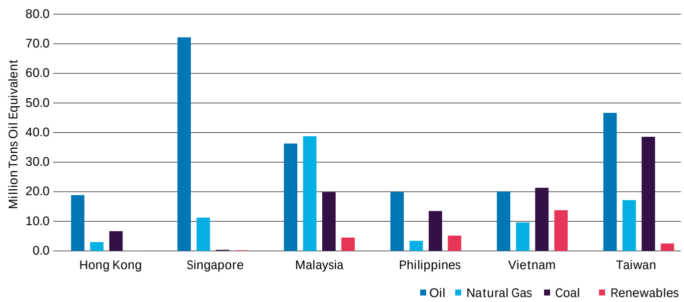
- Several countries have also announced dedicated financing schemes for energy efficiency.
- The Malaysian government launched a US$48 million fund in 2017, to help energy service companies (ESCOs) implement energy-efficient projects in the building sector.
- The Singapore Economic Development Board (EDB) is piloting the Energy Efficiency Financing Programme, whereby a third-party financier provides companies with upfront capital to implement energy efficiency projects, and the energy savings are shared between the various stakeholders.

Renewable Energy: a key element for cleaner transition and security

Oil continues to be the dominant source of energy, though its share of total primary energy consumption declined by around six percentage points during 2017 compared to previous year.

- Fossil fuels that would see the highest increase in usage in the next few decades are coal and natural gas.
  – Oil will slip down in the overall energy mix rankings due to its price volatility and other environmental factors. However, coal and natural gas are more resistant to these issues.
- Natural gas is touted as a viable alternative – **cleaner than other sources of fossil fuels**. Though not as clean as renewable forms of energy, it can help reduce the region's carbon footprint. Electricity generated at gas-fired power plants can produce greenhouse gas emissions anywhere from **50% to 70%** lower than at most coal-fired power plants.
- Natural gas-fired power plants are not only generally cheaper and quicker to build than coal-fired power plants, but also tend to have higher cycle efficiencies and greater operational flexibility.
- Among the modern sources of renewable energy, hydropower has grown rapidly with expanded use in **Malaysia and Vietnam.**
  – So far, non-hydro renewables have played only a relatively limited role in the energy mix.
- Currently, average consumption of natural gas as a share of total energy consumption stands at **20.8%**, while that of renewable energy is only **8.3%**.
- When compared to solar or wind energy, fossil fuels are still more hazardous to the environment but the lure for SEA countries lies in lower costs to deploy and effectiveness of fossil fuels.

Figure 2.2. Energy Consumption by Fuel, 2017 (million tons oil equivalent)



Source: BP Statistical Review of World Energy, 2018

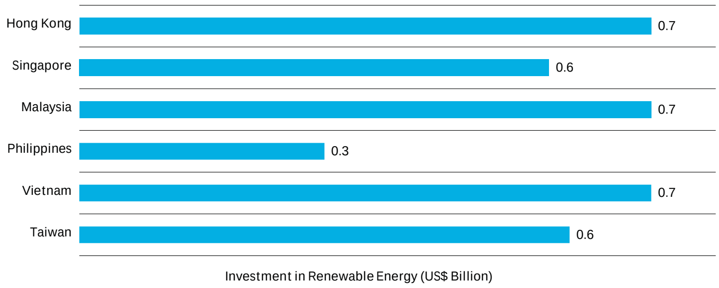
Natural gas is seen by some as a way station on the road to renewable energy

Proponents of coal and gas-fired power plants expect them to remain popular. Thousands of such plants are indeed in the pipeline, although critics warn of falling utilization among coal power plants and rising concerns on long-term gas supply, which could strengthen the case for renewables. Factors such as mounting air pollution and cheaper renewable energy costs are presenting convincing arguments for governments to shrink the role of coal and gas in the region's long-term energy mix.

Investment in renewable energy in the power sector exceeded US$3.5 billion in 2017

Total investment in renewable energy represented about 1.2% of global investment in renewable energy for SEA.

Figure 2.3. Renewable Energy Investment (US$ billion), 2017



Source: BNEF, Global Trends in Renewable Energy Investment, 2017

Hong Kong

- Owed its position in Figure 2.3 to public market activity, rather than to the buildout of renewable energy capacity, in particular, the US$434 million initial public offering by China Everbright Greentech, a company active in biomass generation technology.

Singapore

- The rise in investments is the result of a strong focus on solar rooftop deployment (and novel applications such as floating solar).

Malaysia

- Malaysian Investment Development Authority (MIDA) survey shows the export activities undertaken by top solar companies in 2016 amounted to US$250 million.
- Local sourcing activities in the same year were worth US$320 million.

Philippines

- Developers of more than 1GW of wind projects have been unable to progress because of the lack of a suitable regulatory framework.

Vietnam

- Recently announced a solar feed-in tariff but developers were in cautious mood over the bankability of power purchase agreements.

Taiwan

- The Cabinet has relaxed regulations governing the financial sector to encourage investment in "green" energy development.

The mix of fuels and technologies varies by country, but overall, reflects an emerging preference for a combination of high efficiency coal plants and increased deployment of renewables

Southeast Asia has the potential to leapfrog fossil fuel-based energy generation methods, but only if the renewable energy sector can attract investors. According to BNEF, the modest renewable energy investment figures for the populous Southeast Asian economies with fast-growing electricity demand resulted mainly from policy uncertainty.

Policy uncertainty in countries like Philippines and Vietnam has led to modest investment

Hong Kong

- In 2017, China Everbright Greentech, raised new capital on the Hong Kong Stock Exchange, partly to fund projects that will use agricultural and forest by-products to generate electricity and heat.
- At US$425 million, the offering would be the biggest alternative energy IPO in Hong Kong since China Longyuan Power Group's US$2.6 billion share sale in 2009.

Singapore

- The Singapore Economic Development Board (EDB) secured six clean energy investments across the fields of solar, wind, microgrids and energy management in recent months.
- This includes Shanghai-based Envision Energy setting up its global digital energy hub in Singapore, comprising a global digital R&D center and global headquarters for energy IOT and smart cities.
- Other investors include GCL (solar), Hover Energy (wind) and Jiangsu Linyang (smart meters, solar).
- These companies will establish their respective regional headquarters in Singapore for sales, operations, finance, treasury, and other management functions for Asia Pacific.

Malaysia

- Malaysia has been increasing its focus on the solar power sector over the past few years.
- The Energy Commission of Malaysia has a Request for Proposal (RfP) document, calling for bids from prospective project developers for 460 MW of solar power capacity.
- Under the competitive bidding programme, a large majority (360 MW) will be located in Peninsular Malaysia in the west of the country, while the remaining 100 MW will be installed in the eastern states of Sabah and Labuan.
- In 2017, Scatec Solar and its partner companies closed deals on three PV projects in Malaysia, worth US$293 million.

Philippines

- Vestas of Denmark, the world's largest wind turbine manufacturer, is working on 1,000 MW of wind power projects in the Philippines which awaits firmer government policies for development of the technology.
- In September 2017, VESTAS Asia Pacific Wind Technology expressed anew its concern about the lack of clear-cut policy from the Philippine government on incentives for wind-power projects.

Vietnam

- In September 2017, Vietnam's Ministry of Industry and Trade (MOIT) issued Circular No. 16/2017/TT-BCT ("Circular 16"), which imposes a set of Model PPAs for grid-connected and rooftop solar power projects.
- The MOIT has ignored several key recommendations made by industry participants on the draft PPA issued in April 2017 and is instead banking on the significant investor interest in Vietnam's solar sector to overcome any bankability concerns
- Commercial banks and financial institutions have raised serious concerns regarding bankability shortfalls, despite an attractive feed-in tariff.

Taiwan

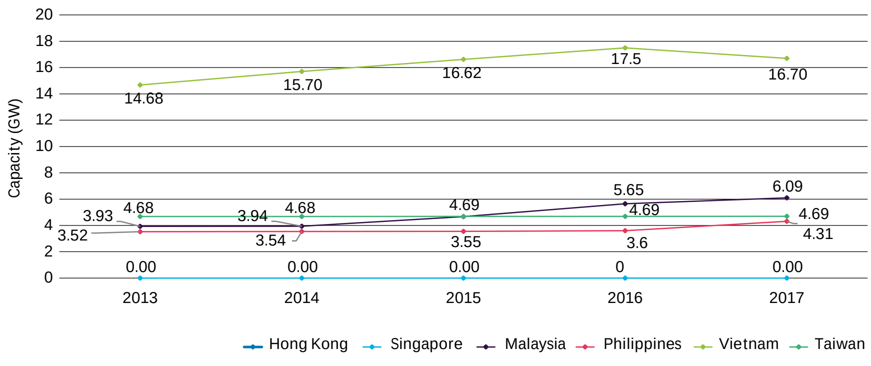
- Taiwanese insurance companies have invested about NTUS$ 5.35 billion (US$178.3 million) in the renewable energy sector, while financial entities are expected to invest up to US$49 billion, after the Cabinet eased the regulations in the Banking Act (in October 2017).

Evolution of Renewable Energy: hydro power

Hong Kong is taking concerted steps to address non-conducive conditions for hydroelectricity generation.

- Hong Kong rivers lack sufficient flow for large-scale hydroelectric generation. However, in October 2017, Prosperity International of Hong Kong agreed a deal to develop a hydro power plant in Aceh with installed capacity of 1,000 MW and total estimated investment of US$3 billion.

Figure 2.4. Hydroelectricity Capacity Evolution, 2013-2017 (GW)



Source: International Hydropower Association (IHA), 2018 Hydropower Status Report

Although the region saw a modest growth in hydroelectricity capacities, it is slated to play a significant role in the Philippines

The Philippines' hydropower sector has experienced limited capacity growth in recent years, but still accounts for 18% of total installed capacity, and there are significant projects under development. The development and trajectory of the country's power sector to 2040 is guided by the 'Philippine Energy Plan' which was published in 2017. The plan outlines that the country's installed capacity will need to increase by some 40 GW to more than 60 GW to meet increasing demand. Hydropower is expected to make up the lion's share of this growth in renewables.

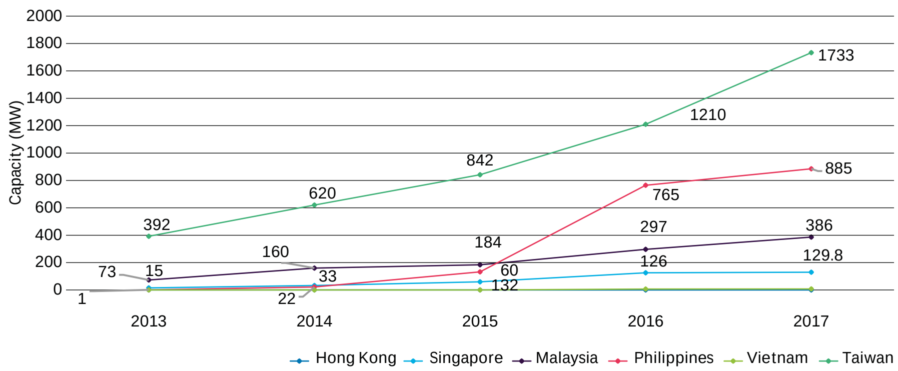
Evolution of Renewable Energy: solar power

Feed-in Tariff schemes have been instrumental in solar photovoltaic (PV) growth

Hong Kong

- Solar energy accounts for a minuscule proportion of the electricity supply in Hong Kong.
- In 2017, the Hong Kong Government implemented two pilot floating PV systems at Shek Pik Reservoir and Plover Cove Reservoir.
- The two pilot systems, each of 100 kW capacity, have been in operation since February 2017 and October 2017 respectively, and can generate some 120,000 kWh of electricity per annum.

Figure 2.5. Solar Power Capacity Evolution, 2013-2017 (MW)



Source: BP Statistical Review of World Energy, 2018

Singapore

- Grid-connected installed capacity of solar PV systems sharply increased from 59.7 MW in 2015 to 129.8 MW by the end of Q1 2017.
- As a densely populated city state with limited space for solar deployment, Singapore is placing emphasis on building up urban solar capabilities which include floating solar as a key focus.
- Singapore is also positioned as a living lab for companies to test and commercialize innovative urban solutions
- In April 2018, REC, the leading European brand for solar PV panels launched one of Singapore's largest rooftop solar installations feeding around 2.6 million kWh annually into Singapore's electricity grid.

Malaysia

- Malaysia, a key exporter of PV cells and modules, is well positioned to benefit from the spillover effects of growing solar power usage.
- The Net Metering Scheme (NEM) introduced in 2017 is seen as a smart move to fuel the Malaysian solar market's ambitious aspirations.
- The country wants to roughly quadruple the current solar PV capacity by 2020, which it hopes is enough to make it the second largest producer in the world.
- With the NEM in place, consumers can generate their own electricity with one meter installed and sell excess power to the national utilities.

Philippines

- Investors are flocking to the Philippines, which until a few years ago had no solar industry until the country launched its Feed-in Tariff (FiT) program.
- Installed solar capacity climbed from 184 MW to around 900 MW in 2017 making the Philippines one of the top markets in the world in additions.
- Emboldened by the positive turnout of the first FiT program, the Government raised the target to 500 MW and created the second FiT program.

Vietnam

- Vietnam is experiencing growing pains when it comes to finding the right approach to spurring solar PV to hit their ambitious long-term targets and ensuring cheaper and wider access to electricity for all.
- The Ministry of Industry and Trade (MoIT) of Vietnam finalized the national solar power development plan on 15 July 2018 and reported to the Prime Minister, the new solar power projects added to the amended National Master Power Plan VII (March 2016).
- So far, the MoIT has approved more than 70 solar projects exceeding 3,000 MW, which will be commissioned before June 2019.

Taiwan

- In October 2017, Taiwan government announced a subsidy of 40% for rooftop solar panel costs with a goal to achieve 3 gigawatts of solar power capacity in Taiwan by 2020 and to encourage this, Premier Lai Ching-te announced "The citizens' green rooftop participation and action plan," for consumers to generate electricity on their roofs with the government.

Strong growth observed in solar PV installations across most countries

One potential enabler of more rapid solar PV uptake is the close links many economies in Southeast Asia have with China, by far the world's largest (and lowest cost) producer of photovoltaic cells, as well as to the Malaysian market, the world's third-largest producer. Existing free trade agreements allow tariff-free access for Chinese manufacturers. Moreover, Vietnam's recently revised National Power Development Plan aims for 850 MW of capacity in 2020, rising to 12 GW by 2030. In mid-2017, Vietnam introduced the FiT scheme for utility-scale projects. The country has seen a recent surge in activity, and in 2017, EVN, the state-owned utility, announced plans for 350 MW of solar PV capacity due to come online in 2021.

Evolution of Renewable Energy: wind power

Wind energy resources vary across the region, with the greatest potential thought to be in the Philippines, which has estimated technical potential of around 70 GW

Hong Kong

- Hong Kong has a number of small wind projects, which together produce less than 1 MW, the largest of which is an 800 kW wind turbine on Lamma Island operated by HK Electric Company.

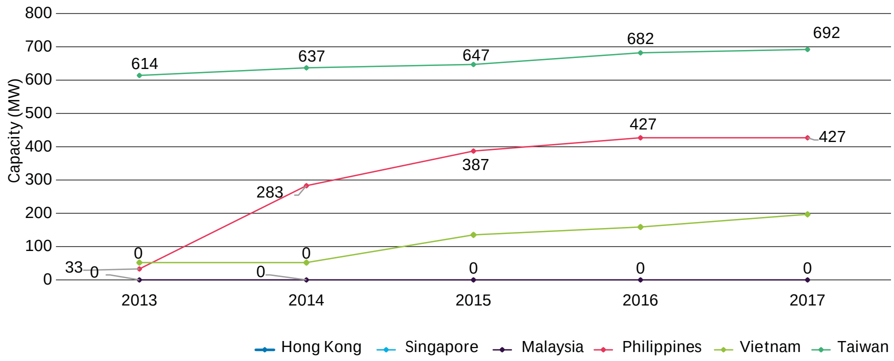
Singapore

- In October 2017, Singapore installed its first long-span wind turbine at Semakau Landfill, producing enough energy to power 45 four-room HDB units a year.

Malaysia

- The Malaysian government is looking to harness wind energy in regions such as Kudat and Kota Marudu, where studies have determined a potential of 300 MW wind energy generation.

Figure 2.6. Wind Power Capacity Evolution, 2013-2017 (MW)



Source: BP Statistical Review of World Energy, 2018

Philippines

- Wind power is slowly taking off in the Philippines; with wind energy comprising only a fraction (1.87%) of the country's installed capacity of 22 GW in 2016.

Vietnam

- Vietnam's wind market is still in the early stages with a total capacity of only 197 MW.
- Following the construction of a wind power plant in South-central Vietnam, four similar projects are set to break ground in the country's Central region and Central Highlands.
- In June 2018, The Global Wind Energy Council (GWEC) opened its first-ever wind power conference in Vietnam, gathering leading national and international industry players to discuss the development of the sector with government.

Taiwan

- In April 2018, Taiwan announced the results of its first major offshore wind farm auction with Germany's WPD awarded 1 GW of capacity and Ørsted 900 MW.
- The nation aims to add 3.8 GW of capacity to its existing network of just 8 MW.

Wind power comprises just 1.87% of total installed capacity in the Philippines; Vietnam's wind market is also in the early stages of development with total capacity of 197 MW

A key factor in the upswing in wind power activity in the Philippines has been the introduction of the FiTs in 2013, which ensured priority grid connection and power purchases. Vietnam's wind resources, particularly along its 3,000 km of coastline, are also notable. Technical potential is estimated at around 27 GW, only a small fraction of which has been developed so far.

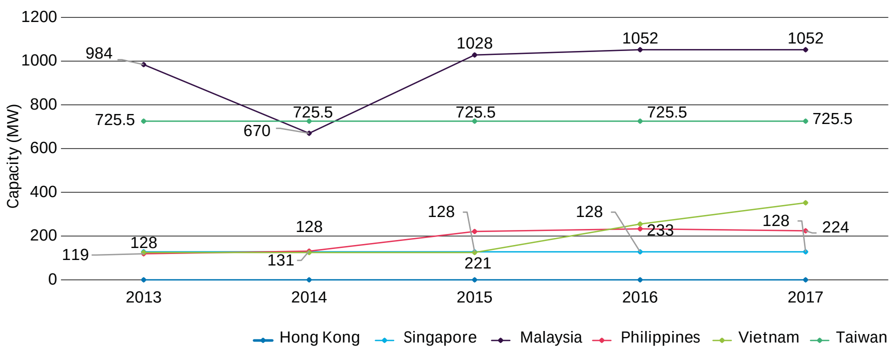
Evolution of Renewable Energy: biogas

Hong Kong is constructing its first integrated waste management facility that will treat 3000 tonnes of waste in a day, after completion of its construction by 2024.

Hong Kong

- In December 2017, Keppel Seghers Hong Kong and Zhen Hau Engineering won a contract for a large scale integrated waste management project, to include a desalination plant, in Hong Kong.
  - The project is Hong Kong's first integrated waste management facility for municipal solid waste and will treat 3,000 tonnes a day of mixed municipal solid waste, and the waste-to-energy plant will produce energy for the grid.

Figure 2.7. Biomass Capacity Evolution, 2013-2017 (MW)



Source: BP Statistical Review of World Energy, 2018

Singapore

- On 17 July 2017, JFE Engineering Corporation hosted a Site Inauguration Ceremony to mark the commencement of site activities for the upcoming US$30 million Waste to Energy (WtE) Research Facility in Tuas, Singapore.
- The facility will employ JFE's High-Temperature Slagging Gasification technology and is expected to be completed by December 2018.

Malaysia

- Malaysia is expected to attract US$0.73 billion in investment for biomass projects between 2017 and 2018.
- In H1 2016, MIDA approved 12 biomass projects worth US$35 million.

Philippines

- The Philippines is pushing ahead with its biomass production and has a total of 18 biomass plants (as on April 2016).
- Biomass energy has a crucial role in the Philippine energy mix, supplying energy up to 30% of the 80 million people in the country.
  - Biomass is usually used for household cooking by the rural poor.

Bioenergy use is undergoing fundamental changes

Industrial agriculture, particularly of sugar and palm oil, are conducive to producing power from biomass. While this is useful as an auto-generation scheme for businesses, it also helps to utilise palm oil mill effluent, which would otherwise produce a large amount of methane gas. In the sustainable development scenario, bioenergy use undergoes two fundamental changes. In the residential sector, its consumption falls by more than 90%, as use of solid biomass is eliminated in all but the most marginal communities. In the transport sector, its use increases more than four-fold, as biofuels are increasingly used.

Key Developments: renewables policies (2017) and impact on Infrastructure

Regulatory frameworks include a wide range of support instruments (e.g. market support, investment support, R&D support, awareness campaigns) to support RE policy implementation.

Hong Kong

- Only about 1% of Hong Kong's electricity is generated from renewable sources.
- To support the deployment of renewables in government and community buildings, the Hong Kong authorities aim to increase funding from US$25 million to US$0.13 billion.
  - The government expects yearly electricity generation from renewables to hit 6 million/kWh, according to PV magazine.

Singapore

- Singapore has announced a plan to install photovoltaic panels wherever it can, including at SEA.

Malaysia

- According to Energy, Green Technology, Science, Climate Change and Environment Minister Yeo Bee Yin, Malaysian government wants to grow the renewable energy industry by opening up the market to foster competition in 2018.
- The government plans to revamp the current feed-in-tariff (FiT) system, where private, small-scale renewable power generators can sell the electricity they produce to the grid.

Philippines

- In March 2018, in a presentation to energy industry stakeholders, the Department of Finance said it was considering removing the zero-rated, value-added tax currently in place for the renewables industry.
- Developers have raised concerns to the government highlighting necessity of fiscal incentives package enabling the renewables industry to provide clean, sustainable and lower-cost electricity to end-consumers.

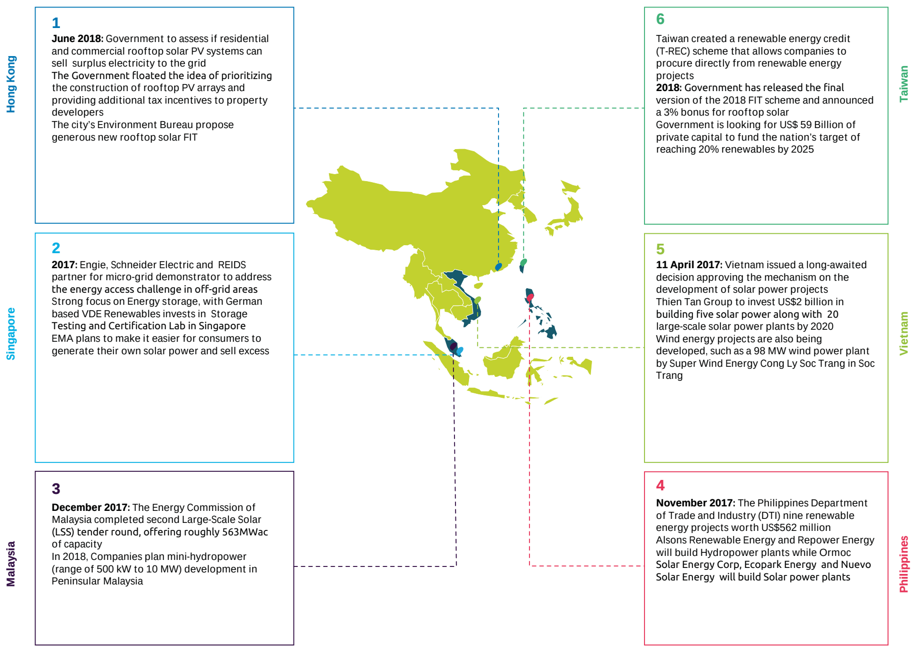
Vietnam

- After introducing FiTs for wind, solid waste, small hydro and biomass, Vietnam established a FiT for solar PV in 2017.

Taiwan

- Taiwan amended Renewable Energy Development Act in January 2017, to create and support new markets for renewable power.
  - The new law opened the country's renewable energy sector to private renewable energy participation, and made it possible for nonutility buyers to procure T-RECs (Taiwan-Renewable Energy Certificate) directly from projects or via newly enabled renewable energy retailers.

Figure 2.8. Key Developments in Renewable Policy and Impact on Infrastructure



Source: WEO 2018 - Capgemini Analysis

To achieve the set targets, countries in the region have made concerted efforts to develop policy frameworks and robust institutions, and have taken steps toward the liberalisation of their energy markets to encourage competition in the sector

The majority of countries have some form of renewable energy national policy (law) or official strategy, most often for specific renewable energy power sources. Countries with well-defined institutions and energy regulatory structures have created dynamic and competitive energy markets and attracted renewable energy investment from the private sector. Some countries have introduced additional incentives for the use of locally manufactured products. This was the case with the Malaysian FiT that provided an additional US cent 1/kWh (MYR 0.05/kWh) for the use of locally manufactured or assembled solar PV modules and inverters (SEDA, 2017).

3-Infrastructures & Adequacy of Supply

Driving factors for an integrated electricity market in SEA are growing regional electricity demand, diverse distribution of supply sources, and different national socio-economic circumstances.

- One of the main priorities for SEA is to develop coordinated planning of generation and transmission infrastructures. Lack of such mechanisms can severely undermine the benefits of market integration. Other important steps for market integration are harmonization of technical and market standards, and a higher degree of empowerment in the regulatory area.

Progress on integration of the electricity sector has been relatively slow due to major obstacles.

- The member countries vary greatly in their size, landscape, levels of economic development, and national energy resources. They also vary considerably in power sector regulations, market structure, and technical characteristics. All of these create barriers for effective regional energy cooperation.

Electricity accounts for the largest share of the increase in final consumption, as rising incomes in the region translate into higher ownership of appliances and increasing demand for cooling from 2017 to 2040, according to Southeast Asia Outlook 2017 report.

- According to the same report, Two-thirds of the increase in Southeast Asia's electricity demand is expected to come from the residential and services sectors.
- Industrial electricity demand is expected to more than double, pushed higher by the lighter industrial branches that are a mainstay of the region's economic activity.

Gas trading in the region lacks transparent hub trading.

- Southeast Asia is well endowed with natural gas resources. Pipeline and LNG facilities exist, however, market and trading do not come close to the levels commensurate with Southeast Asia's needs.
- The geographic diversity and relatively high dependence on LNG for its gas supply, where oil linked pricing and rigid destinations clauses persist, (at least for the medium term), along with low transparency, have made flexible trading and more accurate price discovery difficult.

Energy connectivity, particularly the interconnection of grids and gas pipelines across borders, offers multiple benefits, including expanding access to energy, boosting trade and providing market access to low-carbon energy.

A regional cooperation framework for disseminating new technologies will also hasten the development of non-conventional gas resources, such as coal bed methane and shale gas. The trading of gas by means of cross-border pipelines can generate exports for supplier countries while diversifying the energy mix, improving local air quality and supporting decarbonization efforts in destination countries.

Energy systems interconnection to bolster energy security

Achieving national energy security remains the main driver for energy transition, in order to protect economies from price fluctuations and market instability and reduce dependence on imported energy

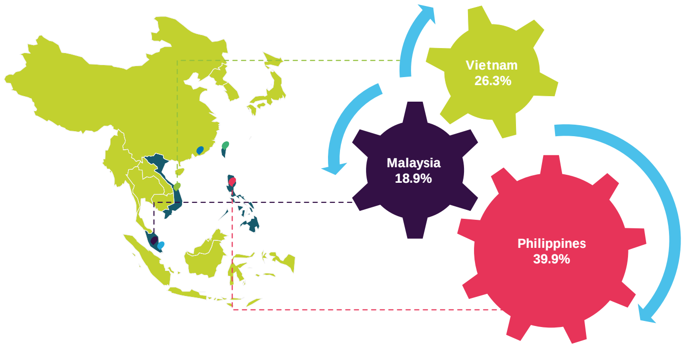
- Governments are increasingly concerned about the ability of existing markets and regulatory frameworks to continue providing a reliable, affordable, and efficient supply of electricity.
- In countries transitioning to less carbon-intensive sources of electricity, system operators are facing multiple challenges, as renewables generally require a higher degree of flexibility from the network to compensate for their intermittency.
- The penetration of renewables requires not just large-scale grid expansion, but also additional integration measures such as storage and demand-management options.
- Rising electricity demand, coupled with the lack of sufficient financial resources to ensure adequate power infrastructure, can provoke unplanned electricity outages that disrupt operations and create losses for manufacturing industries.
  - In Philippines, the percentage of firms experiencing outage is nearly 40%, while 26% of firms in Vietnam are facing electrical outages.
- A reliable and affordable electricity supply is a key element to attract direct foreign investment and manufacturing industries to the region.
- Attracting investment will be contingent on the incentives available to investors, which may be dampened by the presence of electricity price controls or fossil-fuel consumption subsidies, or terms that are unfavorable.

- The interconnection of energy networks and markets across Southeast Asia provides a key route towards a more resilient and secure energy system.
  - Harmonising disparate regimes and intensifying efforts to increase energy interconnections could lead to more efficient and secure use of energy across the region.

Transmission and distribution (T&D) losses

Transmission and distribution (T&D) networks have also been expanding rapidly in Southeast Asia, increasing by around 70% since 2000 to around 3.6 million kilometers (km). This rate of expansion is twice the world average. Many parts of the network need to be modernized to reduce T&D losses. Losses vary by country, from 6% in Malaysia to 9% in Philippines and Vietnam.

Figure 3.1. Firms experiencing electrical outages (% of firms)in selected Southeast Asian countries



Electrical outages and network losses can hinder industrial productivity and development

Source: World Bank (2017)

Electricity Consumption Trends: the future looks electric

Electricity accounts for the largest share of the increase in final consumption, as rising incomes in the region translate into higher ownership of appliances and increasing demand for cooling from 2017 to 2040, according to Southeast Asia Outlook 2017 report.

- Two-thirds of the increase in Southeast Asia's electricity demand is expected to come from the residential and services sectors.
- Industrial electricity demand is expected to more than double, pushed higher by the lighter industrial branches that are a mainstay of the region's economic activity.

Hong Kong

- The total local consumption of electricity in 2017 decreased slightly by 0.6% when compared with 2016.
  - As in the past, the largest category was commercial users, taking up 66.2% of the total local consumption while domestic users came second, consuming 26.7% of the total electricity.

Singapore

- Industries accounted for 43% of total electricity consumption in 2017, followed by commerce and services (36%), household (14%) and transport (6%).

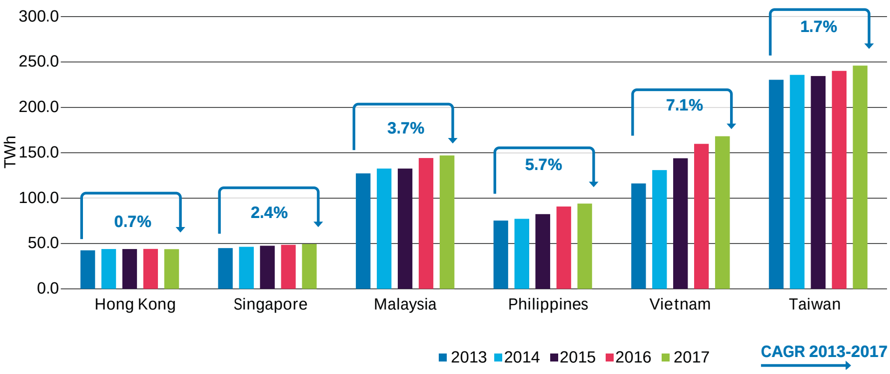
Malaysia

- Malaysia's total electricity consumption rose by 2% from 144 -TWh in 2016 to 147-TWh in 2017.

Philippines

- According to DOE (Department of Energy), electricity consumption in the Philippines increased to 94,370 gigawatt hours (GWh) in 2017.
- The energy undersecretary, Felix William Fuentebella, saw no significant cause for the overall increase.

Figure 3.2. Electricity Consumption, 2013-2017 (TWh)



Source: BP Statistical Review of World Energy, 2018

According to a 2018 whitepaper by Eco-Business Research and Kigali Cooling Efficiency Program (K-CEP) Air-conditioning will consume 40% of electricity in SE Asia in 2040

Air-conditioning systems are to consume 40% of the electricity in Southeast Asia in 2040 at the present rate of consumption. Driven by higher average temperatures and a rising middle class, it is estimated that 700 million new air-conditioning units will be installed by 2030 and another 1.6 billion by 2050. Energy efficient products and lighting can reduce the consumption of electricity by 100 TWh, which is equivalent to the annual production of 50 power plants of 500 MW capacity. The efficient use of air-conditioning in cities can only happen through the use of centralized systems providing services to entire districts, such as in Marina Bay, Singapore, which is serviced by centralized air-conditioning facilities located at a depth of 20 meters (65 feet) underground, resulting in annual savings of 79 million KW.

Impact of electricity flows on the countries' economies

Though the region has adequate energy resources to meet its large and growing demand, most resources are highly concentrated in a few countries.

- A key element of the success of energy transformation in the SEA region will be how countries capitalize on opportunities for energy connectivity and trade.
- Increased interconnection could allow **Hong Kong** to access potential sources of clean energy and create a more balanced generation portfolio as opposed to current dependency on fossil fuels.
  - In a recent study by conservation group WWF-Hong Kong, 'More than half' of Hongkongers will accept 5% rise in power bills to support renewable energy, further reinforcing the need for clean energy.
- Importing electricity will allow **Singapore** to enhance energy security by diversifying energy mix, both in terms of fuel type as well as supply sources.
  - Greater interconnections with neighbouring countries would also support the establishing of a larger regional market for electricity trading, promoting investments and ultimately enhancing regional electricity supply security.
- In September 2017, **Malaysia** agreed a cross-border power deal with Thailand and Laos, that will enable it to purchase up to 100 MW of hydropower from Laos.
  - The utility companies involved are Electricite du Laos, Electricity Generating Authority of Thailand and Tenaga Nasional.
  - Malaysia has been selling electricity to Indonesia since last year, transmitting 70 MW from Sarawak to western Kalimantan on the Indonesian side of the island of Borneo.
- **Philippines** is still far from joining that integration because of its very archipelagic geographic structure.
- However, energy-resource sharing between the Philippines' major islands will soon be realized after the approval of the US$0.96 billion grid interconnection project of the National Grid Corporation of the Philippines (NGCP).

Figure 3.3. Electricity Trade flow in SEA region

Source: WEMO Southeast Asia 2017

Energy Cooperation: The Only Way to Prevent 'Lights Out' in the Region

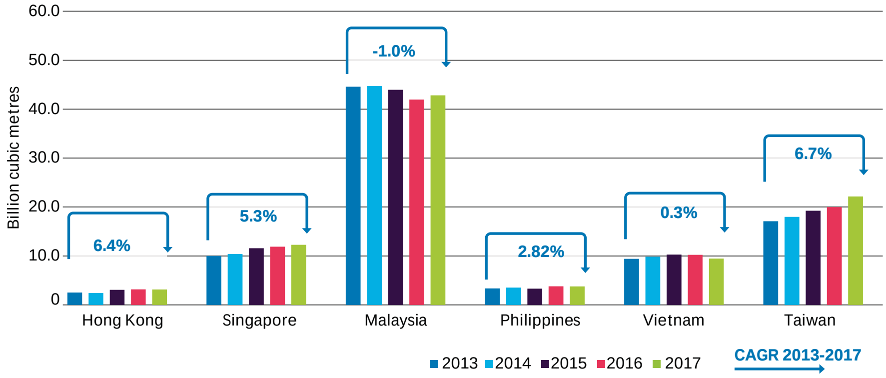
To advance regional economic integration, SEA countries need to work together to make the best use of the potential of renewable energy and establish common efficiency standards. The ASEAN Power Grid and the Trans-ASEAN Gas Pipeline are first steps toward a common and integrated energy market. There is a pressing need to harmonize legal and regulatory frameworks, as well as technical standards for power connectivity and trade has been slow. Also, a new push is needed to share electricity supplies and jointly develop solar, wind, and hydro capacity that can be exported across the region via new interconnections.

Role of Natural Gas in SEA Energy Security: A large increase in gas infrastructure is expected to increase flexibility in Southeast Asian natural gas markets

Southeast Asia, the world's third most populous region, is both a significant LNG exporter and a growing importer.

- Natural gas demand in Southeast Asia is expected to increase at a rate of 2% per year over the period 2016-2040, a marked slowdown from the more than 6% per year over the past 25 years.
  - Gas demand is expected to grow from 170 bcm in 2016 to some 270 bcm in 2040.
- Most of the growth is expected to come from the industrial sector (especially the light industry branches).
  - Gas demand is expected to grow faster than production in the region, and net exports will gradually diminish.
- By the mid-2020s the region will become a net importer of gas. This has important implications for infrastructure development over the next decade.

Figure 3.4. Natural Gas Consumption, 2013-2017 (Billion cubic metres)



Source: BP Statistical Review of World Energy, 2018

- The three regional LNG exporters, Brunei, Indonesia and **Malaysia**, exported 50 Mt of LNG in 2017, accounting for 17% of global LNG exports.
  - The regional LNG importers, Malaysia, Singapore and Thailand, imported 7.8 Mt in 2017, up 22% over 2016.
- Malaysia has two LNG terminals with a combined capacity of 7.1 Mtpa. The country commissioned its second terminal in September 2017 in Pengerang in the southern Malaysian state of Johor. The terminal is expected to be used as an LNG hub and for trans-shipment operations.
- **Singapore** commissioned a land-based terminal at Jurong in 2013 with an initial capacity of 6 Mtpa, currently being expanded to 11 Mtpa.
  - Singapore's strategic location and reputation as a global trading hub for other commodities makes it a frontrunner to become Asia's LNG trading hub.
- There is a growing interest in LNG imports in SEA with more countries planning to start LNG imports for the first time by 2019-2023 **(Philippines, Vietnam)** and most of the existing importers in the region are looking to expand their imports.

Prospects for greater natural gas integration

The role of gas in meeting growing energy demand in Southeast Asia and its increasing role as an important source of flexibility in the power sector was highlighted in Chapter 2. As gas imports rise, better interconnections of pipeline networks, both within and between countries, offers the possibility of much improved supply security.

Southeast Asia could become the fastest growing LNG demand center in the world

- In the **Philippines**, the government intends to replace depleting natural gas reserves by LNG imports.
  - An LNG hub project has been proposed in the Batangas province, south of Manila, initially with an FSRU to be commissioned by 2020, and later with a 5-Mtpa onshore terminal. In addition, there is one private terminal under construction in the south of Luzon Island, the Pagbilao LNG terminal.
- **Vietnam** wants to complement its domestic gas production with LNG imports and intends to start importing LNG at the beginning of the 2020s.
  - The government has plans for two LNG terminals in southern Vietnam and expects both terminals to come online in 2023. The terminals have planned expansions which could bring Vietnam's import capacity to 11 Mtpa.
- The **Taiwanese** Government aims to have 50% of the country's electricity generated by gas-fired plants by 2020, as part of a drive to improve air quality and reduce pollution.
  - Taipower, which owns one-third of the country's existing gas-fired power generating capacity, plans to build 15 new gas-fuelled plants in the years ahead.
  - The company expects to announce a shortlist of preferred bidders for the Taiching LNG supply by the end of Q3 2018 and for the Hsieh-Ho supply by the end of Q1 2019.

Topic Box 3.1: Singapore is being developed as a gas hub

- **According to World Energy Outlook report 2017, Hub-based trading has become a feature of gas markets in North America, the United Kingdom and increasingly in Europe.**
- These hubs provide a focus for physical gas trading, leading to more accurate price discovery through publicly available price reporting, backed by robust governance and regulation.
- These indices allow more advanced trading forms such as swaps, derivatives and futures, enabling risk to be better managed (for example, by allowing producers to lock in certain price levels, thus facilitating production investment, or buyers to purchase gas for a set time period and price).
- Disruptions to supply and demand can be met by rapid adjustments, thus enhancing security of supply and affordability.
- Government price controls and other types of regulatory interventions must be absent, except those facilitating hub trading, notably rules enforcing access to infrastructure, so-called open access.
- **Gas trading in the SEA region lacks this style of transparent hub trading.**
  - The region's geographic diversity and relatively high dependence on LNG for gas supply, where oil-linked pricing and rigid destinations clauses persist, (at least for the medium term) and transparency is low, have made flexible trading and more accurate price discovery difficult.
  - Nonetheless, several centers are being advanced as a basis for hub-based trading in the region, including Singapore.
- Singapore has made important moves towards liberalizing its gas market, providing the basis for more competitive price setting.
- These moves include creating a well-functioning domestic market for gas and greater transparency.
  - A spot market for local use of gas is being created, including secondary markets for gas consumers, and third-party access to facilities such as gas storage is also under development.
  - These moves put Singapore ahead of most countries in the region in terms of progress towards conditions that might enable a hub-style market to develop.

Operating and major planned LNG import terminals in Southeast Asia

Country	Project	Location	Status	Sponsors	Start-up date	Type	Capacity (Mtpa)	Storage (Mtpa)
Malaysia	Melaka	Sungai Udang Port, Melaka	Operating	Petronas	2013	Offshore SRU	3.8	260
	Pengerang LNG	Pengerang, Johor	Operating	Pengerang LNG	2017	Onshore	3.5	400
Philippines	Pagbilao LNG	Pagbilao, Quezon	Under Construction	Energy World Corp.	2018	FSRU	3	130
	Batangas LNG terminal (PNOC LNG hub)	Batangas, Luzon	Planned	Tbd	2020	FSRU (first phase)	5	
Singapore	Jurong	Jurong Island	Operating	SLNG	2013	Onshore	6	540
	Jurong (expansion)	Jurong Island	Under Construction	SLNG	2018	Onshore	5	260
Vietnam	Son My LNG	Son My, Binh Thuan	Potential	PetroVietnam Gas	2023	Onshore	1.8	
	Son My LNG (expansion)	Son My, Binh Thuan	Speculative	PetroVietnam Gas		Onshore	7.2	
	Thi Vai LNG	Thi Vai, Ba Ria-Vung	Potential	PetroVietnam Gas	2023	Onshore	1	180
	Thi Vai LNG (expansion)	Thi Vai, Ba Ria-Vung	Speculative	PetroVietnam Gas		Onshore	1	

Source: New And Emerging LNG Markets: The Demand Shock (IFRI)-June 2018

Topic Box 3.2: Issues and Challenges for Regional Power Cooperation

Concerns	Issues & Challenges	Possible solutions
Licensing of cross-border players	Every country may have different **licensing** regime which may not allow foreign players to participate in cross border power trading/exchange	Non-discriminatory licensing systems that permit cross-border trade can help realize the neighboring or translational (via the third country) electricity power cooperation
Free flow of funds between member states	In the absence of free flow of funds, any cross-border power trade/exchange will not be commercially **feasible**	Utilities have to consult the respective authorities from time to time.
Complexity of entry and labor laws	Complex entry may hamper cross-border trades; the local employment laws may cause inconvenience to foreign experts	Utilities should assist their counterparts where possible, in tackling entry formalities
Information publication and confidentiality of electricity industry	Some state-level electricity power information should be made known to **the public** to facilitate electricity power cooperation. But a few interconnection agreements or bilateral agreements between electricity departments are confidential information and any **disclosure** is forbidden	Common information is to be exchanged via an information center (eg. existing forum and internet). Countries should jointly draft common clauses for non-disclosure of commercial elements
Double Taxation Agreement (DTA) among Southeast Asian nations	Without DTA, electricity power cooperation will be hampered by dual taxation. Although, to date, most countries have signed DTA	All Southeast Asian countries should establish **DTA** and other bilateral agreements between governments
Limitations of corporate tax, customs tariff, electricity power import and export	Currently most countries have no clear regulations or taxation of cross-border trade of electricity power, limitations on electricity import and export etc. and such vague taxation policies increase the business risk of trading	All nations should consider establishing clear policies for **corporate tax and customs tariff of cross-border power trade** to improve trade certainty. The unified import and export limitations of all member states will consolidate the equality of electricity import and export
Expropriation	For all cross-border investment, there is always a risk of expropriation	Agreements entered should contain provision to prohibit expropriation or limit any right to expropriate. If expropriation occurs, compensation should be made in accordance with international laws and standards. Events leading to expropriations should be made known in advance to investors

Source: ASEAN Power Cooperation Report (July 2017)

4-Supply & Final Customer

The surge in electricity demand is being driven by growing income levels, leading to higher ownership of appliances and a growing demand for cooling, adding to the need for a resilient power system.

- Retail competition is being introduced in Singapore and the Philippines.
- Malaysia continues to phase out subsidies, most recently for gasoline and diesel, while working towards doing same for electricity as well.
- Philippines' power rates remain one of the highest in Southeast Asia as of end-2016 due to continued lack of government subsidies, and the country's dependence on expensive imported diesel, oil and coal.
- Vietnam's electricity tariff subsidies and Petroleum Price Stabilization Fund continue to be implicit rather than direct fiscal transfers.

As new players enter a deregulated market, companies are compelled to push for operational and financial efficiency.

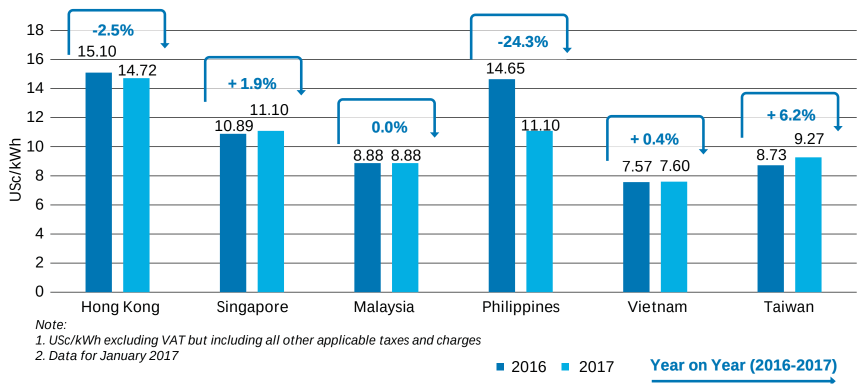
- Hong Kong is driving energy efficiency for its residential and non-residential consumers with low energy consumption.
- Taiwan's current energy policy is developing clean energy and increasing the share of low carbon energy in electricity generation systems is expected to reach 20% for renewables, 30% for coal, and 50% for gas in 2025.

Market Overview - Electricity demand and different levels of regulation/de-regulation create high variances across countries

The surge in electricity demand is being driven by growing income levels, leading to higher ownership of appliances and a growing demand for cooling, adding to the need for a resilient power system.

- Electricity supply market structure comprises a mix of deregulation, tariffs, subsidies, and tariff structures:
  - De-regulated wholesale power markets without fuel subsidies.
  - Single-buyer wholesale market with high fuel subsidies.
- Retail competition is being introduced in **Singapore and the Philippines**.
  - Singapore and the Philippines have the highest power tariffs.
- The context is made of government-influenced monopoly suppliers and fixed tariffs in other countries.
  - Rising energy demand has made fossil-fuel subsidy reform a key issue for many governments, despite the associated political difficulties.
- **Malaysia** continues to phase out subsidies, most recently for gasoline and diesel, while working towards doing so for electricity as well.
  - Domestic consumers in Peninsular Malaysia enjoy the lowest tariff.
  - Prices are now set monthly based on movements in international markets, while residential LPG remains subsidized.
- **Vietnam**'s electricity tariff subsidies and Petroleum Price Stabilization Fund continue to be implicit rather than direct fiscal transfers.

Figure 4.1. Average retail electricity prices



Source: Capgemini Analysis, WEMO 2018

The prevailing scenario

- According to "Power Development Plan 2017 to 2040" by the Department of Energy (DOE), Philippines power rates are among the highest in the region, on a par with the level in Singapore (2017).
- The government of **Malaysia** has approved for the electricity tariff in the current tariff schedule for Peninsular Malaysia to be maintained for the period of 1 January 2018 until 31 December 2020. Malaysia has been using the same electricity tariff since 1 January 2014.
- The electricity tariff in **Hong Kong** remains very competitive compared to those in other major metropolitan cities such as Singapore, London, New York and Sydney.

Price Evolution, Privatization and its impact on end users' buying behavior

As new players enter a deregulated market and companies are compelled to push for operational and financial efficiency, technological improvements in devices like smart meters, home and building energy management systems and efficient power generators are encouraged

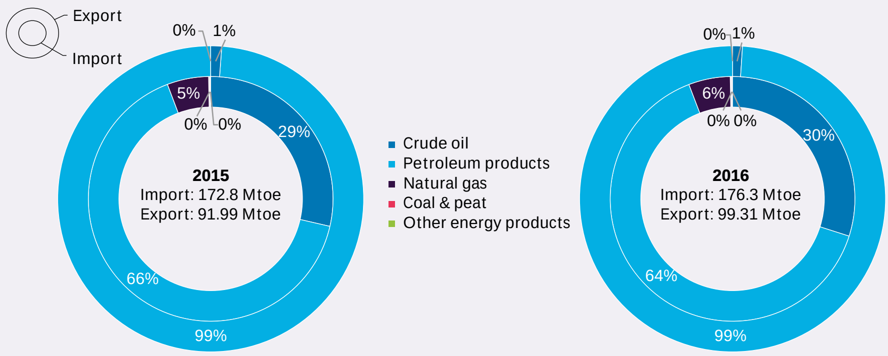
Concerns	Differentiators	Key Initiatives
Hong Kong	Driving energy efficiency for its residential and non-residential consumers with low energy consumption - rising block tariffs structure for domestic tariffs for higher consumption with progressively higher unit rate, along with off-peak and on-peak charges	• Scheme of Control Agreement (SCA) between CLP Power and the Hong Kong SAR Government will launch a number of new initiatives to encourage the community to embrace low-carbon lifestyles by promoting the development of renewable energy (RE) and energy conservation • New initiatives including a Feed-in Tariff (FiT), Renewable Energy Certificates (RECs), the new CLP Eco Building Fund and CLP Community Energy Saving Fund will be introduced
Singapore	Direct wholesale supply or through market service licensee (MSSL) for eligible consumers	• SP Group revised the tariff from 1 July 2018 to 30 September 2018, increasing by an average of 6.9% or 1.50 cents per kWh compared to the previous quarter • For households, the electricity tariff increased from 22.15 to 23.65 cents per kWh
Malaysia	Rebate for consumers with less than RM20 per month electricity bills, including subsidies to help lower income groups	• TNB announced to Bursa Malaysia that companies will have to pay more for their power supply from July 1 to December 2018 following the implementation of a surcharge of 1.35 Sen per kWh due to higher fuel and generation costs • Government has implemented a number of initiatives by the Energy Commission, e.g. incentive based regulation framework (IBR), PPA renegotiation and New Enhancement Dispatch Agreement (NEDA)
Philippines	The Electric Power Industry Reform Act (EPIRA) of 2001 encourages private player competition	• Asia's first solar-plus-storage microgrid to use Tesla's Powerpack energy storage system is designed to end power reliability issues for a Philippines community (Paluan) • In 2016, a total of 781 renewable energy service contracts were awarded with 15,910 MW potential capacity and 4.1 MW installed capacity
Vietnam	Direct subsidies resulting in high regulation, with Electricity Purchase and Trading Corporation (EPTC) reselling the generated electricity	• Vietnam's first Energy Efficiency Network has been officially launched in Ho Chi Minh City, giving a platform for companies to connect and improve energy efficiency
Taiwan	Amendment to Electricity Act allows restructuring of state-owned Taipower and green energy supply, with feed-in-tariffs (2018)	• Electricity sector in Taiwan is regulated by its state-owned electricity power utility company Taiwan Power Company (Taipower) • Taiwan's current energy policy is developing clean energy and increasing the share of low carbon energy in electricity generation systems systems is expected to reach 20% for renewables, 30% for coal, and 50% for gas in 2025

Topic Box 4.1: Case studies Singapore, Philippines & Vietnam

The demand for electricity is projected to expand rapidly in most countries.

- Open Electricity Market in Singapore: As of 1st April 2018, households and businesses in Jurong will have the option to purchase electricity from a retailer. This reduces the reliance on SP group (SP Services) for electricity, where cost is based on a regulated tariff that changes every quarter.
- In Singapore, the 2016 annual electricity tariffs declined by 12.9%, from 21.7 cents per kWh in 2015 to 18.9 cents per kWh in 2016. This was mainly due to lower energy costs, which fell by about three cents from 16.3 cents per kWh in 2015 to 13.3 cents per kWh in 2016, as a result of lower gas prices.
- Since 2001, the Government has progressively opened up the electricity market to competition to promote more competitive pricing as well as give consumers more choice. From July 1 to Sept 30, 2018, electricity tariffs will increase by an average of 1.5 cents per kilowatt hour (kwh) compared with the previous quarter. The increase is mainly due to the higher cost of natural gas for electricity generation.

Figure 4.2. Singapore: Import & Export of energy products (2015-2016)



Source: Singapore Energy Statistics, 2017

- Singapore's imports of energy products grew by 2.0% from 172.8 Mtoe in 2015 to 176.3 Mtoe in 2016. The exports of energy products registered an 8.0% increase, growing from 92.0 Mtoe in 2015 to 99.3 Mtoe in 2016. The bulk of energy imports and exports were petroleum products.
- Imports of NG increased by 2.4% from 9.5 Mtoe in 2015 to 9.7 Mtoe in 2016, with Liquefied Natural Gas (LNG) accounting for 23.4% of these imports.
- End-users' consumption of NG declined 2.6% from 59,096.1 TJ in 2015 to 54,639.3 TJ in 2016, due to weaker demand from industry. In 2016, industry-related consumption of NG was 47,133.7 TJ, 4.2% lower than the previous year.

Power prices in the Philippines remained among the highest in Southeast Asia at Q4 2016 due to continued lack of government subsidies and the country's dependence on expensive imported diesel, oil and coal.

The main reason for high prices is inadequate government subsidies. In addition, taxes, fees and other charges are also levied on the power industry sectors at generation, transmission and distribution levels.

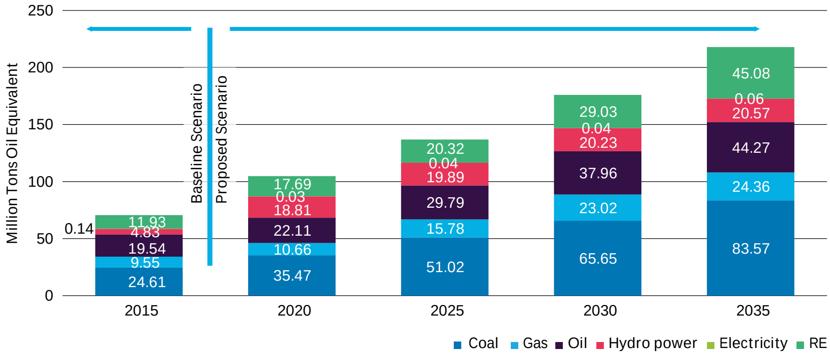
- In Philippines, the cost of electricity generated from solar and wind has plunged in recent years, and prices are likely to fall by 50% by 2020 compared to 2017.
- The Philippines government privatized the country's power industry in 2001, saying the move would help bring more affordable and reliable electricity.
- Consumers have faced higher electricity bills since June 2018, after the energy regulator approved a hike in the feed-in-tariff allowance (FiT-All) rate, which is meant to cover payments to renewable energy (RE) developers.
  - The Energy Regulatory Commission (ERC) approved a new FiT-All rate of 25.63 centavos per kilowatt hour (kWh), higher than the current 18.30 centavos per kWh.

Vietnam's electricity market is dominated by Vietnam Electricity (EVN). The latter (via its subsidiaries) acts a single buyer of all electricity generated from on-grid independent power projects.

Private companies, including foreign-invested ones, are only independent power producers that sell their generated power to EVN's wholesaling subsidiaries.

To create a more competitive electricity market, the government aims to divide EVN-owned power plants and generation companies to become independent generators, wholesalers and retailers (except for power plants of economic, security or defense importance).

Figure 4.3. Vietnam: Primary Energy Supply (Baseline vs. Proposed Scenario) (million tons oil equivalent)



Source: Vietnam Energy Outlook Report, 2017

Baseline scenario (BAU): Baseline economic growth

Proposed scenario: Adjusting the energy demand based on assessments of economic energy saving in various economic sectors and the target of CO_2 emission reduction of 15% in 2030 compared to the BAU scenario

- In July 2012, only 31 generators directly participated in the market. By the end of 2017, this figure rose to 80. This is the most noticeable evidence of operating efficiency, and proper formation and development of policies in the region's electricity market.

Energy Development Scenario

- In this scenario, there is a reduction of the final energy demand, the decrease of 5% of CO_2 emissions in 2020 and then 15% in 2030 compared to the BAU scenario. Total cumulative CO_2 emissions in the period 2016-2035 will decrease by 956 million tons.
- Among primary energy types, coal and oil consumption falls by 204.7 MTOE and 51.6 MTOE respectively while RE and natural gas use increases by 17.1 MTOE and 13.5 MTOE respectively.
- Regarding the primary energy mix per fuel type, coal still covers the major part but tends to be stable in the following years of the planning period at the proportion of 37.3% in 2025 and 38.4% in 2035.
- With the proposed scenario, the share of RE in the total primary energy supply could reach 28% in 2030, and then increase to 30.1% in 2035.

Topic Box 4.2: Singapore to launch Full Electricity Retail Contestability for competitive pricing in 2018

To effectuate competitive pricing and innovative offers from retailers and to benefit consumers, the Energy Market Authority (EMA) in Singapore exposed the retail electricity market to competition (since 2001).

- Until April 2018, only business consumers with an average monthly consumption of at least 2,000 kWh were eligible to choose their electricity provider.
- In April 2018, Singapore carried out a soft launch of its Open Electricity Market in Jurong district, allowing households and small businesses to choose their electricity provider, and opening up a vibrant market with competitive tariffs for residential electricity. A total of 108,000 residential accounts and 9,500 business accounts were able to exercise this choice of electricity provider.
- The Open Electricity Market will be extended to the rest of Singapore from Q4 2018, allowing the remaining 1.3 million accounts (mainly households) to choose their electricity provider and tariff plan.
- Some salient features of the Singapore Open Electricity Market are:
  - Customized solutions to help customers easily switch electricity providers.
  - An option for single consolidated bills for all utilities.
  - Seamless customer switching (next working day for AMI[1] metered customers).
  - Allow customers to adopt greener, sustainable energy practices.
  - Greater customer convenience with more efficient and reliable operations.
  - More pricing options for customers to enjoy greater savings.

1 Advanced Metering Infrastructure (AMI) meters, also known as smart meters, remove the need for manual reading and estimates of consumption.

5-New Business Models & Services

The market for digitalization in the energy sector is set to grow to US$64 billion by 2025, according to BNEF.

- With energy innovation increasingly centering on digital technologies and strategic uses of data, the sector is set for a paradigm shift from its current focus on hardware to the growing importance of software.
- Digital technologies like **big data, analytics and machine learning, blockchain, distributed energy resource (DER) management and cloud computing** can help overcome some of the energy sector's key challenges.

Operations costs that comprise the major portion of buildings' life cycles can be brought under control by adopting smart solutions such as building automation systems (BAS), integrated facility management (IFM), and efficient LED lighting systems.

- On average, commercial buildings use about 29% of their energy for lighting, 40% for HVAC purposes, and 31% for other uses such as equipment and cooking.

Blockchain technology is paving the way towards conceptual models for faster adoption of renewable energy.

- Blockchain is used in distributed energy, mainly rooftop solar, where peer-to-peer energy markets are forming and enabling consumers to purchase energy, such as solar or wind, from a supplier.
- Blockchain can help with **billing and payments** for charging electric vehicles.
- It is particularly beneficial to carbon registries, because some of the limitations around them dealing with foreign markets are often difficult to verify.

Spending on technologies to enable smart cities programmes in Asia-Pacific (APAC) is set to reach US$28.3 billion in 2018, according to IDC.

- Intelligent traffic transit and fixed visual surveillance systems are already seeing a big push from governments in order to streamline traffic and make communities more secure.
- Together, these two use cases represent more than 36% of overall spending throughout the forecast period (2018).

Innovation at the edge of the grid has outpaced internal innovation in the utility sector, creating disruption, while opening up opportunities for digital sector transformation.

From a technology standpoint, digital grid transformation is fueled by the confluence and advancement of several classes of technology:

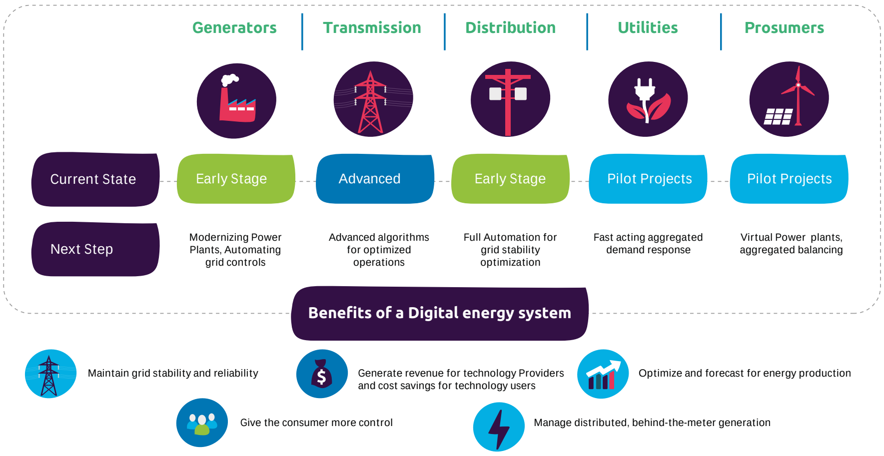
- IT — Big data, blockchain, API economy and meter data management.
- Operational technology (OT) — Phasor measurement units and intelligent electronic devices.
- Emerging energy technologies — Energy storage and combined heat and power.
- Consumer technologies — Consumer energy management systems and electric vehicles.

Digitalization: a new era in energy?

Digital technologies are set to take energy systems by storm – making them even more interconnected, intelligent, efficient and sustainable. Advances in areas like data analytics, artificial intelligence and blockchain technology are starting to make their mark in the energy sector.

- A digitalized energy system will help countries address many challenges related to power generation:
  - Countries like **Taiwan and the Philippines** often face power outage issues and skyrocketing utility bills due to inefficient power systems.
- New technologies like machine learning, blockchain and cloud computing can be used to design a power system to better enhance demand response.
- A digital energy system will also help with balancing system reserves and tapping into power from self-generators such as owners of rooftop solar systems.
- A fully digital energy system can also help in forecasting and optimizing energy production.
  - For example, by forecasting wind and solar output, hybrid systems can be better managed in terms of balancing the use of fossil fuel assets to ensure a smooth and uninterrupted supply of electricity
  - This will also help with the integration of renewable energy into current power generation systems.
- Using blockchain technology, a peer-to-peer energy market can be created where electricity can be bought and sold at cheaper rates.
  - Even owners of home energy production systems like rooftop solar and home wind turbines can participate in such a market by selling back the excess electricity generated into the local grid.
- As Southeast Asia marches towards a digital future, there will be added pressure on utilities providers to modernize their systems.
  - These necessary changes will not only benefit utility companies but also consumers, who will enjoy savings in the long run.

Figure 5.1. Current State Of Digitalization Of The Energy Value Chain



Source: Bloomberg New Energy Finance, 2017

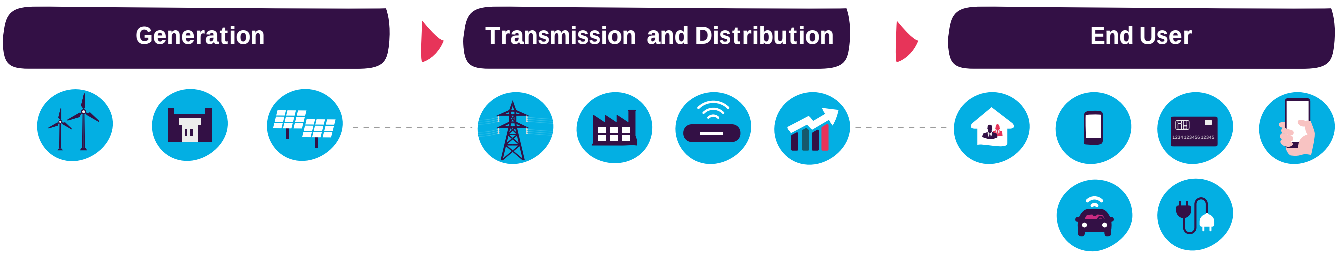
Global revenues from digitalization of energy are set to rise

According to Bloomberg New Energy Finance, the estimated global annual revenue from the digitalization of energy could be worth US$54 billion. In the future, that could increase by almost 19% to US$64 billion by 2025. Already, sales growth in the home energy management market reached US$22 billion in 2017 and is predicted to rise up to US$36 billion in 2025.

Blockchain's potential in solving Southeast Asia's Energy Challenges

Achieving national energy security remains the main driver for energy transition, in order to protect economies from price fluctuations and market instability and reduce dependence on imported energy

Figure 5.2. Blockchain can coordinate traditionally centralized data flows throughout the power system



Generation

Secure power generation and **supply data transcribed to blockchains** allow for visibility, security and accuracy

Renewable energy credits based on actual production are semi-autonomously awarded and traded

Transmission and Distribution

Wholesale power is traded via smart contracts that minimize the need for brokers and indexing agencies

Blockchain-enabled sensors and controls allow for secure, centralized data and improved grid resilience

End User

Real time customer-utility interactions facilitate faster payment cycles, more efficient energy use and streamlined account management

Peer-to-peer microgrids run autonomously, with **blockchains managing contracts for energy flows and instant payments**

Electric vehicles seamlessly connect with infrastructure executing transactions through 'smart wallets'

Smart home appliances coordinate electricity purchase and use with the grid, promoting grid efficiency and extending appliances' useful life

Source: Mckinsey Company website, 2018

- Energy experts in Southeast Asia have started to view the technology as an answer to the region's escalating energy challenges.
- One of the most popular uses of blockchain in the energy sector is in powering a peer-to-peer energy market.
  - It is also used in managing localized demand response in a more cost effective manner.
- Also, blockchain enables the sale of electricity through location-based pricing, which could result in driving down customer electricity costs as they can purchase directly from the supplier and avoid heavy grid costs.
- In **Hong Kong**, New Energy Exchange Limited announced the formation of a strategic partnership with Elastos Foundation to jointly develop a clean energy blockchain project.
- In 2018, **Singapore Power** launched its blockchain marketplace platform that is promoting the transaction of renewable energy certificates (REC) or tradable certificates of energy generated by renewable sources
  - The unique attributes of blockchain provide much higher levels of cybersecurity, increasing the transparency and integrity of the transaction.
- **Energo Labs**, a cleantech start-up that integrates blockchain into the energy sector in Asia and beyond, is set to strengthen its presence in **Singapore**:
  - The Energo regional hub in Singapore will host events that promote discussion about smart cities and smart energy trading using blockchain technology.
  - Energo is also in talks with local authorities and partners on launching peer-to-peer and electric vehicle smart charging pilot projects.

Blockchain could be the missing link in the renewable energy revolution

In the transition to a new energy world - decentralised, digitised and decarbonised - several use case applications have already been developed using blockchain technology, such as automated bill payments, electric vehicles charging and sharing, and renewable cryptocurrencies. In the future, blockchain technology could allow millions of energy devices such as water heaters, electric vehicles, batteries and solar PV installations to transact with each other at the electricity power distribution edge. The United Nations Framework Convention on Climate Change (UNFCCC) recently recognised the potential of blockchain to boost climate action.

Blockchain technology can help SEA to leapfrog in the development of its energy sectors

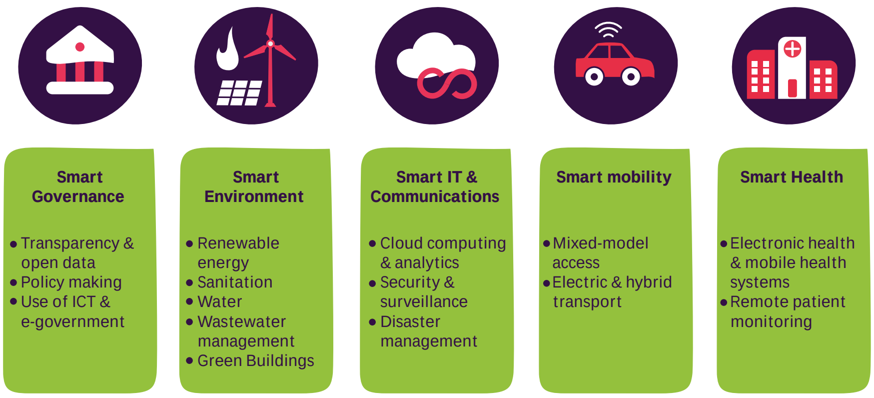
- At the end of 2017, **Malyasian Prime Minister Najib Razak** announced the formation of a national regulatory sandbox, which allows innovative technologies to be tested in a live environment without regulatory constraints.
  - SEDA (Sustainable Energy Development Authority Malaysia) has submitted an application to test a peer-to-peer energy platform.
  - This will allow solar producers to sell their excess electricity to consumers at an even lower rate than what the distribution system operator is willing to buy.
- The **Philippine government** believes that some 17% of the country has limited or no access to electricity and some believe that blockchain can provide a solution.
  - Energo Labs is combining blockchain technology with microgrids to decentralize energy production and consumption, which can help rural electrification as well as grid resilience.
  - Energo Labs uses microgrids with a storage system so that energy producers, such as those with solar panels, can sell energy to their neighbors.
  - Blockchain technology is used to eliminate the need for a third party to carry out energy transactions while ensuring all data is still secure and transparent.
- In January 2018, Bamboo Capital JSC **(Vietnam based)** signed a memorandum of understanding with New Era Energy Ltd. to pilot carbon credit protocol on the blockchain:
  - New Era is a blockchain-enabled certification platform for measuring the clean energy footprint that aims to take the carbon trading market to the masses.
- **Taiwan** has vowed to become the global blockchain development hub at the 2018 Asia Blockchain Summit held in Taipei.
  - On December 29, 2017, Taiwan's legislature passed the Financial Technology Experimentation and Innovation Act, which is widely known as the Regulatory Sandbox Bill.
  - Taiwan tech startups have launched a variety of innovative blockchain-based solutions, including those for agriculture produce traceability systems, hotel management systems, and green power generation and storage.

Smart cities: key investments will be in intelligent transportation, data-driven public safety, and resilient energy and infrastructure

Spending on technologies to enable smart cities programmes in APAC, is set to reach US$28.3 billion in 2018, according to IDC.

- Intelligent traffic transit and fixed visual surveillance systems are already seeing a big push from governments:
  - These two use cases represent more than 36% of overall spending throughout the forecast period (2018).
- Smart cities can help to overcome the strain on urban resources brought upon by rapid urbanization, an aging population, and a changing energy climate.
- The Smart City Blueprint for **Hong Kong**, released in December 2017 by the Government, proposed measures to promote the development of Hong Kong into a smart city.
  - Recommendations cover six areas: smart mobility, smart living, smart environment, smart people, smart government and smart economy.

Figure 5.3. The Five Pillars of Smart City Development



Source: The Asean Post, 2017

  - Many smart city-related tests will take place in **Kowloon East**, a core business district and area designated for trialing innovations.

- **Singapore** has implemented a Smart Nation initiative for innovation in health and living, mobility and services to meet its priorities for sustainable development.
- Meanwhile, these initiatives have to be implemented in a pragmatic way, such as Singapore's drive for smart mobility solutions, which have attracted Robert Bosch as its technology partner.
  - Robert Bosch wants to implement efficient mobility which is accessible to all users.
  - An example of its efforts includes looking at traffic congestion in Southeast Asia as one problem it could help solve.
- In **Malaysia, Kuala Lumpur** signed an agreement in January with Alibaba's cloud service, City Brain, to work on traffic management, town planning and incident response.
- In **the Philippines**, the New Clark City development is envisioned as an alternative to the congested capital Manila.

Hong Kong's ambition to become a world-class smart city in the next five years

In 2017, Chief Executive Carrie Lam Cheng Yuet-ngor doubled R&D expenditure to US$6 billion for next five years to boost 'smart city' innovation in Hong Kong . These initiatives came amid long-standing criticism that the city lacked resources dedicated to technology and innovation. Lam has also introduced some features of the proposed smart city blueprint, that include creating an "e-ID" for every Hongkonger to facilitate online transactions, and installing multifunctional smart lamp posts to collect real-time data to manage traffic.

Formation of Asean Smart City Network (ASCN) to boost adoption

- To successfully realize the Asean integration ideal, individual country programmes need to be linked, and best practices and successes shared.
- It makes the **Asean Smart City Network (ASCN)** - which includes regional capitals like Kuala Lumpur, Hanoi, Bangkok, Manila, Jakarta and Singapore, but also smaller cities like Johor Baru and Phuket an important development.
- Besides this, The ASCN will also link member cities with private investment and secure funding from multilateral funding institutions.
- Few areas of focus for ASCN will be smart mobility, particularly around electric vehicles and ride and car sharing along with connectivity of payments and trade digitization.
- The ASCN will also help attract investment from regions outside the Asean region; for instance, in March 2018, the Australian government pledged US$21 million) into Asean smart cities.
  - Smart technologies that can make city transportation, urban energy usage, building and waste management systems, and even healthcare more efficient (and therefore cleaner and more sustainable) will help alleviate the challenges that accompany the rapid expansion of towns and cities across Asia.
  - ASCN is an excellent start for governments, regulators, city planners and corporates to be on right side of innovation equation and sharing of best practices.

Topic Box 5.1: Singapore's first e-commerce site for energy, Electrify.sg, makes it easy for businesses to choose clean energy

Southeast Asia's first e-commerce platform for electricity was set up by two former Sunseap executives and officially launched in July 2017

- Based on a consumer's power consumption habits gleaned from the site's search filters, Electrify.sg uses a pricing engine to list a range of packages from third-party energy retailers.
  - Users can then compare prices and offers before deciding on the most suitable option.
  - They can also access alternative energy options such as clean energy and carbon offsets.
- Eligible consumers currently have three options to buy power, through customized plans with energy retailers, at the variable wholesale market price for energy, or return to the default provider SP Services tariff rate if their monthly consumption exceeds **4,000 kilowatt hours.**
- Before Electrify.sg, companies that wanted to buy from energy retailers besides, SP Services had to run extensive online searches and make telephone calls for quotes to assess their options.
  - By contrast, it only takes four steps to search, compare and purchase a new power plan on Electrify.sg.
- Electrify.sg has also launched PowerQuotes, a function to allow large energy companies to launch a tender quickly, and is looking into offering bundled deals with transport and telecommunications providers.
- Founders of Electrify.sg also have long term plans to expand in **Vietnam, Thailand and Philippines,** countries that are opening up their energy markets, as well as big energy markets such as **Australia and the United Kingdom,** in the coming years.

How does Electrify.sg work?

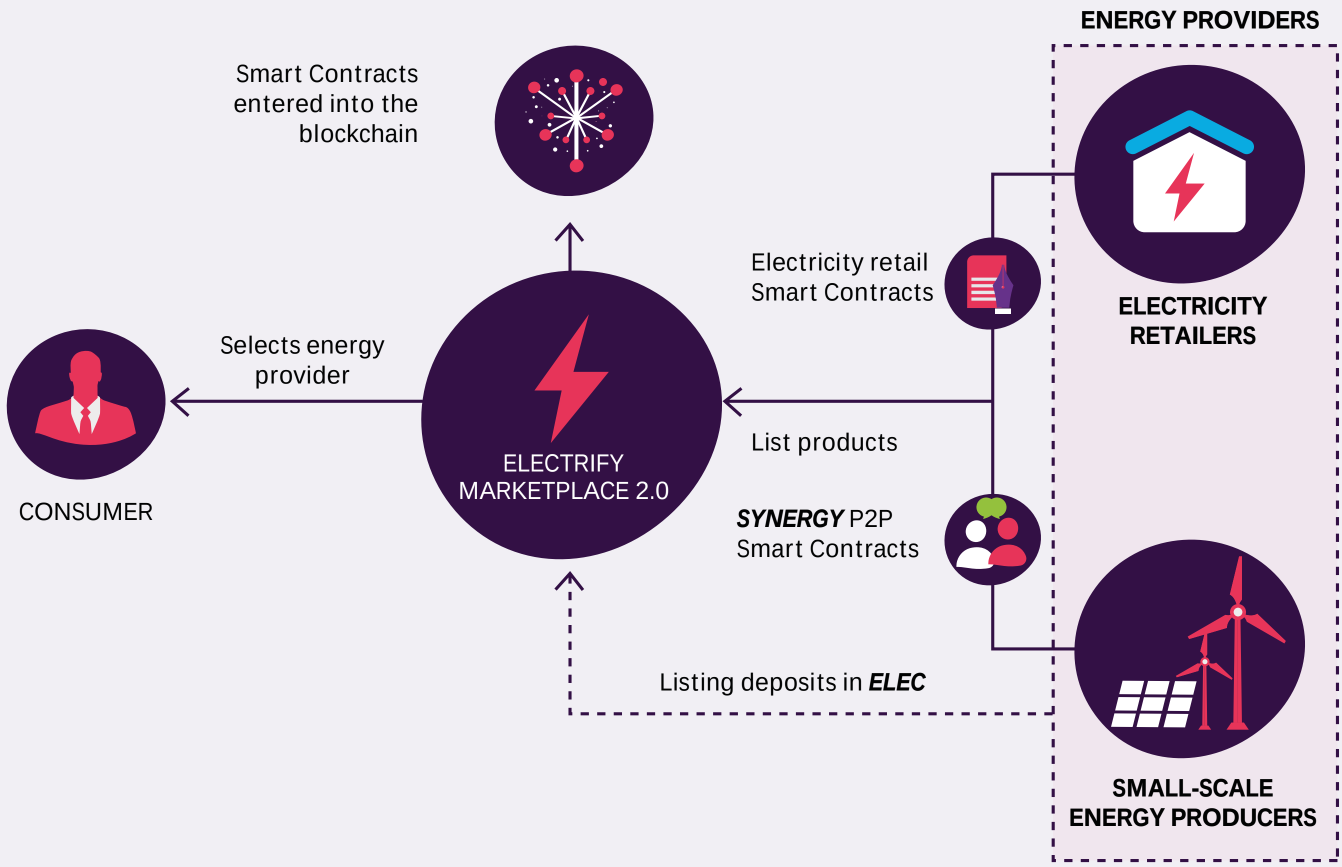
Step 1: TELL US WHO YOU ARE	Step 2: CREATE AN ACCOUNT	Step 3: CHOOSE YOUR PERFECT PLAN	Step 4: SIMPLE PAYMENT AND AGREEMENT
The user enters some basic information, such as who they are currently buying electricity from, their consumption and when their contract ends. Then they click on GET QUOTES NOW.	The user creates a unique ELECTRIFY.SG account or logs in with a Google account. Secure authentication through an SMS OTP provides extra security.	The user chooses their preferred electricity package. The packages have been dynamically generated by Fibonacci, the dynamic pricing engine, based on the user's consumption profile.	After the user has made their choice, they pay online and upload an image of NRIC (National Registration Identity Card) and other documents as required.

Source: www.electrify.sg

According to the year-old company, it has helped Singapore's businesses save upwards of US$554,000 in electricity bills since it began operations. It has transacted US$3.79 million worth of electricity since it began its operation.

In H2 2018, the startup plans to replace its current model with one powered by **Blockchain**. Residential or business consumers can transact with energy retailers via a peer-to-peer network using Electrify's cryptocurrency ELEC, or in fiat money. This will remove the need for middleman fees and reduce transaction cost. The Blockchain model is expected to pare down costs for Electrify and its consumers. The use of "smart contracts" – digital contracts in the Blockchain – removes the cost of legal, accounting, and financial settlements. These can account for as much as 30% of the retail cost of electricity in traditional transactions.

ELECTRIFY's new Marketplace 2.0



Source: www.electrify.sg

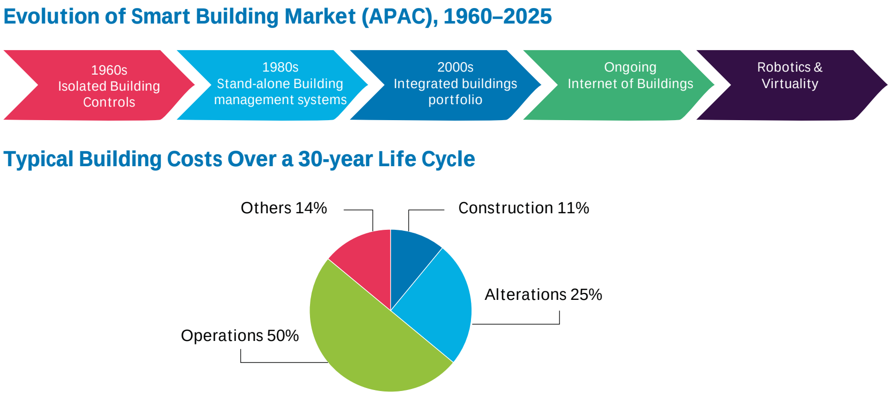
- The ELECTRIFY ecosystem will operate as the consumer-facing, ELECTRIFY Marketplace 2.0, driven by smart -contracts and a peer-to-peer energy trading platform, Synergy.
- Synergy allows consumers to buy power directly from small-scale producers, such as residential rooftop solar and wind turbines.
- Synergy removes the middleman, and reduces energy costs for all consumers.

Smart Buildings: rising electricity tariffs boost growth opportunities for building energy management systems in Southeast Asia

The market for building energy management systems (BEMS) in Southeast Asia is set to grow at a CAGR of 12.2% from 2015 to 2020.

- IT solutions such as big data analytics, cloud computing and the Internet of Things (IoT) are enabling the development of BEMS that offer both comfort and optimised energy performance.
- These systems have large potential for commercial and industrial buildings as they can also support remote monitoring, energy efficiency, and system optimization.
  - **Singapore** is leading in market revenues, as its upgraded service qualification and supporting strategies for energy management provide huge opportunities for development of BEMS.

Figure 5.4. Smart Building Technology Market



Source: Frost & Sullivan, 2017

Obstacles to smart building development

- The slow pace of local government in Hong Kong in implementing regulations and incentives particularly in the retrofitting of existing buildings is the reason for the lag in smart building development.
- Besides regulations, the lack of financial incentives has discouraged building owners from retrofitting existing buildings to attain energy efficiency, as government does not offer incentives for building owners to make existing buildings greener.

IOT push is on Smart Buildings

- In September 2016, **Singapore** used Internet of Things to create 'smart buildings', with 30 buildings becoming connected in a two year project to track energy consumption.
  - The country's Building Construction Authority (BCA) partnered with Microsoft for this project that will monitor cooling systems using machine learning and predict deviations that may result in energy waste, alerting managers via SMS or email to take action in advance.

Data challenges in implementation of smart buildings

- While Asian government agencies have started to certify their buildings with international standards such as the United States' green building certification called Leadership in Energy and Environmental Design (LEED) or Singapore's Green Mark 2015, more data is needed on indicators such as energy efficiency and reduction of materials usage.
- Better data management will allow agencies to create a baseline to start making enhancements effectively.

Cost saving from smart buildings

Operations costs that comprise the major portion of the building life cycle can be brought under control by adopting smart solutions such as building automation systems (BAS), integrated facility management (IFM), and efficient LED lighting systems. On average, commercial buildings use about 29% energy for lighting, 40% for HVAC purposes, and 31% for other uses such as equipment and cooking.

Topic Box 5.2: Innovation at the edge of the grid drives utility sector transformation and requires digitally enabled delivery infrastructure

- According to Gartner (2018), Digital business technology platforms and edge computing are technologies with transformational impact that are expected to mature between 2020-2023, driven primarily by adoption and development outside the utility sector.

  - Similarly, digital twins will take five to 10 years to mature and are also transformational for utilities as an asset-intensive industry.
  - In addition to these technologies that have broad appeal across multiple industry sectors, two vertical technologies — advanced metering infrastructure and energy storage (grid scale) — will have a transformational impact on utilities.
  - They address pressing industry needs for better visibility in customer consumption, as well as increased penetration of intermittent renewable sources.

Artificial General Intelligence

- **Technology:** Artificial general intelligence (AGI) — also known as "strong AI" and "general-purpose machine intelligence" — would handle a very broad range of use cases, if it existed. Current AI technologies do not deliver AGI. Despite appearing to have human-like powers of learning, reasoning and adapting, they lack commonsense, intelligence, and extensive means of self-maintenance and reproduction.
- **Way- forward:** AGI is unlikely to emerge in the next 10 years, although research will continue. When it does finally appear, it will probably be the result of a combination of many special-purpose AI technologies. Its benefits are likely to be enormous. But some of the economic, social and political implications will be disruptive — and probably not all positive. There are currently no vendors of systems that exhibit AGI, but many companies are engaged in basic research. Examples are DeepMind (owned by Google), OpenAI and Vicarious.

Vehicle-to-grid (V2G)

- V2G is a system that enables plug-in hybrid electric vehicles (PHEVs) and/or electric vehicles (EVs) to communicate with energy providers (of both energy commodity and network services) to control energy charging, and to allow electricity to flow from cars back to the grid. V2G allows EVs and PHEVs to be treated by utility companies as distributed energy resources to balance loads.
- **Position and Adoption Speed Justification:** V2G remains in the conceptual stage and hasn't progressed beyond the development of theoretical models and prototypes. However, utilities should continue tracking this technology, because it has a potentially significant impact on several critical areas resulting from energy technology consumerization and the increased percentage of renewable distributed energy generation, the growth in consumer PV and energy storage solutions and EV sales.
- **Business Impact:** V2G can impact on several utility areas, including commodity management (demand response) and network operations (issues with the intermittency of renewable sources). While V2G is expected to have several applications, the most economical entry for this green innovation is the market for ancillary services.

Wireless Electric Vehicle Charging

- **Definition:** Wireless electric vehicle (EV) charging is based on inductive charging that uses the electromagnetic field (EMF) to transfer energy between two objects. Induction chargers typically use an induction coil to create an alternating EMF from within a charging base station. A second induction coil in the vehicle takes power from the EMF and converts it back into an electrical current to charge the battery. Technology could potentially enable dynamic charging for vehicles as they drive down the road.
- **Position and Adoption Speed Justification:** The technology remains in its infancy, and can only transfer small amounts of power over very short distances. It is based on an application of magnetic induction, which uses a changing magnetic flux to push electrons and create a current that transfers electricity from an energy source to a battery.

Energy Efficiency Gamification

- **Definition:** Energy efficiency gamification applies game mechanics to drive ongoing consumer engagement in energy conservation. Although typical strategies include contests and rewards for conserving energy; social media elements, such as communities; and indicators of status and success, including badges and leader boards, gamification is not a rewards program. Gamification is designed to encourage ongoing interaction. It can be part of data and analytics for an energy management system, or a stand-alone program or application.
- **Position and Adoption Speed Justification:** By 2015, the American Council for an Energy-Efficient Economy (ACEEE) had identified 22 gamified solutions deployed by utilities. The largest energy savings were achieved by winners of utility sponsored contests (upward of 50%).
- However, results indicate that average savings among participants can fall in the 3% to 6% range. In 2016, the ACEEE continued to study results and found that games can reduce energy consumption by as much as 6.6%. However, it is not clear if energy savings persist after the game ends.
- Interest in energy gamification is growing, but as yet, takeup is relatively low.

Figure 5.5. Priority Matrix for Digital Grid Transformation Technologies, 2018

Benefits	Years to mainstream adoption			
	Less than 2 years	2 to 5 years	5 to 10 years	More than 10 years
Transformational	API Economy	• Advanced Metering • Digital Business Technology Platform • Edge Computing • Energy Storage (Grid Scale)	• Big Data • Digital Twin • Distributed Generation • Electric Vehicles • Internet of Things in Utilities • Transactive Energy • Virtual Assistants in Utilities	Artificial General Intelligence
High		• Drones (Commercial UAVs) in Utilities • IT/OT Alignment • IT/OT Integration • Meter Data Management	• Advanced Distribution Management Systems • Blockchain In Utilities • Combined Heat And Power • Consumer Energy Storage • Demand- Response Management Systems • Distributed Energy Resource • Management System • Energy Sharing Platform • Industrial Operational Intelligence • In-process HTAP • LPWA • Meter Data Analytics • Microgrids • Phasor Measurement Units	Vehicle-to-grid
Moderate		• Advanced Distribution • Protection and Restoration Devices • CIM Integration Standards • Consumer Smart Appliances • RF Networks for Utility Field Applications • Substation intelligent Electronic Devices	• Customer Gateways • Electric Vehicle Charging Infrastructure • Home Energy Management	Wireless Electric Vehicle Charging
Low			• Energy Efficiency Gamification	

Source: Gartner (Hype Cycle for Digital Grid Transformation Technologies, 2018)

6-Financials

Southeast Asia to spend US$500 billion on power projects in the next five years (2018-2022) with over 32,700 active projects in the pipeline.

- Indonesia leads in project activity with almost 30% of the region's total investment value, followed by the Philippines and Vietnam.

CLP Holdings and HK Electric Investments are projected to be able to pay investors dividend yields of 3.7-4.6% at the share prices under the new regulatory regime.

- The Hong Kong government and the city's two duopoly power utilities have come up with the extension of the "scheme of control [SoC]" regime.
  - The cap on return on net fixed assets will be slashed to 8% in 2019 from the current 9.99%.

Market Overview - Major investments in power sector; few companies control the electricity generation and distribution market due to regulation constraints

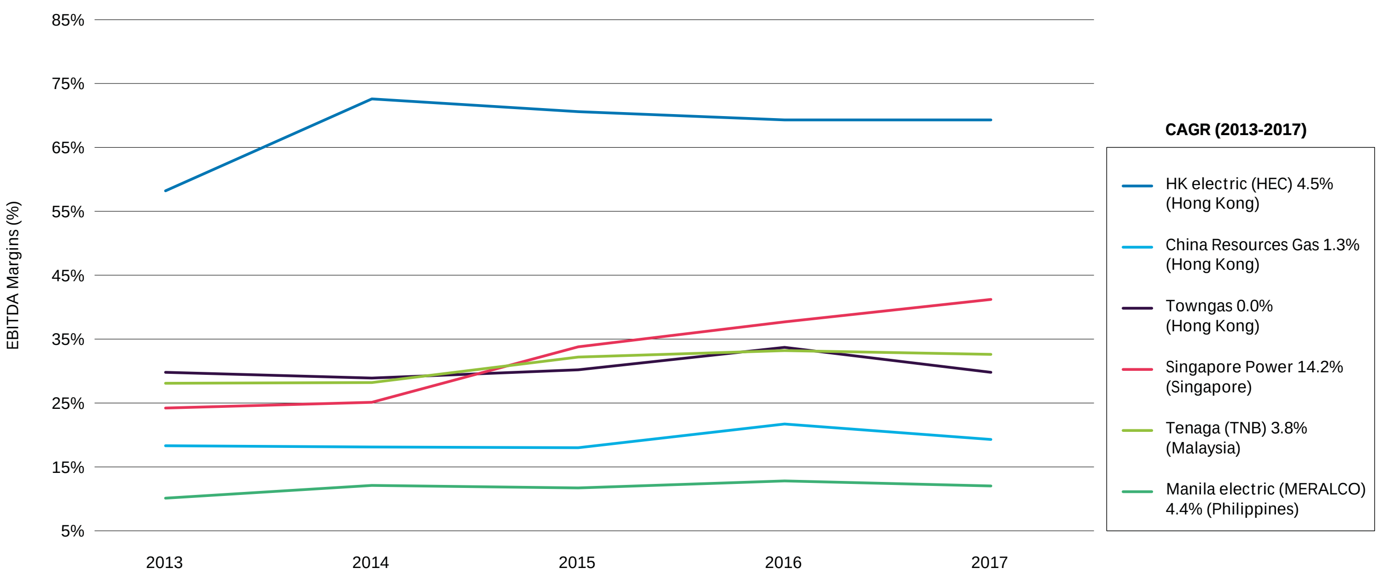
In Southeast Asia, power projects are attracting huge investments, reflecting potential spending of more than US$505 billion.
The Philippines has the highest number of active projects among SEA countries
Coal is still a major fuel source at 29.9% in power generation spending in the region; renewable energy leads with 49.8%.

Hong Kong has no indigenous energy resources. The Government considers the private sector to be in the best position to supply all its energy requirements

- According to Fitch Ratings, CLP Power Hong Kong Limited (CLP HK) has an 'A' rating with a stable outlook (the ratings of CLPH reflect the predictable cash flow from CLP HK, which typically contributes around 70% of CLPH's total EBITDA).

However, the new regulatory period will span 15 years through to end-2033 compared with the previous 10 years, providing stability and visibility over a longer period when increasingly stringent emissions requirements will demand investments in renewables and additional gas-fired generation.

Figure 6.1. EBITDA margins and associated CAGR, 2013-2017



Source: Thomson Reuters EIKON Data ("Normalized EBITDA"), Capgemini Analysis WEMO 2018

Southeast Asia

CLP and HK Electric have reached an agreement with the government - the cap on returns will be cut to 8% in 2019 from the current 9.99%.

According to Fitch Ratings, CLPH's capex will remain elevated over 2017-2020 mainly due to the heavy capex requirements of CLP HK:

- CLP HK's ratings reflect its low business risk from being a monopoly, vertically integrated, wholly regulated electricity business in the Kowloon district and New Territories region.
- Fitch also estimated a moderate dividend payment growth in 2018.

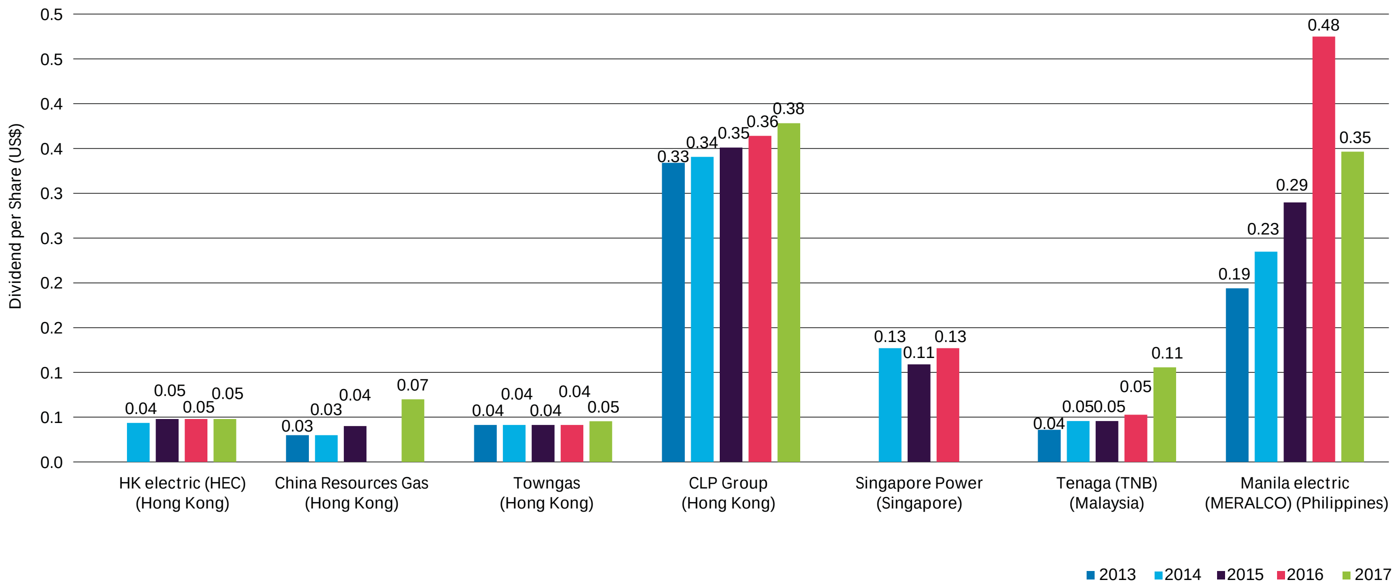
According to JPMorgan (2018), CLP can maintain its absolute dividend per share by raising payouts to 61% in 2019 (from 55.7% in 2017).

- But HK Electric has acknowledged that it must pay its owners all of its distributable income, and also expects its dividend yield to remain at a relatively high 4.6% in 2019, compared to 5.9% in 2018.

TNB has revised its existing dividend policy, from a dividend payout ratio of 30-50% to 30-60% in FY2017.

- The company also announced an annual dividend payout of RM 3.5 billion.
- TNB recognized its low earnings for FY2017 (6.3% lower than FY2016) were mainly due to the increase in finance cost from new borrowing acquired during the year and the rise in deferred taxation expense due to higher capitalization of assets.

Figure 6.2. Dividend per Share in US$ (2013-2017)



Source: Thomson Reuters EIKON Data ("Dividend per Share DPS"), Capgemini Analysis WEMO 2018

Credit Ratings, 2013-2018

Figure 6.3. Credit Ratings by Standard & Poor's, 2013-2018

Credit ratings by Standard & Poor's							
Company	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Outlook**
HK electric (HEC)		A-	A-	A-			
China Resources Gas	AA-	AA-	AA-	AA-	A+	A+	Stable
Towngas		A+	A+	A+	A+	A+	
CLP Group	A	A	A	A	A	A	Stable
Tenaga (TNB)	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	Stable
Manila electric (MERALCO)				BBB-	BB+	BB+	Stable
TaiPower		twAA-			twAAA	twAAA	Stable

Source: Thomson Reuters EIKON Data, Capgemini Analysis WEMO 2018

Topic Box 6.1: Southeast Asia's Rating Trends

Rating trends across utilities in SEA remain mostly stable, supported by a stable regulatory framework and moderate demand growth. Anticipated regulatory developments and planned capital expenditure (capex) can be generally accommodated within the rating headroom.

Hong Kong: Hong Kong's financial and institutional strengths support the stable outlook on Hong Kong's rating. Large fiscal and external buffers and a strong track record of effective fiscal and economic policy provide ample flexibility to cushion the economy and financial system against negative shocks.

- In May 2017, Moody's Investors Service downgraded Hong Kong's local currency and foreign currency issuer ratings to Aa2 from Aa1 and changed the outlook to stable from negative.
- HK Electric and HK Electric Investments Limited have maintained high credit ratings, and in February 2018, Standard & Poor's changed the outlook to stable.

Singapore: According to Moody's Investors Service, Singapore's (Aaa stable) credit profile reflects the city-state's very high per-capita income, diverse and competitive economy, strong fiscal position, robust institutional framework and low susceptibility to event risk.

- Most large power generation companies in Singapore have strong shareholders with diversified portfolios of generation assets.

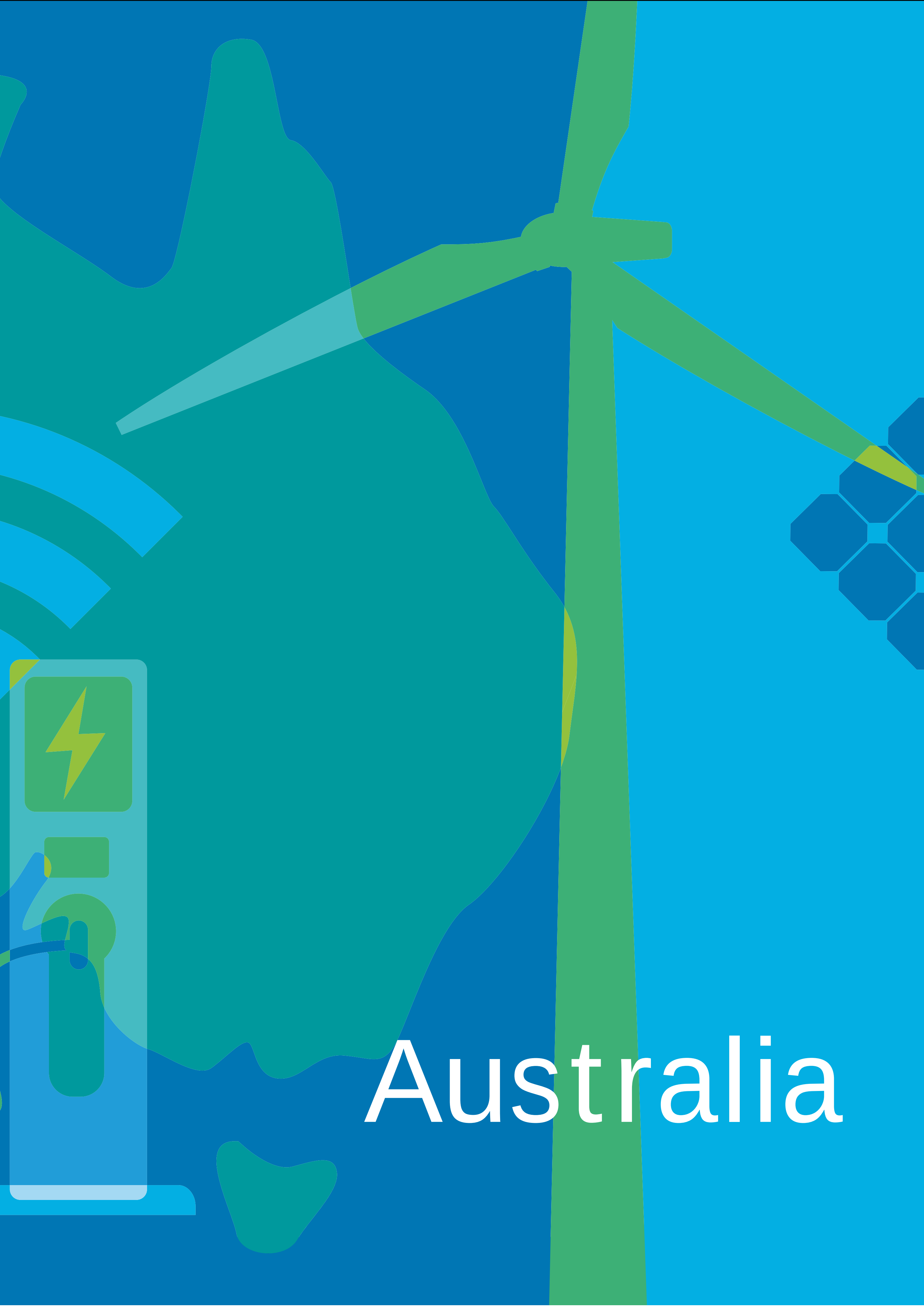
Malaysia: According to Fitch Ratings, the Malaysian rating reflects positive growth trends for the country and its position as a net external creditor that is supported by sustained current account surpluses and the large external assets of its private sector, besides falling government debt and deficit levels.

- Central government debt declined to 50.8% of GDP by the end of 2017 from 52.7% of GDP at at the end of 2016. However, the rating is constrained by weaker governance standards and lower levels of income per capita and human development compared to the median for sovereigns rated in the 'A' category.

According to Moody's, Tenaga Nasional Berhad's (Tenaga, A3 stable) financial results for the fiscal year ended 31 August 2017 (FY2017) are in line with Moody's expectations and continue to support its ratings. The outlook on the rating is stable.

Philippines: S&P Global Ratings has raised its outlook for the Philippine economy, citing strong economic growth, healthy external position, and improving policy making.

- A higher credit rating translates to more foreign investments, and lower borrowing costs for both the government and private sectors.
- S&P has upgraded Meralco's long-term corporate credit rating from 'BBB-' to 'BB+' with a stable outlook, which indicates that the company has "adequate capacity" to meet its financial commitments, but adverse economic conditions or changing circumstances may lead to a "weakened capacity" to meet financial commitments.



Australia

WEMO 2018 Australia Editorial

Jan Lindhaus & Anastasia Klingberg

Australia has progressed its management of the climate change journey over the last year. Investment in renewable projects has increased over 2016/17, federal policies were created to assist in managing the stresses of a disruptive industry. Governments at State and Federal level increased their focus on predominately renewable supply, but with increased pressure on the affordability of energy consumption for the end consumer.

Australia did not encounter any disruptions to supply due to energy shortage in 2017/18, but the good-news story stops there: The inquiry of Australia's competition regulator (ACCC) into retail electricity prices revealed a 56% increase in residential customer prices and 35% increase in residential customer bills between the period 2007/08-2017/18.

The control and reduction of consumer energy prices was the primary focus over the last two years, resulting in the Federal Government's National Energy Guarantee (NEG). Just when State Governments were getting to closer to endorse the NEG, Australia was again shaken by a change in Federal Government outside its election cycle. At the time of publishing the NEG's future is again uncertain and as we draw closer to an election the question still remains: will Australia continue the push to meet its emissions and renewable energy targets or will we see a change of direction, following the United States' disengagement of Climate change policies. 2019 is shaping up to be an exciting year in Australia's Energy Market.

Climate Change

Australia is on track to meet both its 2020 and 2030 emissions targets. It will exceed its 2020 target by 3.6% and has had a consistent reduction in emissions projections for 2030 since 2012. This is making us optimistic that the 2030 target can be achieved as well. Lower electricity demand, phase down of HFC (Hydrofluorocarbon) and progress in implementing policies at state level, are likely to be the key driving forces to achieve the 2030 target. An accelerated uptake of electric vehicles might lead to an unexpected increase of consumption and remains to be monitored.

Let us take a closer look at the relevant key policies that Australia has progressed over the 2017 /18 period:

- **National Energy Guarantee (NEG):** Electricity retailers are to use a mix of renewable and non-renewable sources to ensure reliable energy supply while reducing emissions simultaneously. All Australian states and territories must still agree to ratify the policy.
- **HFC phase-down:** The Government has initiated the phase down of HCF imports from January 2018 to meet international commitments of the Montreal protocol. The aim is to reduce generation of substances that deplete the ozone layer of the atmosphere.
- **RET:** Australian Government supports the uptake of renewable energy through the Renewable Energy Target (RET). The scheme is expected to deliver at least 23.5% of Australia's electricity generation from renewable sources by 2020

Energy Transition

As the momentum for adoption of renewable energy continues to build through 2018, Australia appears to be well-positioned to meet its 2020 Renewable Energy, mostly driven by state-level initiatives.

Accord to the Clean Energy Regulator (CER) a sufficient amount of projects has now been committed to achieve the objective: 700 MW of renewables projects were completed in 2017 and nearly 5,000 MW were under construction by the end of the year.

Generation in renewable energy were largely driven by wind and solar, both of which recorded increase in percentage share over 2016. For the first time in 2017, contribution of wind in the nation's electricity generation was at par with hydro, both accounting for about 6% share. Large scale solar and wind projects attracted investment worth A$11.7 billion in Australia, which is an increase of 150% from 2016.

More than 1.1 GW of solar PV was installed in the small-scale market in 2017, eclipsing the previous best record in 2012 as per the CER. More than one in five Australian households now have solar panels installed on their roof, which represents the highest rate per capita in the world.

Commencement of the operation of the world's largest lithium-ion Tesla battery at Neoen's Hornsdale Wind Farm in South Australia thrust energy storage into (global) spotlight. It already proved its mettle responding quickly when coal-fired Loy Yang power plant tripped and went offline in December last year, effortlessly outpacing traditional generators to help stabilise the electricity system.

Infrastructures and Adequacy of Supply

Thorough planning by the Australian Energy Market Operator (AEMO) ensured a robust system performance in the NEM during the summer of 2017/18. No consumers experienced interruptions to their electricity supply due to shortages. This was achieved by the generation of an extra 2,000 MW that were sourced as follows:

- Reopening of three mothballed gas-powered-generators across South Australia, Queensland and Tasmania enabled generation of 833 MW of additional electricity into the National Energy Market (NEM)
- 867 MW of additional resources was procured through demand-response programs via the Reliability and Emergency Reserve Trader (RERT)

Supply and Final Customer

In the backdrop of unsustainable electricity price rises in Australia, the ACCC produced a report identifying the root causes and developed recommendations to address these:

- **Network Cost:** Very high reliability standards caused increased expenditure in certain networks while it was unclear if consumers are willing to pay for marginal increases in security of supply.
- **Wholesale Cost:** The sudden closure of unprofitable coal-fired generators resulted in shortage of supply and excess demand in the market. This consequently drove prices up as the shortfall had to be compensated through more costly sources of generation like hydro and gas.

Grattan Institute also identified "Gaming" of the system (artificial creation of shortage of supply by generators) as another root cause driving cost.

- **Environmental:** Most state governments implemented excessively generous solar feed-in tariff schemes. Subsidies and payouts to the producers of solar energy were then funded at the expense of higher network and wholesale prices charged from end consumers.
- **Retail Cost and Margins:** Excessively high prices charged for standing offers, along with confusing price structure offered by retailers have left limited options for consumers to switch.

The percentage share of each driver is quite evenly distributed across regions. Network and wholesale account for 72–79% of the cost stack, followed by retail costs, retail margin and environmental costs which together contribute 21–28%.

New Business Models and Services

Fast paced technological changes are rapidly reshaping Australia's energy market, transforming it from a centralised system dominated by few players to a more decentralised, heterogeneous environment. Secondary participants and new entrants are creating a new dynamic and thus more opportunities to innovate and improve.

- Experimentation in wave, bio energy and battery storage technologies is driving growth in innovative renewable generation.
- Blockchain technology and its application in energy trading is gaining traction.
- Big data, analytics and IoT are being leveraged by city councils and businesses to improve energy efficiency, facilitate smart city development and ensure consumer retention.

Traditional players invest in the exploration of new business models, fostering of promising start-ups (locally and globally), working with new and unusual partners.

Financials

Generation and Retail

The power generation market continues to be dominated by GenTailer AGL despite growing competition. The energy retail market is largely covered by Origin Energy along with its Tier 1 competitors AGL and Energy Australia.

- In 2017, AGL accounted for the largest market share in generation capacity across regions of Victoria, South Australia and NSW. Streamlined cost reduction programs and rising wholesale electricity prices helped AGL improve its bottom-line.
- Origin Energy continued to dominate the electricity and gas retail market across Queensland, South Australia and NSW, along with AGL.

Network Service Providers

The AER decisions in the current regulatory period led to lower total network revenues of electricity and gas, reflecting more stable financial markets and reduced capital expenditure.

- Regulated electricity and gas network revenues are forecast to decline by an average 13.5% and 12% respectively.

AEMO has also abolished the Limited Merits Review (LMR) regime removing the right of Network Service Providers (NSPs) to apply for LMR of most of the decisions of the Australian Energy Regulator (AER). This will assist in reducing the uncertainty around network pricing and ensure that the downward momentum facilitated by AEMO is maintained in the long run.

Whilst Australia stabilised its approach to Energy Transition in 2017/18 and began addressing its consumer pricing concerns, we look towards 2019 and wonder on the possibilities on where Australia's Energy Transition will head.

We look forward to reporting to you in our next edition of WEMO.

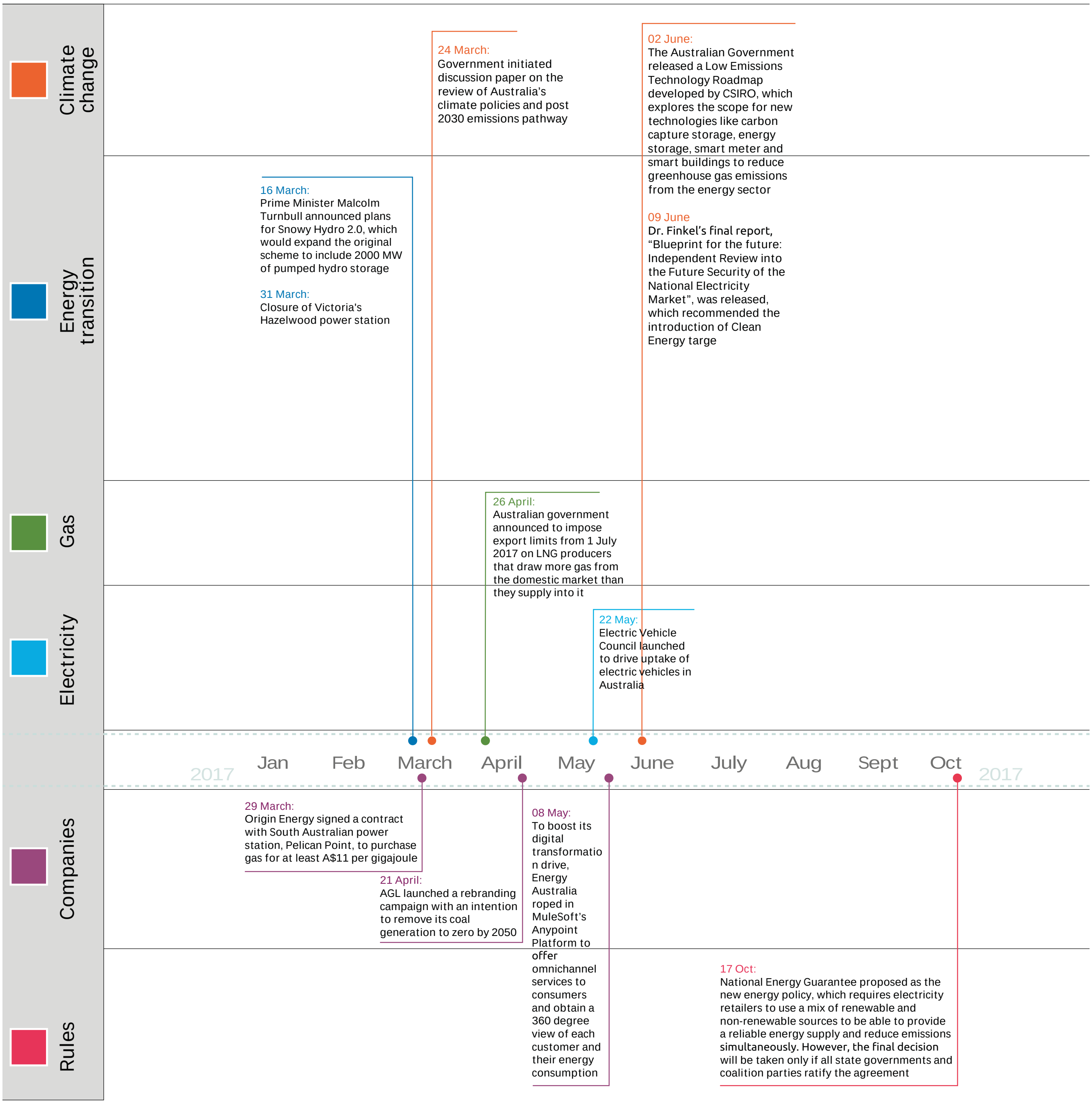
Jan Lindhaus

Vice President, Head of Energy & Utilities Australia

Anastasia Klingberg

Industry Practice Lead Energy & Utilities, Australia

Major energy events (2017 and H1 2018)



19 Dec:
Final report on 2017 review of Australia's climate policies was released

01 Jan:
Australian government commenced phase down of HFC import, as a part of its agreement in Montreal protocol to reduce greenhouse gas emissions

01 Dec:
Official commissioning of the world's largest lithium ion battery by Tesla in South Australia, which has a total generation capacity of 100 MW and 129 MWh of energy storage, that is capable of powering more than 30,000 homes

20 Dec:
Snowy Hydro 2.0 feasibility study approved and reveals that it is technically and financially viable – further work to be undertaken to reach a final investment decision in 2018

09 May:
Australian Government agreed to the Consumer Data Right model that will allow consumers to share their electricity consumption data with price comparison service providers and help them compare and switch between goods and services on offer

2017 Nov Dec Jan 2018 Feb March April May June July 2018

18 Dec:
As a part of its digital transformation initiative, AGL has selected SAP's S/4 HANA platform for its new unified ERP planning

06 June:
Endeavour Energy roped in Cognizant for its digital transformation project, which will leverage the SAP S/4HANA suite and a range of SAP Cloud solutions. Likewise, many companies across generation, distribution and retail businesses are leveraging digital transformation to reduce cost for their future operations

10 July:
AER released a draft on Rate of Return Guidelines wherein it announced plans to reduce the return on debt, to ensure a balance between system reliability and efficient network investment that would help keep energy prices down

1-Climate Challenges & Regulatory Policies

Australia's emissions have increased in the past three years and the momentum is expected to continue till 2030. Despite the upward trend, estimates suggest that Australia is on track to meet its 2020 target of reducing emissions to 523 $MtCO_2e$ (i.e. 5% below 2000 level)

- Lower emission from manufacturing and electricity sector, as well carbon sequestration from regrowing forests, have been driving down emission projection for 2020 between 2012-2017.
- As of 2017, the estimated emission for 2020 stands at 551 $MtCO_2e$ and this number is expected to decline further with the forthcoming projection updates.
- Moreover, Australia is expected to overacheive the cumulative emissions reduction required between 2013-2020, by 3.6%.

The country has also set an ambitious target of reducing emissions 26-28% below 2005 level by 2030, and is on track to achieve that as well

- Despite an upward trend in Australia's emissions for last three years, the country is optimistic in meeting its 2030 target. This is evident from the falling 2030 emissions estimates with each projections update from 2012-2017.
- Lower electricity demand, phase down of HFC and progress in implementing policies at state level, are likely to be the key driving forces.

Government is considering implementing the National Energy Guarantee (NEG) as Australia's future energy policy to deliver more reliable and affordable electricity; however this is subject to several debates and criticisms

- The policy which has been designed in collaboration with Energy Security Board and COAG Energy Council requires electricity retailers to invest in enough dispatchable energy resources to tackle peak demand, while maintaining the emissions threshold when purchasing electricity.
- Currently in a consultation phase, NEG has been facing criticisms for its less ambitious and non-inclusive approach.

In absence of a robust federal climate policy, state and territories are playing crucial roles in driving the Australian energy transition – all except Western Australia have renewable energy and/or net emissions targets in place

- South Australia, Australian Capital Territory (ACT) and Tasmania are leading the pack in the renewable race with the later two having a target of 100% renewables by 2020 & 2022 respectively
- From having no formal targets in place, both NSW and Northern Territory have witnessed significant positive shifts in policy support for renewables in the last two years.

Australian government has put forth a set of policies to reduce greenhouse gas emissions, however, some of these are currently subject to consultation, and as such, domestic efforts might need to increase further to meet the country's long run emissions target. The government has committed to review these policies on a five yearly basis, aligned to the timeframe of Paris Agreement, to ensure they remain effective in achieving emission reduction targets.

Australia's greenhouse gas emission projections

Australia's emissions have risen in the past three years and the reflects an overall upward trend till 2030.

- A major factor in this growth has been the rapid expansion of the LNG sector, which is expected to grow further as more plants commence their operation in 2018.
- However, increased emissions from LNG are expected to be largely offset by flat electricity emissions, as renewable generation – an especially strong growth in solar generation is expected – compensates for the electricity demand growth.
- In addition, decline in emissions intensity of generation due to the Renewable Energy Target (RET) and the announced closures of coal power stations like Hazelwood and Muja are also expected to contribute to the trade-off – this explains the decline in projected emissions in 2020.
- Emissions in direct combustion sector are expected to be mainly driven by production growth in LNG plants till 2020, after which no further facility expansions are projected till 2030.
- Fugitive emissions expected to increase from LNG production and coal mines, as under-construction LNG plants ramp up to full production from 2018, coupled with increase in coal production.
- Legislated phase down of hydro-fluorocarbons (HFCs) from 2018 are expected to lower long term emissions from industrial processes and product use.
- Increase in recycling and methane capture rates are likely to marginally reduce wastewater emissions from domestic, commercial and industrial sources between 2017 to 2020, after which it is expected to remain stable till 2030.

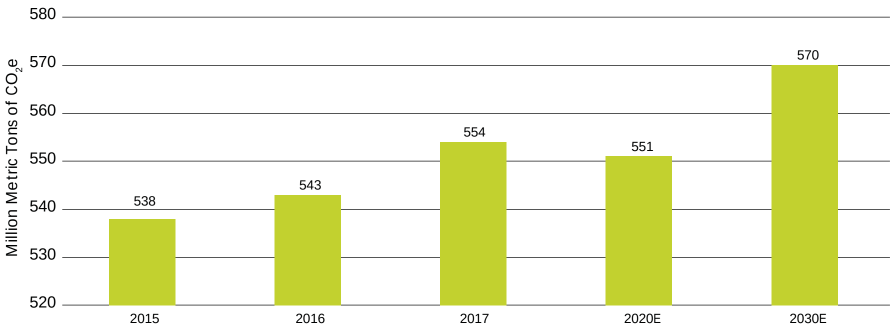
Emissions in 2030 are projected to grow by 3.5% above 2020 levels, mostly driven by transport and agriculture sectors; emissions in other sectors are projected to stabilize or grow slowly in the post 2020 period.

Cars and light commercial vehicles are projected to continue to be the largest source of transport emissions till 2020, after which emissions from heavy vehicle activity for freight will continue to persist, aligned to the projected growth in Growth Domestic Product (GDP) and rising demand for consumer goods.

Increase in agriculture emissions will be underpinned by rising food demand; beef cattle is projected to continue to be the biggest contributor to sectoral emissions, followed by sheep and dairy cattle.

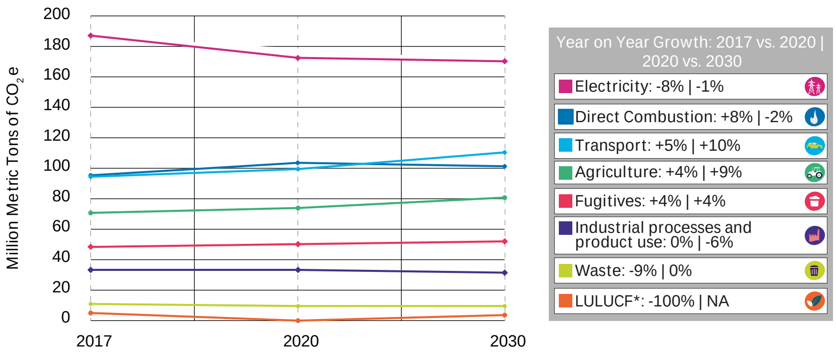
- Closure of Hazelwood, Muja and Liddell power stations coupled with increase in renewable generation to meet RET is expected to drive down emissions from electricity sector till 2030.

Figure 1.1. Annual emissions in Australia, 2015-2030 (million metric tons)



Source: Australia's emissions projections 2017, Dept. of Environment and Energy – Australian Government (Dec 2017)

Figure 1.2. Sectoral breakdown of emission projections, 2017-2030 (million metric tons)



Source: Australia's emissions projections 2017, Dept. of Environment and Energy – Australian Government (Dec 2017)
* Land Use, Land Use Change and Forestry

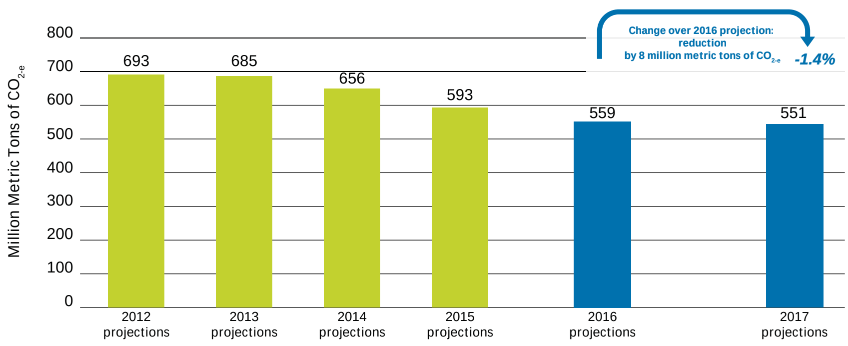
Despite the continuous rise in emissions, Australia is on track to achieve its emission reduction target of 5% below 2000 levels i.e. 523 $MtCO_2e$ by 2020.

- This is evident from the steady decline in 2020 emission estimates with each projection update, over the last six years between 2012-2017; this trend is expected to persist in near future as well.
  - As per 2017 estimate, total emission in 2020 was projected to be 551 $MtCO_2e$, a downward revision of 1.4% since the 2016 projections.
  - This is largely owing to higher projected carbon sequestration[1] in re-growing forests and lower projected emissions from mining, manufacturing and electricity sector.

Australia expected to not only meet the 2020 emission reduction target but also overachieve the amount of cumulative emissions reduction required through the period till 2020, by 3.6%.

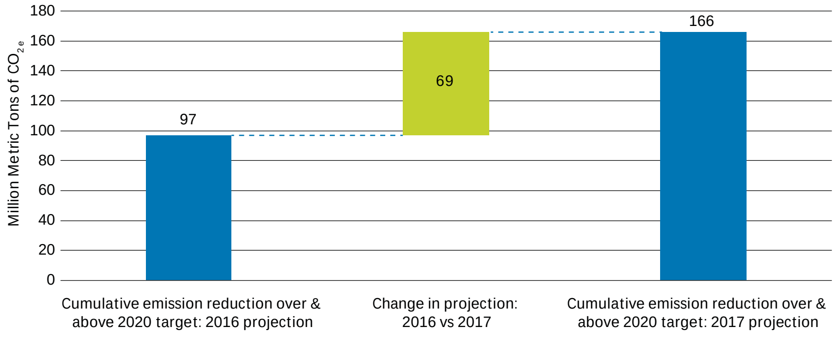
- As per 2016 estimates, Australia was expected to overachieve on its 2020 target by 97 $MtCO_2e$ (without carryover).
- In 2017, this estimate on overachievement increased to 166 $MtCO_2e$, reflecting Australia's continued progress in reducing emissions.

Figure 1.3. Evolution of emission projections for 2020 over time (million metric tons)



Source: Australia's emissions projections 2017, Dept. of Environment and Energy – Australian Government (Dec 2017)

Figure 1.4. Projected cumulative surplus in emission reduction between 2013-2020, above 2020 target (million metric tons)



Source: Australia's emissions projections 2017, Dept. of Environment and Energy – Australian Government (Dec 2017)

1 Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide in plants, soil, geological formation and ocean. It is one of the methods of reducing the amount of carbon dioxide in the atmosphere with the goal of avoiding dangerous global climate change

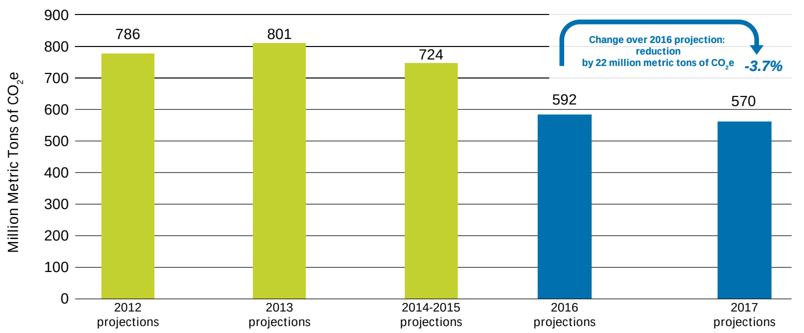
For 2030, Australia has a target of reducing emissions to 442-430 MtCO_2e i.e. 26% to 28% below 2005 levels. Estimate for emissions in 2030 has been falling with each projections update, thus indicating that the country is on track to achieve its 2030 target as well.

- As per 2017 estimates, total emission in 2030 is projected to be 570 MtCO_2e, reflecting a reduction of 3.7% from the 2020 estimates published in 2016. This change can be attributed to:
  - Lower electricity demand and falling technology costs in the electricity sector
  - Progress in implementing policies including the Government's National Energy Productivity Plan (NEPP) and the legislated phase-down of hydro fluorocarbons (HFCs)
  - Higher projected carbon sequestration in regrowing forests
  - Lower than forecast emissions from mining and manufacturing than projected in 2016.

According to 2017 projection update, approx. 122 MtCO_2e lesser cumulative emission reduction of CO_2e is required between 2020-2030 to meet the 2030 target, compared to 2016 update.

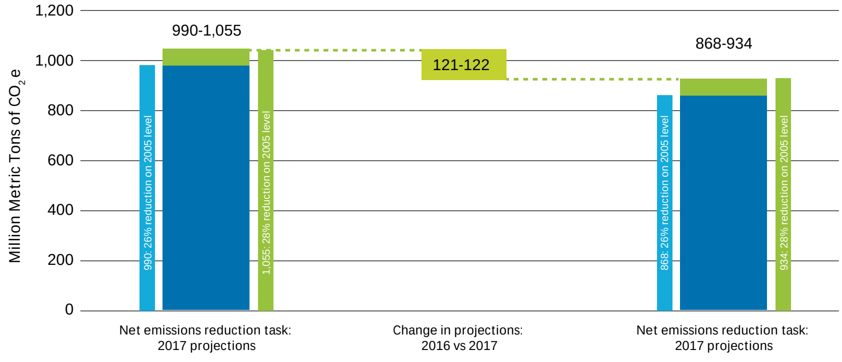
- 2017 estimate indicates that cumulative emission reductions of 868 MtCO_2e to 934 MtCO_2e is required over the period 2021-2030 to meet Australia's 26% and 28% targets respectively.
- This estimate stood at 990 MtCO_2e to 1,055 MtCO_2e in 2016 projection update.
- The decline in emission reduction requirement is primarily driven by new policy measures undertaken by the government.

Figure 1.5. Evolution of emission projections for 2030 over time (million metric tons)



Source: Australia's emissions projections 2017, Dept. of Environment and Energy – Australian Government (Dec 2017)

Figure 1.6. Projected cumulative emission reduction required between 2021-2030 to meet 2030 target (million metric tons)



Source: Australia's emissions projections 2017, Dept. of Environment and Energy – Australian Government (Dec 2017)

Review of climate change policies in operation

Consistent with the timelines of the Paris Agreement, the government is undertaking five-yearly 'review and refine' cycles to ensure its domestic policies are on track to meet the energy and emission targets. Australia is one of those first countries to have aligned their policy review timeframe with the Paris agreement

- **In 2017, the Australian Government reviewed its current policies in operation which include:**
  - **Emission Reduction Fund (ERF) and Safeguard Mechanism:** ERF is a incentive based initiative that enables Australian businesses, local councils, landholders and others to earn carbon credits from projects which reduce or avoid greenhouse gas emissions. These carbon credits are then purchased by Clean Energy Regulator on behalf of the Australian government and can also be sold to other businesses seeking to offset their emissions in exchange of monetary benefits. The Safeguard Mechanism, which has been in operation since July 2016, puts emission limits on Australia's largest emitters to ensure that emission reductions purchased by the Australian Government through the ERF are not offset by increases in emissions above business-as-usual levels elsewhere in the economy.
  - **Renewable Energy Target (RET):** It supports growth and employment in the renewable energy sector by providing a financial incentive for investment in new renewable energy projects. Household use of solar energy has surged under the Renewable Energy Target. Australia has one of the highest number of solar panels on roofs per capita in the world, representing 17% of Australian households. The scheme is expected to generate at least 23.5% of Australia's electricity from renewable sources by 2020.
  - **The National Energy Productivity Plan (NEPP):** It consolidates national, state and territory government to provide an economy wide work plan that aims to accelerate a 40% improvement in Australia's energy productivity by 2030. Measures under the National Energy Productivity Plan are already delivering cost savings and emissions reductions.
  - **The National Carbon Offset Standard:** Provides benchmarks for organizations seeking to make their operations, products, services, buildings, precincts or events carbon neutral. The Carbon Neutral Program provides a framework for certifying carbon neutrality against the National Carbon Offset Standard.
- **New policies and measures are also underway to meet the emission reduction targets:**
  - **National Energy Guarantee (NEG):** The Australian government proposed the National Energy Guarantee in October 2017. The policy requires electricity retailers to use a mix of renewable and non-renewable sources to be able to provide a reliable energy supply and reduce emissions simultaneously. For the NEG to be implemented, all of the states and territories must agree to ratify the policy. A final decision on the NEG is due to be made at the COAG Energy Council meeting in August 2018.
  - **HFC phase-down:** Government has initiated the phase down of HCFs imports from January 2018 to meet international commitments of the Montreal protocol that aims to reduce generation of substances that deplete the ozone layer of the atmosphere.

ERF will continue to play a critical role in helping Australia meet its emission reduction target. Many projects contracted under ERF currently are expected to deliver emission reduction beyond 2020 and will contribute to Australia's 2030 emissions reduction target.

- ERF comprises of three interrelated elements namely:
  - **Crediting:** This refers to carbon crediting that enables businesses, community organizations and local councils to earn carbon credits for undertaking approved emission reduction activities like improving energy efficiency, fuel switching, capturing methane from landfills and storing carbon in forests and soils. Participants receive one Australian carbon credit unit for every ton of emissions they reduce or avoid. As a next step, these carbon credits are purchased by Clean Energy Regulator (on behalf of the Australian government) through an action or bid process.
  - **Purchasing:** Participants register a project and bid to enter into a 10 year contract with the government. During the contract tenure, participants are obligated to earn carbon credits by undertaking approved emission reduction activities and sell the same to the government for auction price. If a project does not earn sufficient credits to meet the contractual obligations, the project proponent may need to compensate by buying carbon credits from other project owners. Participants may also sell carbon credits achieved under the ERF privately to entities wanting to offset their emissions. Currently, over 700 emission reduction projects are registered under ERF.
  - **Safeguard Mechanism:** It is designed to ensure emissions reductions purchased by the Australian Government through the ERF are not offset by significant increases in emissions above business-as-usual levels elsewhere in the economy. The Safeguard Mechanism does this by placing emission limits (or baselines) on Australia's largest emitters. Facilities covered by the Safeguard Mechanism are required to reduce emissions or purchase carbon credits to ensure net emissions remain below the baseline.

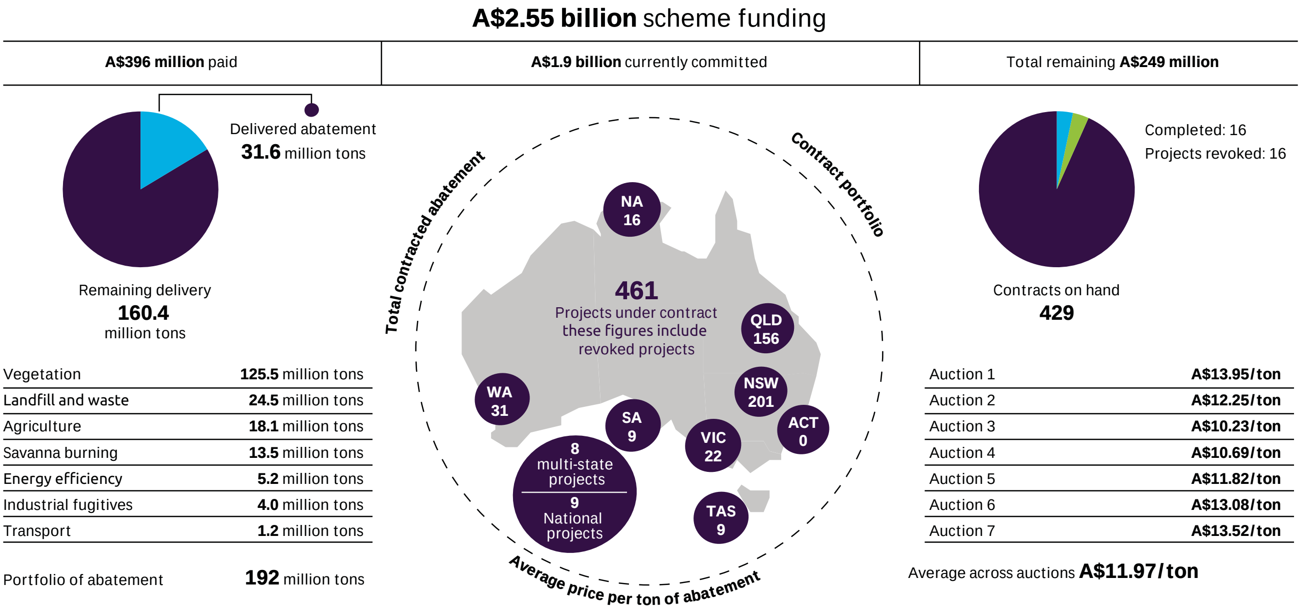
New approach in ERF Safeguard Mechanism

- In 2017, Australian government reviewed ERF and its Safeguard Mechanism and as an outcome it released a consultation paper that proposed an approach, to make the mechanism fairer and simpler. This includes:

- **Updating baselines by transitioning all facilities to calculated baselines over 2018-19 and 2019-20**
- **Updating baselines annually for actual production, so they continue to reflect facility circumstances and enable growth.**

- Under the current proposed rules, new facilities and significant expansions commencing operations before 2020 will be using the calculated baseline approach, whereas, for new investments operational after 2020, baselines will be set with respect to government benchmarks once the approach for existing facilities is settled.
- **Many industry experts have criticized the new approach and are of the opinion that if baselines are continually increased over time, the fixed benefits of the ERF will inevitably be wiped out.**

Figure 1.7. Emission Reduction Fund contract portfolio (as of 15th June, 2018)



Vegetation	**125.5** million tons
Landfill and waste	**24.5** million tons
Agriculture	**18.1** million tons
Savanna burning	**13.5** million tons
Energy efficiency	**5.2** million tons
Industrial fugitives	**4.0** million tons
Transport	**1.2** million tons
Portfolio of abatement	**192** million tons

Auction 1	**A$13.95/ton**
Auction 2	**A$12.25/ton**
Auction 3	**A$10.23/ton**
Auction 4	**A$10.69/ton**
Auction 5	**A$11.82/ton**
Auction 6	**A$13.08/ton**
Auction 7	**A$13.52/ton**
Average across auctions	**A$11.97/ton**

Source: 7th auction contract portfolio, Clean Energy Regulator, June 2018

The Australian Government has allocated A$2.55 billion to purchase carbon credits through the ERF, using a competitive process of auctioning; approx. A$2.30 billion have already been paid or committed for the purchase.

- As of June 2018 (i.e. from the first seven auctions) the government has declared to have purchased carbon credit (in other words, contracted emission abatement) worth 192 million tons from 461 projects at an average price of A$11.97. Lower registration rates owing to administrative complexity has resulted in lesser competition, thus driving up the auction price since late 2017 i.e. auction 5.
- Of the 192 million tons of emission reduction contracted, 16.4% abatement has already been delivered while 83.6% is yet to be delivered –vegetation sector dominates the abatement portfolio.
- Of the 461 projects currently contracted under ERF, 3.5% are already completed, while 93% are in progress - New South Wales and Queensland dominate the contract portfolio and they together account for 77% of total projects contracted in ERF.

Australia's other domestic policies are also having positive effects, evident from the fact that the country is on track to achieve both its 2020 and 2030 emission reduction targets

- **RET:** Australian Government supports the uptake of renewable energy through the Renewable Energy Target. The scheme is expected to generate at least 23.5% of Australia's electricity from renewable sources by 2020. The policy has two components - the large-scale Renewable Energy Target of 33,000 GWh by 2020 which encourages investment in large scale renewable projects, and the small-scale Renewable Energy Scheme which helps home-owners and small businesses to install eligible small-scale renewable energy systems and solar hot water systems.
  - **Large scale RET:** Eligible large-scale renewable energy generators, like solar and wind farms, hydro-electric and biomass power stations, can create certificates under the Large-scale RET. Electricity retailers are legally obligated to buy and surrender a certain amount of certificates to the Clean Energy Regulator each year and this operates as a subsidy to renewable energy generators. In August 2017, more than 70% of the estimated capacity required to reach the 2020 target had been accredited.
  - **Small-scale Renewable Energy Scheme:** Assists homeowners and small businesses with upfront costs of installing small-scale wind, hydro and solar panel systems. This scheme has assisted Australian households to install more than 1.8 million solar PV systems and one million solar water heater systems. In August 2017, Australia hit a milestone of 6,000 MW capacity across 2.8 million small-scale installations of renewable energy systems which is sufficient to power 1.8 million homes.
- **NEPP:** Aims to boost competitiveness and growth, help families and businesses manage their energy costs and reduce emissions. Key achievements include:
  - **Tighter energy standards for equipment:** To accelerate the impact of the Equipment Energy Efficiency (E3) program, new proposed standards have been consulted on for air conditioners, commercial refrigerated display cabinets, industrial fans, swimming pool pumps, lighting, refrigerators and freezers. These measures will deliver an estimated A$7 billion in economic benefits and reduce emissions by 45 $MtCO_2e$ (cumulative to 2030).
  - **Expansion of the Commercial Building Disclosure program:** Requires most sellers and lessors of large office spaces to provide energy efficiency information to prospective buyers and tenant. From 1 July 2017 the mandatory disclosure threshold for buildings size was lowered from 2,000 square meters to 1,000 square meters. This is expected to generate A$50 million savings in new energy and about 3.5 $MtCO_2e$ reduction till 2019.
  - **Further improvements to NEPP are underway, which include:**
    - **Commercial launch of the Victorian Residential Efficiency Scorecard's assessment tool** in April 2018 - The tool measures the energy efficiency of existing homes, helps homeowners identify and prioritize upgrade opportunities to reduce energy costs and subsequently improve the health and comfort of their homes. Investments in energy efficiency upgrades driven by broad use of this Scorecard is expected to result in greenhouse gas reduction outcomes. The Victorian Government has committed to funding the Scorecard program until 2020.
    - **Implementation of the Australian Government's Smart Cities Plan,** including the A$100 million a year Sustainable Cities Investment Fund, that aims to accelerate the deployment of clean energy, renewable energy and energy efficiency technology in cities.
- **Carbon offset Standard and Carbon Neutral Program:** The Standard sets out how to measure, reduce, offset, report and audit greenhouse gas emissions, and how to achieve carbon neutral certification.
  - Some of Australia's best known organizations are part of a group of leading enterprises certified as carbon neutral.
  - These businesses are investing in carbon offset projects that deliver additional environmental or social outcomes such as improved water quality, increased biodiversity and indigenous employment.

New policies and measures developed

Work is underway on additional policies to reduce emissions in the electricity sector through a National Energy Guarantee, and to meet international commitments of the Montreal Protocol through phase-down of hydro fluorocarbons

National Energy Guarantee:

- What is National Energy Guarantee?
  - A policy mechanism designed to retain existing resources and encourage new investment in the National Energy Market (NEM) while ensuring that emissions standards are met and the system operates reliably.
  - On 17 October 2017, the Australian Government announced to accept the recommendation of the Energy Security Board for a new National Energy Guarantee, which replaces the 50th recommendation of the Finkel Review.
  - The Government will work with the independent Energy Security Board and with the states and territories through

the Council of Australian Governments Energy Council to implement the new policy.

– For the NEG to be implemented, all of the states and territories must agree to ratify the policy; a final decision on the NEG is due to be made at the COAG Energy Council meeting in August 2018.

- **Operation Mechanism of NEG**

If implemented, NEG will require energy retailers to ensure that the electricity they contract for or purchase meet the 2 key targets:

– Reliability Guarantee: Requires electricity retailers to invest in enough dispatchable energy resources (e.g. coal, gas, hydro, battery storage, demand response) to cover a set amount of their peak load in a region if a shortfall is predicted.

– Emission reduction guarantee: Requires electricity retailers to meet a defined emissions level for the electricity they purchase from the wholesale market to be aligned with Australia's emissions reduction commitments under the Paris Agreement.

– If the federal government does manage to get all the states and territories on board, the reliability component of the NEG will start in 2019 and the emissions component will succeed the RET in 2020.

- **How will NEG impact NEG prices?**

– As per initial estimates by Energy Security Board (ESB), the NEG will reduce household power bills by approximately A$120 per year between 2020 and 2030.

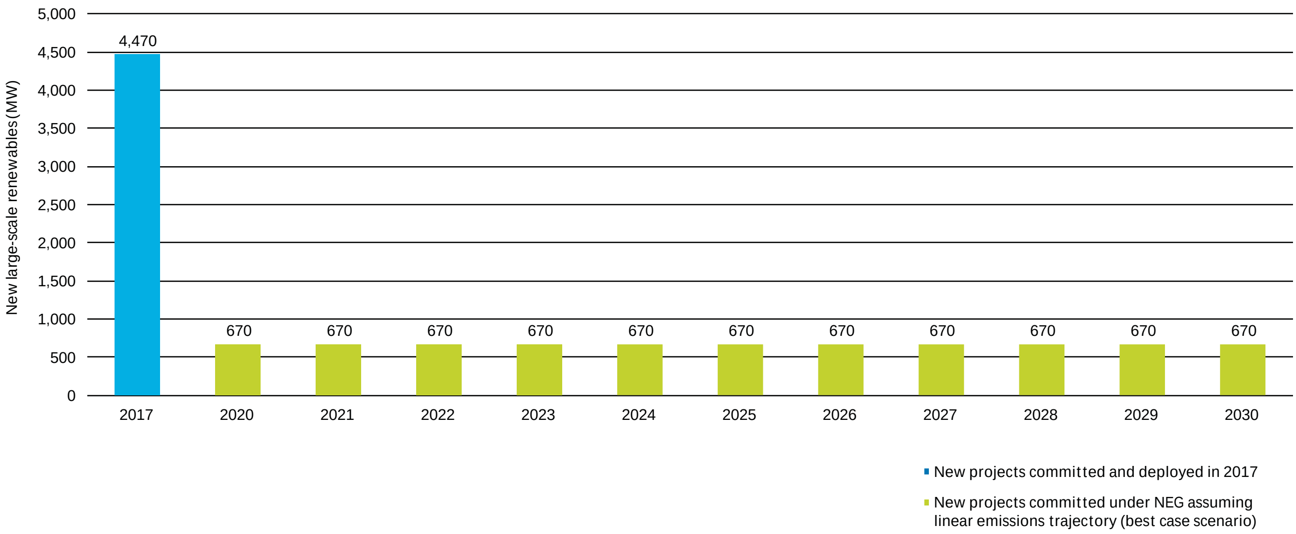
– This savings will receive a further boost from the additional A$280 million per year reduction expected from the entry of 6000 MW of new renewable generation in next few years, under RET.

- **How will NEG contribute to emissions abatement?**

– Currently, the government has set the emissions abatement component of the NEG at 26% i.e. the lower limit of Australia's 2030 emission reduction target, under Paris Agreement.

– This, however represents only a minor reduction from what is expected under a 'business as usual' scenario.

Figure 1.8. Potential new energy projects under NEG (in MW)



Source: Clean Energy Council

Effect of NEG on renewable energy projects

- According to the ESB, renewable energy will account for 28-36% of total energy generation in 2030 under the NEG (including hydro and rooftop solar).
- This suggests that between 250 and 670 MW of large-scale renewable projects will be deployed each year from 2020-2030.
- Considering that approximately 4300 MW of renewable energy projects are currently committed or under construction, this would involve a significant reduction in renewable projects, over the next 10 years.

Phase-down of hydrofluorocarbon (HFC) imports

Background

- Refrigerants Australia (a peak organization responsible for the supply chain of refrigerants both in bulk and in equipment) had recognized that most of the gases used in refrigeration and air conditioning have high global warming potential and as such it is imperative to reduce the emissions from such gases. Hence, in early 1990s the organization started encouraging import and use of next generation of refrigerants i.e. HFCs in Australia, which were considered non-flammable and expected to have lesser climate change impact compared to previous generation of gases.
- From the late 2000s, however, there was an increasing focus on reducing greenhouse emissions even further and by 2007 Refrigerants Australia launched the policy proposal that HFCs should be subject to a phase-down.
- In 2010, this proposal was launched by the US, Canada and Mexico in the Montreal Protocol, and the Australian Government came on board in 2012. Refrigerants Australia actively supported both domestic and international moves to agree to a phase-down of HFCs.
- In October 2016, nearly 197 countries across the globe agreed to phase down HFC as a part of the Montreal protocol. The agreement called for an international phase-down of 85% of HFCs for developed countries by 2036, with developing countries reducing use of HFCs by 80% a decade later. On October 28th 2017, the Australian Government ratified to the protocol and the phase-down commenced from 1 January 2018.

Australian Target:

- HFC phase-down for Australia includes restriction on the maximum amount of bulk gases (e.g. cylinders) that can be imported in the country and does not apply to gas imported in pre-charged equipment such as air conditioners or refrigerator. The annual import limit is currently at 8 CO_2e per year.
- Australia has a target to phase-down use of HFCs by 85% within 2036 and is ahead of the global phase-down since it begins a year early than the Montreal Protocol.

Impact of HFC phase-down

- HFC phase-down along with other measures like improvement in equipment maintenance is expected to reduce emissions by up to 80MtCO_2e till 2030.
- It is also expected to provide environmental benefits and pave the way for the introduction of state-of-the art refrigeration and air conditioning equipment.

Potential replacements for HFCs

- There are a number of potential replacements for HFCs- several refrigerants with no or very low global warming potential are now available in Australia, which may be appropriate for use in the same applications as HFCs. This includes natural refrigerants like ammonia, carbon dioxide and hydrocarbons, as well as manufactured substances like hydrofluoro-olefins or HFOs.
- Natural refrigerants and HFOs may offer improved performance and energy efficiency in 'fit-for-purpose' system, but could be hazardous in case of systems that require a specific type of HFC.

State, Territory and Local government policies

All of Australia's states and territories, with the exception of Western Australia, now have strong renewable energy targets and/or net zero emissions targets in place; South Australia, ACT and Tasmania have emerged as the front runners in the renewable energy race, with Queensland and Victoria catching up fast.

South Australia (SA):

- **Policy**
  - Has a 50% by 2025 renewable energy target, a "zero net emissions" target for 2050 and introduced a new Energy Plan in 2017.
- **Renewable power**
  - As of August 2017, SA had the highest capacity of renewable energy (excluding large hydro) worth 1,625 MW – increase in share of renewable energy largely driven by an increase in wind power and a decrease in coal generation.
  - Completed construction of world's biggest lithium-ion battery storage facility in December 2017 and has plans of installing a 150MW solar thermal power plant that will supply 100% of the state government's electricity needs.
- **Household solar penetration**
  - 30.5% of households with rooftop solar PV – second highest proportion after Queensland.

Australian Capital Territory (ACT):

- **Policy**
  - Legislated target of 100% renewable energy by 2020 and net zero greenhouse gas emissions by 2050, at the latest.

- **Renewable power:**
  - The ACT Government has been progressively transitioning to renewable power sources since 2012, by holding five large-scale renewable energy reverse auctions aimed at purchasing renewable energy from wind and solar projects at the lowest price –this supported 600 MW of wind power and 40MW of large scale solar projects. The ACT completed its final renewable energy reverse auction in 2016, putting the territory on track to reach 100% renewable electricity by 2020.
- Household solar penetration.
  - Approximately 14% of ACT households have solar PV - The ACT is the first state or territory in Australia where both major political parties have provided bipartisan support for its renewable energy target.

Figure 1.9. Renewable energy policy and performance status across states and territories

State/Territory	SA	ACT	TAS	QLD	VIC	NSW	WA	NT
Solar Households (%)	31%	14%	13%	32%	15%	15%	25%	11%
Renewable Energy Targets	50% by 2025	100% by 2020	100% by 2020	50% by 2025	25% by 2020; 40% by 2025	20% by 2020		50% by 2030
Net zero emissions target	Net zero emissions by 2050	Net zero emissions by 2050	Net zero emissions by 2050	Net zero emissions by 2050	Net zero emissions by 2050	Net zero emissions by 2050		
Progress since 2016	SA Energy plan – completion of 100 MW lithium ion battery plant, Renewable Technology Fund and a 150MW solar thermal power plant	Renewable Energy Target legislated	New renewable energy target and zero net emissions target	Powering Queensland Plan -Largest number of large-scale renewable projects under construction	Renewable Energy Target Legislated as part of the Climate Change Act, 2017	Continued policy support. Largest capacity of new projects under construction	Growing penetration of rooftop solar	Expert panel and consultation on approach to Renewable Energy Target – implementation by mid 2018

Source: Australia's emissions projections 2017, Dept. of Environment and Energy – Australian Government (Dec 2017)

Robust planning at state and territory level, coupled with existing and announced closures of coal plants (such as Liddell Power Station) are expected to help Federal Government achieve its 2030 emission reduction target, even without any action from the Federal Government.

- New South Wales and Queensland are set for a significant increase in renewable energy - The greatest capacity and number (respectively) of large scale wind and solar plants under construction in 2017 are in New South Wales and Queensland respectively, which is expected create thousands of jobs in construction and operation of plants.
- Queensland, South Australian and Western Australian households continue to lead in the proportion of homes with rooftop solar.
- Energy storage gains popularity as part of state and territory energy policy - Northern Territory, ACT, Capital Territory, South Australia, Victoria and Queensland are rolling out or planning for battery storage to provide greater grid security. In December 2017, SA completed construction of world's largest lithium ion battery storage facility at the Hornsdale Wind Farm in collaboration with Tesla, which reportedly is performing well and delivering rapid response to change in frequency.

Tasmania (TAS):

- **Policy**

  The Tasmanian Government has committed to 100% renewable energy by 2022 and net zero emissions by 2050.

- **Renewable power**

  More than 90% electricity in Tasmania is generated from hydro power and it has the second highest capacity of new renewable energy per person (excluding large hydro), after South Australia. Tasmania's major hydro resources are ideally positioned to supply large-scale pumped hydro energy storage to the mainland grid as renewable supply increases and coal plants close in future. Pumped hydro energy storage schemes predicted to deliver up to 2,500MW of power are also being considered by ARENA.

- **Household solar penetration**

  13.2% of Tasmanian households have solar PV.

Queensland (QLD):

- **Policy**

  In July 2017, the Queensland Government announced a new emissions target to achieve net zero emission by 2050, in addition to its target of 50% renewable energy generation by 2030.

- **Renewable power**

  Queensland has experienced strong growth in its large-scale renewable energy industry, with almost 1,200MW of projects either under construction or having finalized commercial arrangements as of July 2017. Australia's largest solar power plant has also been approved near Wandoan in Queensland and when built, the 1,000MW solar farm will be among the largest solar power plants in the world. The Powering Queensland Plan, worth A$1.16 billion (released in 2017), aims to deliver stable energy prices, ensure long-term security of electricity supply, transition to a cleaner energy sector, create new investment and jobs, improve large-scale renewable project facilitation, planning and network connection.

- **Household solar penetration**

  It has the highest proportion i.e.32% of households with solar PV and target to install 1 million solar rooftops or 3,000MW of solar photovoltaics by 2020.

Victoria (VIC):

- **Policy**

  In 2017, Victoria government legislated its renewable energy target of 25% by 2020 and 40% by 2025 and a net zero emissions target by 2050. The aim of Victoria's targets is to encourage investment in renewable energy and increase the number of jobs, particularly in regional Victoria. The Victorian Government has proposed a reverse auction scheme to achieve its renewable energy targets, designed to deliver up to 1,500MW and 5,400MW of new, large-scale renewable energy projects by 2020 and 2025 respectively. Additionally, the state is also imposing some restrictions on fossil fuels which are a key driver of climate change and results in very high emissions in the state. For example, the Victorian Government has imposed a gas exploration moratorium which puts a permanent ban on onshore unconventional gas exploration in the state, with a moratorium on conventional onshore gas exploration until the end of June 2020.

- **Renewable power**

  Has successful large scale renewable projects in place which include the 30MW Kiata Wind Farm and the 66MW Gellibrand Wind Farm that commenced operation in late 2017 and mid 2018 respectively. A proposal for a 250-wind turbine, 2000MW offshore wind farm by Offshore Energy Pty Ltd was presented in 2017 to the Victorian government, which if built, could potentially provide 18% of Victoria's electricity needs, capable of powering 1.2 million homes.

- **Household solar penetration**

  Victoria has 15% of households with solar PV.

New South Wales (NSW):

- **Policy**

  The state has witnessed one of the most dramatic positive shifts in policy support for renewable energy since 2016. In November 2016, the NSW Government announced its plan to reach net-zero emissions by 2050 and The NSW Renewable Energy Action Plan was developed to support the achievement of the national target of 20% renewable energy by 2020. In 2017, the state government allocated A$500 million from its Climate Change Fund over the next five years to help drive investment in making the transition. The government consulted on a range of initiatives including those aimed at attracting investment in new generation capacity and ensuring energy security.

- **Renewable power**

  New South Wales had the greatest capacity of new renewable energy under construction in 2017, which amounted to 1,018MW of large-scale renewable energy. This included five solar farms that were awarded funding under the Australian Renewable Energy Agency's Competitive Solar Round, boosting NSW's lead in large scale solar. A sixth solar farm is under construction near Goulburn and will be Australia's first solar project to be co-located with a major wind farm, making efficient use of the existing network and demonstrating a more reliable and diverse renewable energy model.

- **Household solar penetration**

  15% of households with solar PV.

Western Australia (WA):

- **Policy**

  Despite its excellent renewable energy resources, Western Australia has lagged behind other states on renewable energy. It is the only state or territory without a target to increase renewable energy or achieve net zero emissions by 2050.

- **Renewable power**

  Although there is an absence of a formal renewable energy and emissions reduction targets, the state government has committed to investing in research into renewable energy and battery technology. A commitment of A$19.5 million has been made to renewable energy projects in Albany including the deployment of wave energy technology, development of common user infrastructure to facilitate connection of wave energy with the State's electricity grid, and the establishment of a Wave Energy Centre of Excellence.

- **Household solar penetration**

  The third highest proportion (25.4%) of households with solar PV.

Northern Territory (NT):

- **Policy**

  After very little progress in the past few years, pursuing a 50% renewable energy target by 2030 is a major step forward for the Northern Territory, where no specific targets or policies were in place to encourage renewable energy. In 2017, a panel of experts was established, which formulated a Roadmap to Renewables report to provide the Northern Territory Government with advice, options and recommendations on how best to achieve the target.

- **Renewable power**

  The Northern Territory has also taken steps on energy storage. At the end of 2017, the state government-owned electricity provider installed a 5MW battery storage system in Alice Springs to support increased generation from solar power.

- **Household solar penetration**

  Has the lowest proportion i.e11% of households with solar panels, despite the high electricity cost.

Topic Box 1.1: Criticisms of National Energy Guarantee policy

Despite the government's push towards implementing the National Energy Guarantee (NEG), the policy is facing opposition from some of the states and criticisms from renewable experts and industry analysts.

- **Emissions obligation proposed under Australia's National Energy Guarantee lacks ambition; various activists group, industry experts and representative bodies are urging the state governments to torpedo the policy in its current form or lend support only on basis of select conditions.**
  - The policy propagates deployment of 2,500-6,700 MW of renewable energy projects between 2020-2030, however, since 4,300 MW of large-scale renewable energy projects are already in process currently, this implies no or very little renewable energy projects to be installed between 2020-2030.
  - Moreover, the Energy Security Board designed the NEG policy assuming the lower or the bare minimum limit of 2030 target i.e. 26% cut in energy sector emissions from 2005 levels by 2030. However, the policy does not yet have any provision for reducing the emissions beyond the stipulated level and thus, is not aligned to the comparatively robust renewable energy target set by some of the states - John Grimes, the chief executive of the Smart Energy Council (which represents the solar industry) was of the opinion that NEG's emissions reduction target for electricity of 26% on 2005 levels by 2030 was considerably less ambitious than Queensland's state target of achieving 50% renewables by 2030.
  - State-based renewable energy schemes such as the Victorian Renewable Energy Target and the Powering Queensland Plan will be acknowledged under NEG, however, any new renewable energy capacity installed as part of these schemes will be incorporated into the national emissions reduction target of 26%. A number of states have expressed opposition to this requirement, claiming that it will result in some states taking on more of the emissions reduction burden than others.
  - As an alternate, the Smart Energy Council as well as environmental groups including Australian Conservation Foundation put forth that, the states should consider providing support only on the condition that the Australian government increased the ambition in the emissions reduction effort, otherwise they should deal themselves out of driving emissions reduction.
- **The policy has also been criticized for not being inclusive enough in its approach.**
  - As a part of the proposed plan, NEG will apply only to National Electricity Market (NEM) which excludes Western Australia and Northern Territory – this implies that post 2020 these two regions have no emission reduction targets in place.

Implementing the NEG requires consensus from the states and territories, with any jurisdiction having the power to reject the policy. It is also possible for jurisdictions to abstain in deliberations of the COAG energy council. In an effort to pacify the situation, a range of groups, from the Business Council of Australia to the National Farmers Federation, to the Clean Energy Council (the peak body for the renewables industry), is urging the government and the states to come to terms, and settle the decade-long climate and energy wars.

2-Energy Transition

2017 was overall marked as a year of positive developments in the renewable energy front, despite the marginal decline of 2% in renewables share, owing to low hydro output

- Clean Energy Regulator announced that there are enough projects now committed to meet the 2020 Renewable Energy Target: 700 MW of renewable projects were completed in 2017 and seven times that amount were already under construction by the end of the year.
- Generation in renewable energy were largely driven by wind and solar, both of which recorded increase in percentage share over 2016 – for the first time in 2017, contribution of wind in nation's electricity generation, was at par with hydro, both accounting for about 6% share.
- Tasmania continues to lead in renewable energy with 88% penetration rate – however, lower rainfall in catchment area pushed down its hydro output and therefore the penetration rate from 2016.

Boom in large-scale renewable projects, driven by declining prices of solar and wind

- Large scale solar and wind projects attracted investment worth A$11.7 billion in Australia i.e. 150% higher than 2016.
- Tremendous amount of activity witnessed in wind sector with 547 MW of new capacity added in 2017- the third highest amount in the history of the Australian wind industry.

Robust growth in rooftop solar industry

- More than 1.1 GW of solar PV was installed in the small-scale market in 2017, eclipsing the previous best record in 2012.
- As per data by Clean Energy Regulator, more than one in five Australian households now have solar panels installed on their roof, which represents the highest rate per capita in the world.

Commencement of operation of the much touted Tesla battery at Neoen's Hornsdale Wind Farm in South Australia

- Installation of the world's largest lithium-ion battery in 2017 thrust energy storage into spotlight.
- It already proved its mettle responding quickly when the coal-fired Loy Yang power plant tripped and went offline in December last year, effortlessly outpacing traditional generators to help stabilize the electricity system.

As the momentum for adoption of renewable energy especially around solar and wind continues to build through 2018, Australia appears to be well-positioned to meet its 2020 Renewable Energy, mostly driven by state-level initiatives.

Renewable Energy Generation in Australia

Clean energy industry is on the verge of a major breakthrough – 16 renewable energy projects were completed in 2017, which amounted to 701 MW of capacity and 34 renewable projects were under construction at the end of 2017, which is expected to generate 2,563 MW of capacity, on completion.

- Although 2017 was a record year for the renewable energy sector, contribution of renewable energy in Australia's total electricity generation fell slightly from 17.3% in 2016 to 16.9% in 2017 - this was largely because of a significant decline in hydro generation due to reduced rainfall in catchment areas.
- Wind and solar continued to drive electricity generation from renewable sources - both exhibited increase in their percentage share over 2016.
  - A key driver of investment in renewable generation has been the large-scale renewable energy, which has made a remarkable progress evident from the 450 MW of large-scale solar capacity that has now been built across the country, up from just 34 MW at the end of 2014. Additionally, 21 large-scale solar projects also commenced their construction at the beginning of 2018.
  - Rooftop solar experienced a robust growth in 2017 owing to growing interest from the commercial sector as well as a growing number of households investing in solar panels.
  - 2017 was a successful year for wind power as well, with 547 MW of new capacity installed and more than a dozen projects actively underway.

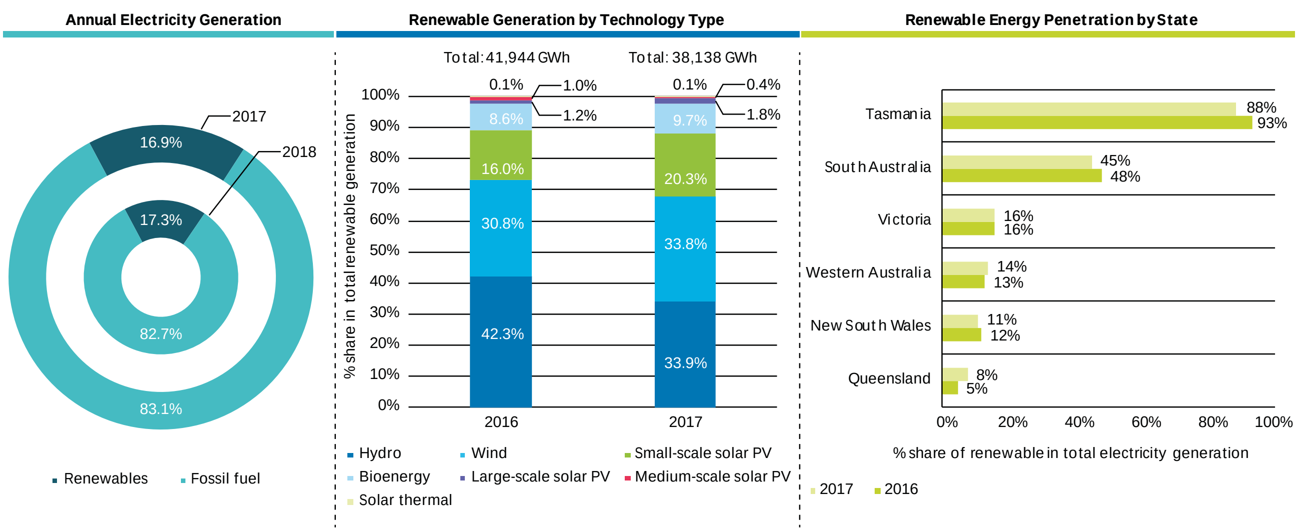
State governments have undertaken various initiatives to maximize their share of the billions of dollars in investment on renewable energy, as well as to help reduce emissions. Tasmania recorded the highest penetration in renewable energy, followed by South Australia.

Tasmania:

With its extensive hydro power network supplying more than 90% of the state's energy needs, Tasmania has traditionally been Australia's renewable energy leader. However, below average rainfall in catchment areas compared to previous year, resulted in lower penetration of renewable energy in 2017.

- In April 2017, Tasmanian government announced the 'Battery of the Nation' initiative which encourages undertaking studies and projects that would boost Tasmania's clean energy generation. As a part of the initiative, the state government is collaborating with ARENA and focusing on studies into three areas including – role of Tasmania in future NEM, pumped hydro storage assessment and hydropower system improvement.
- The state is currently undertaking feasibility studies which has the potential to double the state's renewable energy capacity from 2,500 MW to 5,000 MW through pumped hydro storage, wind farms and upgrades to existing hydro power facilities.
- New wind firms are also under development with the state's north-west being touted as 'Australia's wind farm capital' - The Robbins Island Renewable Energy Park is a proposal for a 450 MW project, with the possibility of being expanded to 1,000 MW , which would make the wind farm the largest in the Southern Hemisphere.

Figure 2.1. Electricity Generation: Renewable vs. Fossil



Source: Clean Energy Australia – Clean Energy Council (April 2018 and 2016)

South Australia:

- South Australia had set a robust target of 50% renewables by 2050, which it had almost achieved in 2017, with 45% of the state's electricity coming from renewable sources. However, renewable energy penetration recorded a decline over 2016, primarily owing to two factors:
  - Restrictions on wind output by Australian Energy Market Operator (AEMO): In the wake of a massive blackout in 2016, AEMO introduced a rule since July 2017 that required a minimum amount of "synchronous" generation, which if not met would restrict the wind output to a maximum 1,200 MW unless four gas units are operating in the state: In July 2017, wind output was curtailed thrice in the month as strong winds in southern states pushed wind generation very near to full capacity, but the withdrawal of one gas fired generator for few days led to scale back of wind power by one-fifth. However, currently AEMO is gradually relaxing the constraints as it undertakes more studies on how the system can be managed with growing share of variable renewables – in late 2017, it published a notice increasing the maximum wind output to 1,295 MW from 1,200 MW.
  - Gas deal signed between Engie and Origin Energy, amid significant pressure from the Federal government : The deal was intended to meet the gap in energy supply post closure of Hazelwood coal plant, which supplied electricity to SA through the interconnector. As a part of the deal, Engie's Pelican Point generator started operating both its units continuously from second half onwards which resulted in two to three times as much as gas powered electricity generation in the second half of the year.
- In March 2018, the state elected a Liberal government which is currently focusing on two key elements including - a A$200 million interconnection fund to improve the state's connectivity with the National Electricity Market and a A$100 million household battery program offering means-tested grants.
- The new government has also promised support for storage at the household level and has backed the 220 MW Bungala Solar Farm situated near Port Augusta. Once completed, it will be Australia's largest solar farm, generating enough electricity to power 82,000 Australian households.

Victoria:

- Victoria started undertaking and driving the transition to renewable energy more seriously from August 2017, when it legislated its state based renewable energy target of 25% by 2025 and 40% by 2050.
- The state government intends to meet these targets through the Victorian Renewable Energy Auction Scheme, which is a reverse auction to fund 650 MW of new renewable energy, with 100 MW of this specifically for large-scale solar. The scheme is the largest renewable energy reverse auction in Australia and will result in a significant increase in renewable energy projects in Victoria.
- It is a condition of the auction that the successful projects will begin commercial operation before the last quarter of 2020, with an overarching goal of reducing greenhouse emissions by 16% by 2035, and eventually achieving its legislated net-zero emissions target by 2050.

Western Australia:

- WA has traditionally lagged behind other states in terms of renewable energy target, but during 2017 more than 1000 MW of wind and solar projects were seeking connection approvals and finance in the state's south-west.
- In late 2017, the WA government announced that state-owned power utility Synergy will set up a green power fund with investment from the Dutch Infrastructure Fund.
- The Australian Energy Market Operator (AEMO) estimates that another 700 MW of new renewable energy capacity will be required to meet WA's share of the Renewable Energy Target.

NSW:

- The government's Climate Change Fund Strategic Plan aims to double the state's level of renewable energy capacity to more than 10,000 MW by 2021 - NSW was one of the leading states for new large-scale renewable energy projects at the beginning of 2018, with the government approving 11 large-scale solar energy plants in the previous 12 months.
- Notable projects currently under construction or beginning in 2018 include the 170 MW Finley Solar Project in the Riverina, the 270 MW Sapphire Wind Farm in New England and the co-located White Rock Wind and Solar Farms, which will generate almost 400 MW of renewable energy upon completion.

Queensland:

- In 2017, only eight percent of Queensland's electricity came from renewables, however, the state is poised to witness a remarkable growth in the share of renewable electricity generation over the coming years, driven by variety of policies and programs that are underway to help the state meet its Renewable Energy Target.
- As part of the A$1.16 billion Powering Queensland plan, the government's Renewables 400 initiative held a reverse auction for up to 400 MW of new renewable energy capacity, including 100 MW of new storage. Renewables 400 attracted 115 proposals from 79 businesses, adding up to more than 9000 MW of new capacity, which is more than 20 times the amount needed.
- Several areas of Queensland have emerged as large-scale solar hubs, including Townsville in North Queensland and the Darling Downs west of Toowoomba ; it also has the largest number of rooftop solar installations among any state or territory, as well as eight of the top ten solar postcodes in the country.

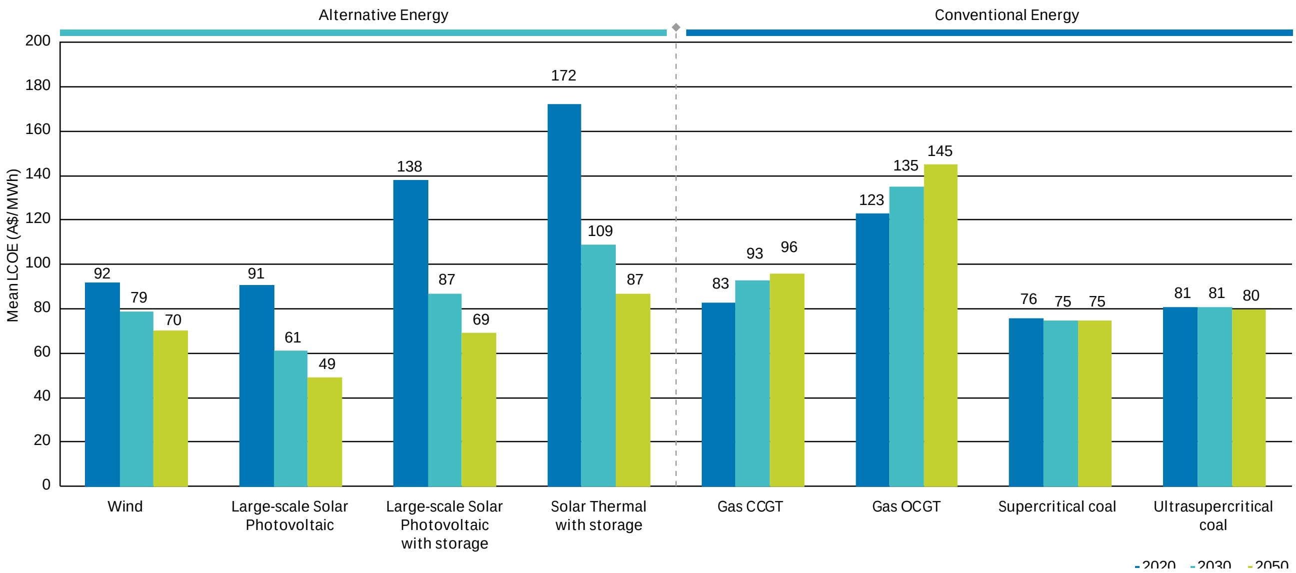
Investments in Renewable Energy

Australia is witnessing an unprecedented construction boom in large-scale renewable energy projects. According to Bloomberg New Energy Finance data, large-scale wind and solar project activity pushed investment in Australia up 150% to a record A$11.7 billion in 2017

Several factors have contributed to this spike in investment including:

- **Extraordinary cost reductions in renewable energy:**
  - New renewable energy such as wind and solar power is now cheaper than new coal or new gas plants and the trend is likely to continue through 2050.
  - The cost of renewable energy in power purchasing agreements (PPAs) is also steadily declining making it a highly competitive option for businesses seeking contracts for energy supplies. For example:
    - During 2017, Origin Energy sold the Stockyard Hill Wind Farm to Goldwind Australia for A$110 million and agreed to buy all the power generated by it for less than A$60/MWh.
    - Meridian Energy signed up for more than twice the amount of renewable energy it had intended in early 2018 while negotiating PPAs (Purchasing Power Agreements) for its retail business Powershop Austral.
- **Additional support from the Australian Renewable Energy Agency and the Clean Energy Finance Corporation:**
  - Clean Energy Finance Corporation (CEFC) have made commitments of more than A$4.3 billion for projects worth over A$11 billion (as at 30 June 2017).
  - Australian Renewable Energy Agency (ARENA) have made commitments of more than A$1 billion coupled more than A$2.5 billion in co-funding (as at 30 June 2017).
  - ARENA also recently announced a A$370 000 funding for a micro-grid designed to test the feasibility of a local energy marketplace of connected energy users who can buy and sell locally produced renewable energy. The virtual micro-grid will incorporate solar PV serving around 200 dairy farms.
- **Various state and territory government initiatives:**
  - The government is supporting carbon capture and storage (CCS) to capture emissions from power plants and industrial sites. It has also introduced a Bill to the Parliament to remove the CEFC's prohibition from investing in CCS technology.
  - South Australian government has invested up to A$110 million for a new concentrated solar thermal power plant in Port Augusta and supplementing funding would also be made available through ARENA and the CEFC, if required.

Figure 2.2. Projected Average Levelized Cost of Energy (A$/MWh)



Source: Clean Energy Australia — Clean Energy Council (April 2018 and 2016)

By 2050, cost for alternative energy (including wind and solar) is expected to decline by an average of 40%; highest decline is likely to be witnessed in solar PV with storage and solar thermal with storage segments.

- Cost for both large-scale solar PV with storage and solar thermal with storage is expected to fall 37% by 2030 and a further 20% by 2050.
- Significant cost decline in both these segments indicate expansion opportunities for energy storage market, driven by favorable public policies and innovation around storage technology.

With a substantial project pipeline, the country is well placed to experience a robust year in 2018 and is on track to meet its 2020 Large-scale Renewable Energy Target.

- The Clean Energy Regulator (CER) had previously estimated that approximately 6,000 MW of large-scale generation capacity has to be built between 2016 and 2019 to meet the target of 33,000 GWh of renewable energy by 2020.
- 6,532 MW of new large-scale generation have been announced since 2016, and in 2017, CER chair David Parker highlighted that Australia has already reached a major milestone ahead of schedule.
  - Out of 6,532MW of new large-scale generation announced, close to 96% i.e. **6,239 MW (amounting to 42 projects) are fully financed and are currently under construction or expected to commence** in 2018.
  - Furthermore, the CEC highlights that projects in the 2018 construction pipeline (i.e. currently under construction or will commence soon) are poised to deliver about **A$9.7 billion in investment, with a total of 5,354 direct jobs created at the construction sites.**

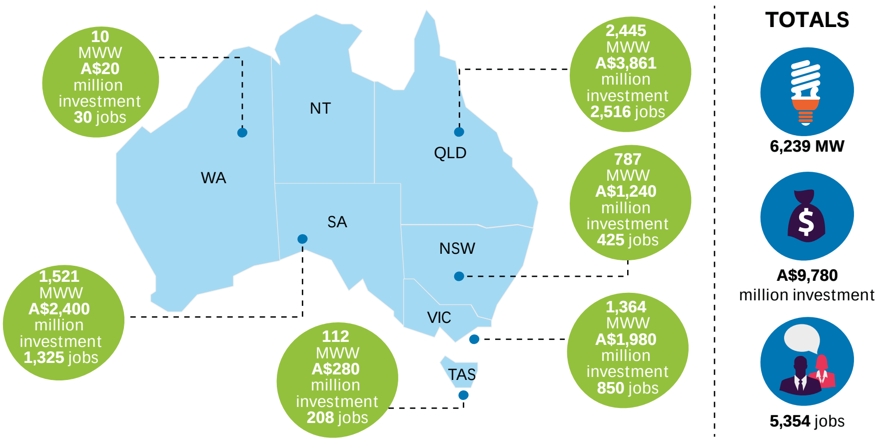
Queensland will witness the bulk of the construction, followed by South Australia, Victoria and NSW.

- Of the 42 large-scale renewable projects that reached financial closure in 2017 and currently in 2018 construction pipeline, 18 are from Queensland, followed by South Australia with eight and Victoria and New South Wales with seven projects each.
- Western Australia and Tasmania currently have one project each in the construction pipeline.
- The total of 42 also incudes 12 projects across the states of NSW, Queensland and Western Australia that were funded by ARENA Australian Renewable Energy Agency (ARENA) through a A$91.7 million grant in 2016.

Solar is an important emerging player in the energy mix and solar farms will continue to proliferate across Australia beyond 2018.

- Smart Energy Council estimates that the nation's large-scale solar capacity is set to soar by 2.5 to 3.5 GW, with nearly 30 new solar farms scheduled to come online in 2018 alone, the majority being in Queensland and NSW – this estimate is aligned to the statistics released by Clean Energy Council, which states that 3.1 GW of solar are under construction or will commence soon in 2018, with Queensland accounting for nearly 46% of the new capacity.
- Meanwhile, merchant development[1] is gathering pace, indicating the attractive economics of large-scale solar in Australia. Although merchant projects have typically been difficult to finance in Australia, given the risk around future energy prices and the requirement from most major Australian lenders for a PPA, the market now seems to have found the way to access funds for projects without off-take[2] partner. More projects are starting to proceed on a merchant basis, often as a result of accessing funds from overseas in the form of private equity.

Figure 2.3. Large scale renewable energy projects under construction or starting in 2018



Source: Clean Energy Australia – Clean Energy Council (April 2018)

Outlook for small-scale renewable energy also looks promising- almost 1.1 GW of rooftop PV was installed in the small-scale market in 2017 and given the rate at which electricity prices are increasing, solar industry is expected to exhibit a strong growth in 2018 as well

- Australian businesses, especially the SMEs are finding it difficult to secure affordable long-term contracts for their electricity, making solar and storage increasingly attractive options, particularly with the range of finance options that are now available like merchant development - this medium-scale section of the market has been driving a large part of the growth over the last few years.
- In addition, households in outer suburbs and regional towns will continue to turn towards small-scale renewable energy to help protect them from future price hikes.
- As per Solar consultancy SunWiz, high electricity prices coupled with good momentum in the sector and a robust market is likely to drive rooftop solar PV installation in residential and SME market to more than 1.2 GW in 2018.

The rooftop solar sector has reported a shortage of qualified electricians in some areas, in the backdrop of unprecedented level of industry activity

- At the end of 2017, many established solar retailers were reporting that the increased level of activity sometimes made it difficult to find enough qualified electricians to complete all the work that was coming in, and these market conditions helped trigger a steady increase in the number of accredited solar installers.
- As per statistics released by the Clean Energy Council, the number of installers accredited by end of 2017, had grown to 4,941 which was slightly more than the 4,824 registered at the end of 2012, which was the previous highest year for the sector.
- The number of new accredited installers per month increased from 60 in 2016 to 96 in 2017, registering a 60% growth.

The way forward, beyond 2018

- Considering the growing confidence to invest in renewable energy, evident from the large-scale pipeline, the dynamics will inevitably change once the 33,000 GWh target is met.
- The market could drop off for a while in 2020, but the build out is most likely to continue being fueled by other drivers like closures of coal fired power stations and increased investment from industrial users and large corporates as they realize the cost benefits of solar and build dedicated facilities.
- Moreover, the cost of large-scale generation certificates[3] under the Large-scale Renewable Energy Target (LRET)[4] is likely to decrease, as the amount of renewable energy built or under construction is capable of generating certificates in excess of the volume needed to meet the 2020 RET, thus resulting in excess supply and price fall.

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1 Merchant developers build commercial buildings and sell it out for profit

2 Off take is an agreement that is negotiated usually before the construction of a natural resource facility in order to secure a market for the future output of the facility. The off-take partner or lender wants a guarantee that some of its product will be sold and negotiates with the buyer to purchase or sell a portion of its future production

3 Large-scale generation certificates (LGCs) are based on the amount of eligible renewable electricity produced by the generators above their baselines. These certificates act as a form of currency and can be sold at a negotiated price to the retailers, who are required to surrender a set number of certificates to the Clean Energy Council (CEC) each year

4 LRET is a scheme that encourages investment in renewable power stations to achieve 33 000 GWh of additional renewable electricity generation by 2020. Power stations accredited in the LRET are able to create LGCs (Large Scale Generation Certificate) for electricity generated from that power station's renewable energy sources and can sell of the LGCs to liable entities (mainly the retailers) and help them meet their compliance obligation with Clean Energy Council

Energy Storage Investments in Australia

The most crucial milestone in energy storage was achieved in 2017 with the construction and commissioning of the world's biggest lithium-ion battery in South Australia, installed by Tesla and owned by Neoen.

- The lithium-ion battery is situated alongside the Hornsdale Wind Farm and has been constructed in partnership with the South Australian Government and Neoen, the French company that owns the wind farm.
- The battery has a total generation capacity of 100 MW and 129 MWh of energy storage - this is reportedly capable of powering more than 30,000 homes.
- It is charged using renewable energy from the wind farm and then delivers electricity during peak hours to help maintain the reliable operation of South Australia's electrical infrastructure.

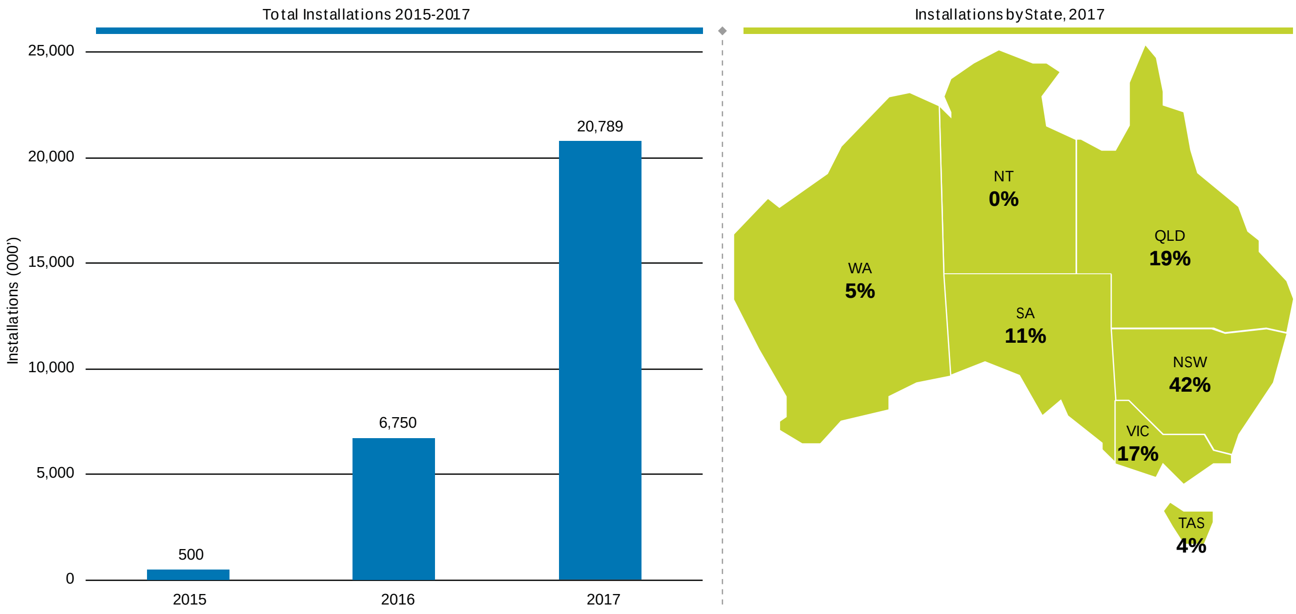
Impact of the installation:

- Shortly after its official commissioning in December 2017, the Tesla battery proved its worth responding quickly when the coal-fired Loy Yang power plant tripped and went offline, delivering 100 MW into the national electricity grid in 140 milliseconds.
- Tesla also reported a surge in sales of its commercial energy storage products and has won a number of other contracts since then, including the 20 MW battery that will be linked to the 196 MW Bulgana Wind Farm in Victoria, and will provide Australia's biggest greenhouse with 100% renewable energy.

The way forward - adoption of battery storage technology expected to gain further traction in coming years

- German battery maker Sonnen announced that it would be transferring its operations from Sydney to Adelaide - it will manufacture 50,000 energy storage systems in Adelaide over five years to create a Virtual Power Plant (VPP) under a five year deal with the South Australian Government.
- A number of companies are also either exploring or actively planning to build new pumped hydro facilities, including Genex Power's project at Kidston near Townsville in North Queensland and Tilt Renewables' pumped hydro plant project at a decommissioned quarry north of Adelaide.

Figure 2.4. Residential energy storage system installation



Source: SunWiz, 2018 Battery Market Report, March 2018

Household battery activity is gaining momentum in the country, driven by VPP and other state government initiatives like 'Battery of the Nation' initiative by Tasmania. Investment in domestic battery storage systems is expected to increase as prices come down to a level where they become affordable for average home owners

- According to solar consultancy firm SunWiz, 20,789 energy storage systems were installed in 2017, representing a three-fold increase on the installations in 2016.
- On a state-by-state basis, nation's highest storage installation was estimated to be in NSW, followed by Queensland, Victoria and South Australia.
- SunWiz predicts that 300 MWh of distributed systems will be built across 33,000 installations, along with 136 MWh of projects by the end of 2018 – this is expected to more than double the number of storage systems installed since 2017.

Technology Profiles: Hydro

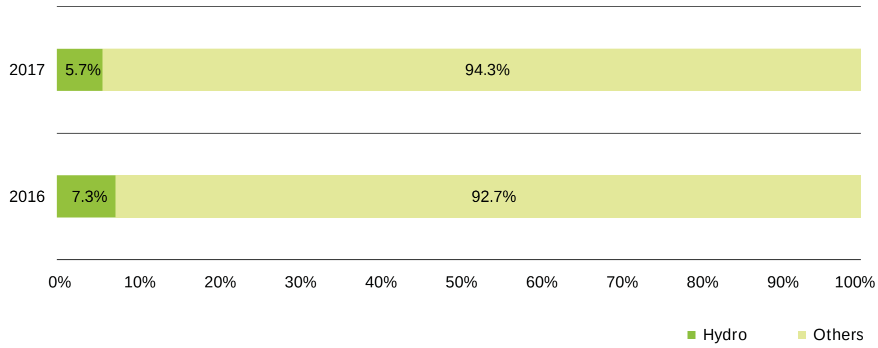
Hydro power has traditionally been Australia's leading form of renewable energy and it accounted for almost 34% of Australia's clean energy and 5.7% of total electricity generated in 2017. There are more than 120 active hydro power stations in Australia, with most of the nation's hydroelectricity generated by Hydro Tasmania's network of power plants and the Snowy Mountains Hydro Scheme in New South Wales.

- Overall hydro output in 2017 was low compared to the previous year principally due to below average rainfall in catchment areas compared with the year before.
- With the support of ARENA, Australian National University (ANU) has identified 22,000 potential pumped hydro sites across Australia, mostly in NSW and Victoria – according to ANU, only the top 0.1% of these are sufficient to help Australia attain the 100% RET.
- Initial studies from the 'Battery of the Nation' initiative of Tasmania have identified significant pumped hydro potential in the state and is currently examining four large and nine small scale pumped hydro projects, boosting its capacity and creating a battery for the mainland.
- South Australia is undertaking a feasibility study into a pumped hydro facility at Cultana that would be the first in Australia to make use of seawater.
- Queensland plans to redevelop the Kidston mine site which will co-locate a large scale solar farm with a large scale pumped hydro project.

Proposal to expand the Snowy Hydro Scheme likely to be a game-changer for renewable energy in Australia

- In March 2017, Snowy Hydro announced plans to carry out a A$29 million feasibility study into a pumped hydro expansion of the Snowy Mountain Scheme which originally began in 1949 and generates on average around 4,500 GWh of clean energy each year.
- The feasibility study released in December 2017, showed that Snowy 2.0 is both technically and financially viable, and when complete, it will increase the Snowy Hydro Scheme's generation capacity by up to 2,000 MW, and at full capacity will provide approximately 350,000 MWh of energy storage.
- Snowy 2.0 will act like a giant battery by absorbing, storing and dispatching energy – Pumped hydro works like a conventional hydro-electric scheme, but instead of releasing the water after energy generation, it will recycle or pump water back to the upper reservoir and store it there for further reuse at the time of peak demand. Snowy 2.0 can also absorb excess wind capacity overnight to pump water uphill to reservoir, before letting it down again to spin turbines and generate electricity at times of peak demand.

Figure 2.5. % share of hydro in total Australian electricity generated in 2016 vs. 2017



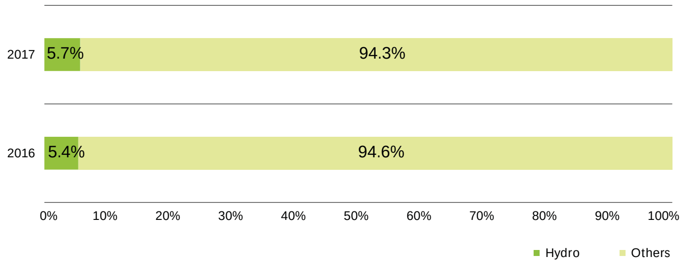
Source: Clean Energy Australia – Clean Energy Council (April 2018 and 2016)

Technology Profiles: Wind

For the first time in 2017, wind contributed an identical amount of Australian electricity as hydro energy - it accounted for almost 34% of Australia's clean energy and 5.7% of total electricity generated in 2017.

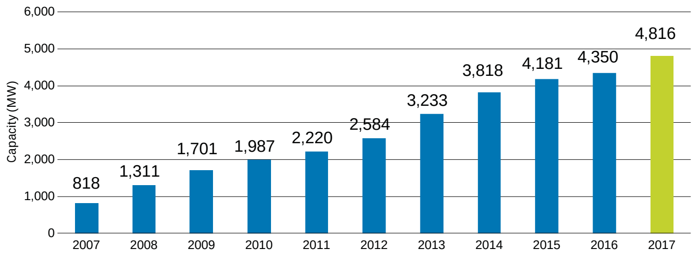
- 2017 saw a tremendous amount of activity in the wind sector, with 15 new wind farms either under construction or financially committed at the end of the year.
- 547 MW of new capacity was added in 2017 (the third-highest amount added in the history of the Australian wind industry), which amounted to 4,816 of installed capacity at the end of 2017.
- The largest project in 2017 was the Ararat Wind Farm, with Neoen's Hornsdale 2 and 3 projects being the significant additions.
- On a state-by-state basis, South Australia accounted for the largest share of 38% in total wind generated by the nation in 2017, followed by Victoria (32%) – rest of the states including Tasmania, Western Australia, NSW & ACT together accounted for 30% share in total wind generation.

Figure 2.6. % share of wind in total Australian electricity generated in 2016 vs. 2017



Source: Clean Energy Council (April 2018)

Figure 2.7. Cumulative installed wind capacity (in MW)



Source: Clean Energy Council (April 2018)

Technology Profiles: Small-scale solar PV

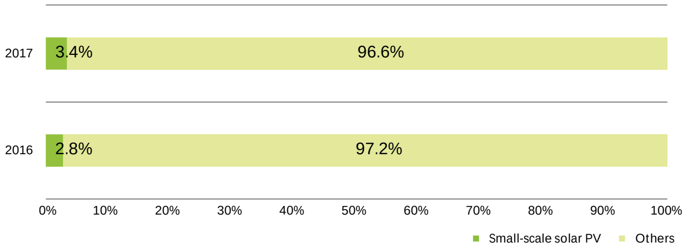
2017 was a record year for Australia as it achieved a total installed capacity of more than 1.1GW, surpassing the previous best in 2012. Small-scale solar PV accounted for about 20% of Australia's clean energy and 3.4% of total electricity generated in 2017.

- In 2017, installed capacity of the solar PV systems increased by 50%, whereas the number of annual new-built increased by only 35%. This is because fewer systems with larger capacity were installed i.e. more commercial sized systems were installed, targeting the small and medium sized businesses.
- Annual installations rebounded in 2017, largely driven by falling price of solar panels and the rising cost of grid power.
- In 2017, Queensland had the highest penetration both in terms of number of annual solar PV and capacity installed - Eight out of the top ten solar postcodes were in Queensland, continuing a trend of several years.
- NSW was not far behind with investments flowing in from the agriculture sector - Leading egg producer Pace Farms invested A$3.2 million in three separate solar projects across its New South Wales operations in 2017.
- South Australia which already has a well-developed rooftop solar PV industry had relatively lesser new installations in 2017, compared to other regions.
- The strong growth witnessed in small scale solar sector has translated into increased employment opportunities, with the number of new Clean Energy Council Accredited Installers per month growing by 60% in 2017.

Figure 2.8. Regional Split 2017

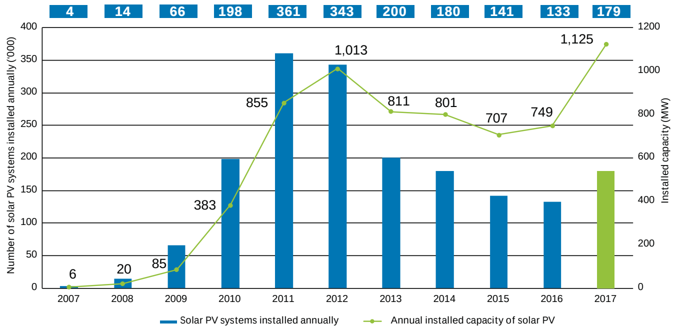
Regional Split: 2017		
States	**Solar PV installed annually (% share)**	**Annual installed capacity (% share)**
QLD	27%	28%
NSW	25%	23%
WA	19%	17%
VIC	17%	17%
SA	9%	10%
TAS	1%	1%
NT	1%	1%
ACT	1%	1%
TOTAL	**179,457**	**1,125 MW**

Figure 2.9. % share of small-scale solar (up to 100 KW) in total Australian electricity generated in 2016 vs. 2017



Source: Clean Energy Council (April 2018)

Figure 2.10. Annual solar PV installations and installed capacity (up to 100 KW)



Source: Clean Energy Australia – Clean Energy Council (April 2018)

Topic Box 2.1: Revolution in rooftop solar

Small-scale rooftop solar panel installations have been steadily increasing in Australia under the Renewable Energy Target. According to the Clean Energy Regulator, more than one in five Australian households now have solar panels installed on their roof, and this represents the highest rate per capita in the world.

- Rooftop solar experienced its best ever year in 2017 in terms of installed capacity and continues to gain momentum owing to growing interest from the commercial sector, as well as a growing number of households investing in solar panels.
- As of August 2017, the number of small-scale solar panel installations on Australian household roofs passed 1.8 million, with a capacity of six GW—enough to power more than 1.8 million homes or every home in Sydney.
- According to AEMO's forecasts, 25-40% of Australia's electricity will be coming from rooftops solar by 2040, and 45% by 2050.
- While the commercial sector has been the biggest driver of growth in the rooftop solar segment, organizations such as universities, schools and government bodies have also recognized the benefits of rooftop solar - Notable new projects commissioned in 2017 include Australia Post's 2.1 MW rooftop solar system at its Chullora sorting centre in Sydne- the largest single-roof solar system in Australia, and the installation of a 1.8 MW rooftop solar system at Charles Sturt University's Wagga Wagga campus.
- Recognizing the important role that communities and household solar play in Australia's transition to a low emissions economy, the Federal government announced the A$5million Solar Communities Program in 2017- this was aimed at providing funding for community groups in selected regions across Australia to install rooftop solar PV, solar hot water and solar, connected battery systems at their facility to reduce emissions, electricity cost and support transition to renewable energy.

While high penetration of rooftop solar is a positive outcome for Australia, this also presents significant operational challenges going forward, which needs to be addressed to ensure a reliable and affordable power supply

- Australian households, especially those with rooftop solar are expected to adopt more residential batteries to store solar energy, as their prices fall and the technology becomes more efficient - this increase in Distributed Energy Resources (DER) represents a huge disruption for the National Electricity Market.
- Compared to previous years, it is more difficult for AEMO now to predict the demand for electricity from households, given the rapid deployment of solar and batteries that the market operator has no visibility over – as a part of the national accreditation scheme, they can only track where rooftop solar is installed but not how much electricity is being generated. Therefore, AEMO faces the challenge of balancing supply and demand, and power flows system-wide.
- If these small scale assets are orchestrated collectively, it has the potential to displace the need for grid scale power stations and consequently cut the electricity bills, however, if these are not monitored and optimized fully, it could lead to instability in future Australian electricity system and even higher energy costs.
- In order tackle these plausible challenges, AEMO has proposed for developments in DER monitoring and management standards and also the way distributed resources are integrated. The key suggestions put forth include:
  - Incentivizing people to allow access to their solar and battery storage devices and appliances
  - New market rules to allow these unregulated assets to be properly valued as part of the energy mix.

3-Infrastructures & Adequacy of Supply

Thorough planning by AEMO ensured a robust system performance in the NEM during the summer of 2017/18– no consumers experienced interruptions to their electricity supply due to shortage

- AEMO had identified the need for additional resources to meet market demand during the summer of 2017/18 and accordingly undertook various initiatives to generate additional resources amounting to 2,000 MW- of this, 98% amounting to 1,974 MW was ultimately generated.
- The additional resources were sourced by:
  - Reopening three mothballed gas-powered-generators across South Australia, Queensland and Tasmania which led to generation of 833 MW of additional resources in NEM
  - 867 MW of additional resources was procured through demand response programs via Reliability and Emergency Reserve Trader (RERT).

In collaboration with Transmission Network Service Providers (TSNPs), AEMO completed all network upgrades and ensured network availability during summer of 2017/18

- Upgraded Heywood Interconnector and access to full capacity of the Murraylink Interconnector, both increased the capacity at South Australia and Victoria.
- All risk management activities pertaining to planned maintenance were completed before summer, to ensure continuous network availability.
- The number of unplanned transmission outages reduced significantly across states, compared to summer of 2016/17.

AEMO focused on various initiatives to improve operational efficiencies during the summer, especially related to demand supply forecasting

- AEMO is investing in tools, systems, on-site meteorologist and weather forecast suppliers for real time alerts, to improve their preparedness in case of adverse situations.
- Initiatives are being undertaken to improve visibility on Distributed Energy Resources (DER), in order to factor that into demand forecasting models – AEMO intends to continue improving its demand and supply forecasting models including forecasting peak demand with the help of machine learning techniques.
- AEMO is also focusing on refining its systems for solar forecast – it is exploring options like satellite imagery to improve the Australian Solar Energy Forecasting System (ASEFS), which provides forecast on large-scale solar farms and residential rooftop PV.

During the summer of 2017/18, AEMO successfully met the objective of delivering a secure, reliable cost efficient power system, by collaborating closely with TSNPs and other industry participants.

For summer 2018-19 and future years, AEMO aims to pursue further initiatives on improving forecasting mechanisms, ensuring provision of strategic reserves and unlocking potential of distributed resources.

Increased generation and demand resources in the NEM for summer 2017/18

In H2 2017, AEMO had identified the need for additional resources for summer 2017/18 to reduce the risk of load shedding arising from withdrawal and temporary discontinuation of some generation capacity from the market due to commercial reasons. Accordingly, it had planned action points to bring about 2,000 MW of additional resources to the NEM, of which ultimately 1,974 MW were made available. This included two major components.

Market generation resources worth 833 MW

After AEMO highlighted the potential supply shortfall for the summer of 20017/18, the market responded by returning previously mothballed gas-powered-generation (GPG) capacity worth 833 MW to service. This included:

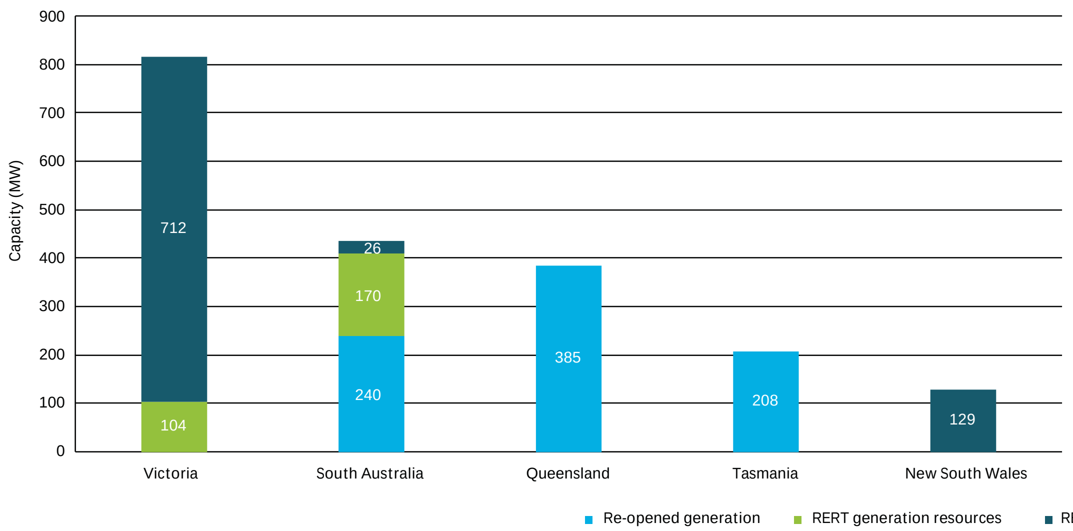
- Pelican Point Power Station (South Australia), which returned to full capacity from July 2017, adding 240 MW
- Tamar Valley Power Station (Tasmania), which returned its combined-cycle gas turbine (CCGT) plant to service from May 2017, adding 208 MW
- Swanbank E Power Station (Queensland) was operational earlier than projected, from December 2017, adding 385 MW.

Procurement of off-market demand and generation reserves worth 1,141 MW through existing RERT (Reliability and Reserve Trade) arrangements

RERT is a function conferred on AEMO under the National Electricity Rules (NER) that allows AEMO to reserve contracts and procure additional generation or load reduction capacity (not available to the market) if needed, to ensure reliability of supply and maintain system security.

- A total of 1,141 MW of resources was available via RERT in the summer of 2017/18, including generation resources worth 274 MW and demand resources worth 867 MW.
- **RERT generation resources :** Emergency diesel generation amounting to 170 MW in South Australia and 104 MW in Victoria offered to AEMO through the RERT tender process.
- **RERT demand resources:** Of the 867 MW of resources available through demand response programs, Victoria accounted for 712 MW, followed by 129 from NSW and 26 MW from South Australia. The total also includes 141MW delivered through the joint AEMO/ARENA demand response trial.
  - The demand response trial is a three year initiative that started in summer 2017/18 to pilot demand response projects across Victoria, SA and NSW. The trial has delivered 141 MW in year 1 and is expected to deliver 190 MW in year 2 and 202 MW in year 3.
  - The pilot projects require energy users from both commercial and industrial segments to volunteer to conserve their energy for short periods during peak demand events and dispatch the reserves to AEMO, in lieu of usage charges/monetary incentives under RERT agreement.

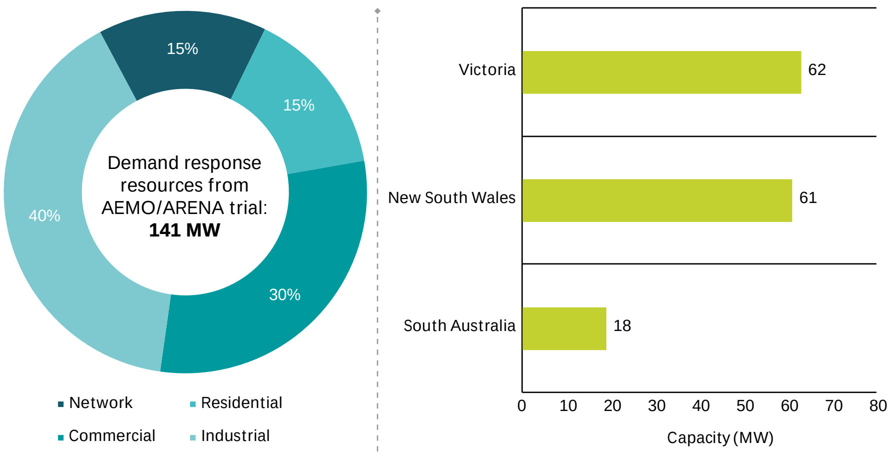
Figure 3.1. Additional resources for summer 2017/18 (in MW)



Total re-opened generation resources	833 MW
Total RERT generation resources	274 MW
Total RERT demand response resources	867 MW
TOTAL	1, 974 MW

Source: Summer 2017-18 operations review (May 2018)

Figure 3.2. AEMO/ARENA demand response trial for summer 2017/18, by sector and region



Source: AEMO Summer 2017-18 operations review, May 2018

Improved performance of generators and fuel availability during the period of summer

Generators cooperated with AEMO to minimize the amount of time of generation unavailability during summer due to planned maintenance outages. This included identifying planned outages and moving them to either before or after summer where possible

- Plant availability was accurately reflected in AEMO's market systems when generators were bidding to supply to the market.
- AEMO also observed a noticeable improvement in the accuracy of generator's bidding capacity under high ambient temperatures compared to summer 2016/17.
- Generator bids and plant/unit availability issues were communicated promptly and accurately with AEMO well in advance.
- As a part of the future plan, AEMO intends to continue working with generators to further enhance communication on plant availability, to improve market transparency and short-term reserve management.

Throughout summer, AEMO worked closely with industry participants to secure fuel supplies for gas, and hydro generation. Generators had sufficient fuel supply to operate, and any limits were reflected accurately in their bids

Gas

- Longford Gas Plant in Victoria provided the four southern NEM regions (excluding Queensland) with more than twice the amount of gas as all other south-east Australian gas plants combined during the past summer.
- The most significant threat to supply of gas for gas-powered-generation (GPG) occurred on 30 November 2017, when an unplanned outage at Longford reduced gas supplies to Victoria and was not capable of meeting forecast demand for GPG. In order to address this, AEMO issued a notice of a threat to system security in the Victorian gas market to increase gas supplies and enable GPG plants to continue operating to meet electricity demand.
- Three gas plants in Victoria were also affected by bushfires on 17 March 2018. However, sufficient wind generation production in the region nullified the effect of gas outages.

Hydro

- Despite the reduction in hydro output in Tasmania over 2016, water supplies were still sufficient for all hydro generation across the NEM to operate under their normal operating and market conditions.
- There was no report of any hydro generator unavailability due to lack of water, before or during summer.

AEMO plans to continue to work with generators and the AER on improvements to the provision of information on any fuel limitations that may impact capacity or reserves in the NEM. Quality information provided to AEMO is essential for the security and reliability of the grid, and to maximise transparency for AEMO in its decision-making.

Maximizing network availability and network upgrades in Australia

AEMO worked proactively with Transmission Network Service Providers (TNSPs) to ensure network availability during the critical summer period of 2017/18, which resulted in a robust system performance during that time.

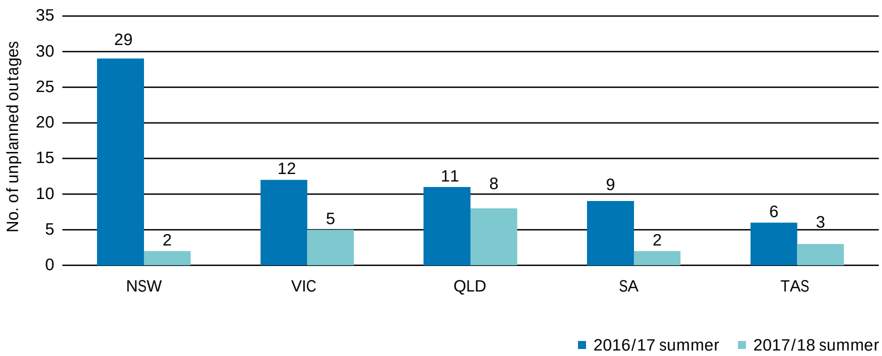
Through the Power System Security Working Group, AEMO and TNSPs undertook various action initiatives including:

- Completion of risk management activities like maintenance and easement clearing to reduce bushfire risk, before summer.
- No planned maintenance on days of high demand during summer, especially where lack of Reserves (LOR) shortfalls were identified.
- Completion of planned interconnector and other transmission network upgrades before summer, to support inter-regional energy transfers. This included:
  - Upgrade of the Heywood Interconnector with an aim to increase the capacity at both ends i.e. South Australia and Victoria, through commissioning of two control schemes that ElectraNet has started working on since late December 2017
  - Improving ability to access the full capacity of the Murraylink Interconnecter between South Australia (SA) and Victoria, during very high demand conditions.
- Introduction of proactive tripping schemes at SA wind farms to increase the power export capacity from SA to Victoria and ensure stable operation of the SA network in the unlikely event of the interconnector failing.
- In collaboration with TSNPs, AEMO is working to enhance the existing network through the implementation of other schemes that maximize the transmission capacity – like, short-term and emergency ratings of transmission elements that temporarily increase transfer capability under extreme operating conditions.

Outcomes of the actions for summer 2017/18

- Proactive collaboration between AEMO and TSNPs ensured maintenance for bushfire risk management was completed before summer, and there were no planned outages at peak times – AEMO allowed a total of 20 planned outages during summer and all of them were completed before the peak, sufficient reserves were available to meet demand, and thus outages did not affect any generation or interconnector capacity.
- Voltage maintenance in low loads condition emerged as a key issue during the summer periods, which AEMO managed without any breach of operating limits. However, it intends to pursue more efficient longer-term outcomes to avoid adverse market impacts.
  - It plans to collaborate with the Energy Security Board and AEMC to explore market design changes that incentivize avoidance of minimum load conditions.

Figure 3.3. Number of unplanned transmission outages in NEM regions over summer 2017/18 vs. 2016/17



Source: AEMO Summer 2017-18 operations review (May 2018)

There were unplanned transmission network outages in all NEM regions but none had an impact on reserve levels, system security, or reliability.

- There was a reduction in the number of unplanned outages across the NEM compared to summer of 2016/17 - this was largely owing to the efforts of the TNSPs in preparing their assets for the summer period.
- A reduction in the continuous rating of Basslink interconnector between Victoria and Tasmania, in early summer reduced some supply capacity in Victoria, however this risk was managed with the RERT AEMO procured as part of summer preparedness - Basslink's capacity reduced from 594 MW to 478 MW, and it remains at this level until further notice.

Operational Improvements

AEMO has been working with generators to improve its understanding of asset performance under severe operating conditions and also updated its forecasting tool to improve the visibility of risks in the power system and enable informed decision making. It has also implemented a range of additional training for the control room and support staff

Generator risk profiling

- AEMO is engaging with each scheduled generator in the NEM to better understand restrictions and risks of partial outages that could apply under high summer temperature conditions.
- This generator risk profiling will help AEMO better understand the risk of unexpected reductions in the availability of scheduled generating units on days of extreme heat.
- It is also implementing a more robust process for generators to communicate the recall capability of their out-of-service generating capacity, to improve decision-making on intervention strategies.

Lack of Reserves (LOR) Thresholds

- AEMO has been reviewing how LORs are defined and how they take into account risks of unexpected reductions in reserves due to factors not covered in the existing Rule. As a result, it has come up with a revised LOR definition, that will also take into account a measure of reserve forecast uncertainty due to the risk of partial outages of scheduled generating units, and weather-related changes that affect levels of demand and the availability of variable renewable generation.
- In October 2017, AEMO proposed changes to the National Electricity Rules to update the LOR definitions and therefore the criteria and thresholds for AEMO to intervene in the NEM during peak demands. AEMC approved this proposition and new rules are effective from February 2018.

Improved Forecasting Mechanism

- AEMO is continuously developing its operational forecasting capabilities (especially around variable output) which is crucial in maintaining the demand supply balance in the system amidst growing share of solar and wind in the nation's electricity supply. Current initiatives include:
  - Updating demand forecasting models to take into account latent heat build-up and the modelling of micro-climate zones leading to improved forecasting accuracy during extreme conditions.
  - Collaborating with weather forecasting suppliers to obtain detailed alerts on weather-related events that could impact power system operation.
  - Developing tools and systems to provide real-time alerts when weather events cause forecasting uncertainty to increase.
  - Deploying a resident meteorologist (from the Bureau of Meteorology) at the AEMO office who can provide expert weather forecast advice directly to operational staff.
  - Rapid deployment of DER in the NEM presents challenge in short term forecasting. As a part of its future plan to address this issue, AEMO intends to:
    - Leverage machine learning techniques to procure solar generation forecasts for 100KW to 30MW facilities
    - Develop a Market Participant 5-minute forecast interface (MP5F) that will enable solar and wind facilities to submit five-minute self-forecasts
    - Model price elasticity for synchronized DER and demand response which responds to price signals
    - In March 2018, implemented a project to improve the Australian Solar Energy Forecasting System using satellite imagery – this is expected to improve the forecasting for summer 2018/19.

Operator Training

- Increased operating training requirement from four days a year to 120 hours a year with focus on topics like system restart, dealing with complex environmental impacts on the power system, reserve and contingency management-benefits of this commitment are expected to continue to be realized in the coming summers.
- The additional training provided to NEM operators ahead of summer was found to be valuable for the preparation for peak period. Through use of the NEM Simulator, operations staff were able to refine their skills and responses to simulated scenarios, which increased their situational awareness and ensured faster response time to events.

Topic Box 3.1: Additional jurisdiction actions in South Australia

AEMO, in collaboration with the local Transmission Network Service Providers and the South Australian government has been undertaking various initiatives to avoid repetition of the 2016 state-wide black out scenario, in events of peak demands

- In November 2017, AEMO reported on a range of actions that were underway arising from the South Australia black system which occurred in September 2016. A key focus of this work was to avoid a cascading failure of the South Australian power system in the event of an unexpected loss of the Heywood Interconnector, which connects South Australia to Victoria, using a control system called a System Integrity Protection Scheme (SIPS).
- On 21 December 2017, ElectraNet (the TNSP for South Australia) successfully completed the commissioning, and armed the automatic load shedding component of the South Australian SIPS- this materially reduces the risk of a black system in the event of the loss of the Heywood Interconnector. The basis of ElectraNet's design was the detailed power system analysis undertaken by AEMO.
- ElectraNet and AEMO intends to work more closely in 2018 to further enhance the SIPS, and explore opportunities for other technologies to participate in the system security services in South Australia.
- AEMO has also published recent studies outlining the minimum number of synchronous machines required to maintain system strength in South Australia. Operating procedures are currently in place to ensure a minimum number of synchronous generating units are in service in South Australia at all times, until a permanent technical solution (addressing system strength issues like non-synchronous plant stability, synchronous plant stability, operations of protection equipment and voltage management) is commissioned, which is expected to be operational by mid-2020. The permanent technical solution proposed by AEMO refers to a framework that intends to understand how a portfolio of technology can support the services expected to be delivered by a robust power system. The portfolio of technical solutions are related to:
  - Supply side, which includes controlled generation from synchronous and non-synchronous generators
  - Network side, which includes transfers between regions (AC interconnection, DC interconnection), transfers within regions (transmission and distributed networks) and stabilizing devices (like grid reactor, grid capacitor, static synchronous compensator and synchronous condenser)
  - Demand side, which includes solar PV, battery storage, load from large industrial, residential and commercial segments.
- AEMO's operating procedures identify the conditions and generator dispatch combinations needed to satisfy the system strength requirements. Where natural market outcomes do not deliver the specific needs for system strength, AEMO has powers under the National Electricity Law and National Electricity Rules (NER) to direct the necessary resources into service - for example, in order to avoid the repetition of the massive blackout of 2016 in South Australia, AEMO introduced a rule in the state since July 2017, that required a minimum amount of "synchronous" generation, which if not met would restrict the wind output to a maximum 1,200 MW unless four gas units are operating in the state. However, currently AEMO is gradually relaxing the constraints as it undertakes more studies on how the system can be managed with growing share of variable renewables.
- During summer 2017-18, AEMO issued 22 directions to South Australian generators to ensure the correct level of system strength was maintained at all times and these were security directions, for the provision of fault current.

4-Supply & Final Customer

ACCC's final report on inquiry into the retail electricity prices revealed a 56% increase in residential customer prices and 35% increase in residential customer bills between the period 2007/08-2017/18

- **Network cost:** Largely driven by increased expenditure due to very high reliability standards set for some networks without prior understanding consumers' willingness to pay for marginal increases in reliability.
- **Wholesale cost:** Arising mainly from the sudden closures of coal-fired generators which resulted in shortage of supply and excess demand in the market, which was then compensated through costly sources of generation like hydro and gas.
- **Environmental:** Most state governments implemented excessively generous solar feed-in tariff schemes and the subsidies and payouts to the producers of solar energy were then funded at the expense of higher network and wholesale prices charged from end consumers.
- **Retail cost and margins:** Excessively high prices charged for standing offers, along with confusing price structure offered by retails have left limited options for consumers to switch to other retailers and they end up paying more than what they need to for electricity.

Abolishment of limited merits review (LMR) regime introduced in 2017, is expected to keep the network costs at check

- LMR regime allowed network owners to appeal regulatory decisions and challenge determination of network revenue by AER, in case of exceptional situations.
- However, this power was misused by most of the network service providers and it became more of a routine than exception, which resulted in unjustifiably high prices for consumers and has created significant uncertainty around network pricing.
- In order to address this issue, on 16th October 2017, the federal Government passed the Abolition of Limited Merits Review Bill 2017 which removes the right of Network Service Providers (NSPs) to apply for LMR of most of the decisions of the Australian Energy Regulator (AER).

Percentage share accounted by the five different cost stack components are relatively same across regions. Network and wholesale account for 72–79% of the cost stack, followed by retail costs, retail margin and environmental costs which together contribute 21–28%

While the relativities are generally similar, there are some differences between regions, including:

- Network costs are more significant in Queensland followed by South Australia, NSW and Tasmania
- Wholesale costs are more significant in South Australia
- Retail cost and margins are higher in Victoria
- Environmental costs are higher in South Australia and lower in Queensland.

In the backdrop of an unsustainable electricity pricing situation, ACCC put forth few recommendations to address the rising cost challenge - it is imperative that the government implements these recommendations on a priority basis and also conduct proactive review to ensure that the implementations are on track.

Rising customer electricity prices and factors driving supply chain cost in NEM

Australia is facing a challenging time in electricity market with high prices and rising bills placing enormous pressure on household budgets and business viability. A retail pricing inquiry by Australian Competition and Consumer Commission(ACCC) has revealed inefficiencies at each stage of the supply chain which has resulted in a stark increase in prices over time

Network cost:

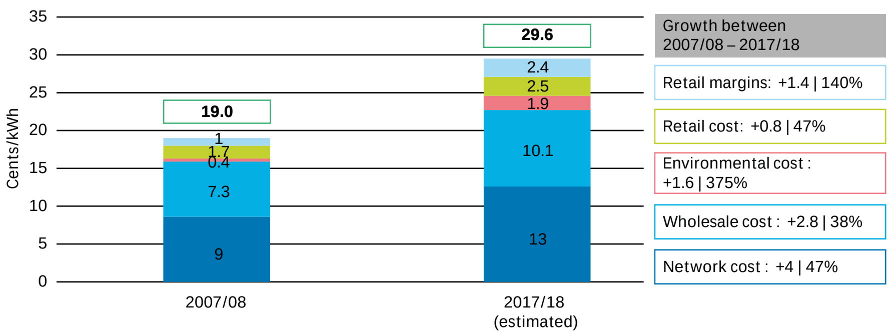
- Network costs have accounted for the largest share in residential customer effective prices and customer bills over time from 2007–08 to 2017–18.
- Over these years, network owners have made significant investments in order to replace ageing assets, meet stricter reliability and bushfire safety standards, and respond to forecasts at the time of rising peak demand. These large investments occurred during a time of instability in financial markets which increased financing costs and as such these billions of additional dollars were largely recovered from the consumers that led to significant rise in network costs.
- The framework that governs regulation of monopoly infrastructure was loosened, leaving the regulator with limited ability to constrain excess spending by network owners. Moreover, reliability standards for some networks were set too high without taking into account consumers' willingness to pay for marginal increases in reliability.

Recommendation by ACC:

- Immediate steps should be taken by NSW, QLD and TAS state governments to remedy the past over-investment of their network businesses in order to improve affordability of the network.
- AER should be given the power to monitor the effect of the write-downs of regulatory asset base and rebates on network charges effectively faced by retail customers.

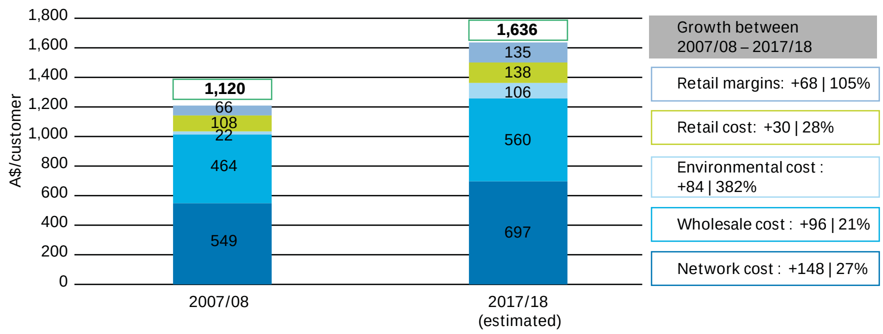
- Residential consumers have faced a 56% increase in electricity real price and 35% increase in their bills.
- Bills have increased at a comparatively lower rate than the prices because of declining average electricity usage between 2007/08 and 2017/18, owing to higher number of customers with solar PV.
- Solar customers are paying, on average, A$538 less per year than non-solar customers, suggesting that affordability concerns are most acute for those who have not installed solar PV.

Figure 4.1. Change in average residential customer effective prices (c/kWh) from 2007/08 to 2017/18, NEM-wide, real A$2016/17 (excluding GST)



Source: ACCC, Retail Electricity Pricing Inquiry—Final Report, June 2018

Figure 4.2. Change in average residential customer bill from 2007/08 to 2017/18, NEM-wide, real A$2016/17 (excluding GST)



Source: ACCC, Retail Electricity Pricing Inquiry—Final Report, June 2018

Wholesale cost:

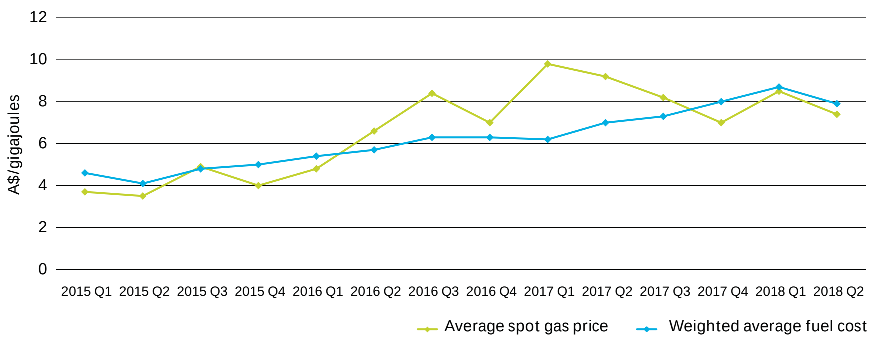
Key factors driving wholesale costs include:

- **Demand supply imbalance:** Despite demand being relatively stable in the wholesale market over the past few years, sudden exit of coal-fired generation facilities have resulted in tightening of supply or excess demand leading to price rise. Over 5,500 MW of generation capacity was retired or mothballed between 2012 and 2017, with less than 3,000 MW of new investment over this same period, indicating a lack of orderly transition in the NEM. Also, the steady growth in intermittent renewables indicated more variability in generation availability, which has added to the tightness of supply on some occasions when wind and solar output have been low.

- **Concentration in the NEM:** All regions of the NEM are highly concentrated. In each NEM region the current three most significant generators (AGL, Origin, Energy Australia) account for more than 70% share in generation and more than 80% share in dispatch capacity. Market concentration in the NEM has recently increased further through both acquisitions and closures of significant assets – in Queensland, the government consolidated the generation assets of three businesses into two, and in NSW, both generators owned by Macquarie Generation were sold to AGL. Significant concentration in NEM has affected the competitive nature of the market, resulting in prices above efficient levels

- **Increase in cost of generation, especially rise in gas prices:** Gas is a an important fuel source of generation, especially as existing coal-fired generators are retired. However, a ramp-up of LNG exports linking domestic gas to international prices along with government moratoria on on-shore gas exploration and development have stifled the availability of gas at a low price. Gas-powered generators have also faced increasing fuel costs, which appear to be reflected in higher-priced offers. While gas prices eased in the latter half of 2017 and early 2018, they remained at higher levels relative to three years ago.

Figure 4.3. Quarterly gas generators' fuel costs and average spot gas prices across all mainland NEM regions, Q1 2015 to Q2 2018 (A$/GJ nominal)



Source: ACCC, Retail Electricity Pricing Inquiry—Final Report, June 2018

Recommendations by ACCC

- Additional resources generated through demand responses services should be directly made available to wholesale market.

- Promotion of competition allowing A wide range of providers to participate in the demand response services is essential, to ensure effective pricing.

Environmental cost:

- Federal and state governments have introduced environmental policies to encourage greater uptake of renewable generation, promote energy efficiency measures and reduce carbon emissions. However majority of these schemes impose costs on retailers that are recovered through consumer's electricity bill.

- Environmental cost comprises of:

  – **Large scale Renewable Energy Target (LRET) and Small scale Renewable Energy Scheme (SRES) within national schemes:** These schemes require retailers to purchase large-scale generation certificates (LGCs) and small-scale technology certificates (STCs) from renewable generation sources and surrender the same to the regulator, in proportion to the overall amount of energy consumed by the retailer's customers. Increase in prices of LGCs and the number of STCs that must be surrendered, driven by rapid uptake of rooftop solar PV has increased retailers' cost which was passed on to consumers bill.

  – **State certificate and efficiency schemes and Premium feed-in tariff (FiT) schemes within state schemes:** Premium FiT scheme was introduced to encourage uptake of rooftop solar and it was done by providing payments to households and businesses for the electricity generated through solar panels. Distributors funded these payment costs through increase in network prices charged to consumers. As more households and businesses participated in the scheme, value of payments increased putting an upward pressure on cost.

Recommendations by ACCC

- Costs of schemes like Premium FiT, should be borne by state governments through their budgets, as Queensland has done for the next three years.

- Ongoing scheme eligibility rules should be reviewed and tightened to ensure underlying costs are minimized.

1 A national framework that regulates the connection, supply and sale of energy (electricity and gas) to grid-connected residential and small business energy customers. It was developed to provide same level of consumer protections to all customers irrespective of the location

Retail cost and margin:

Retailer cost comprises of:

- **Costs to Serve (CTS) which essentially refers to operating cost:** Main drivers include increase in the level of bad debts and cost of debt collection arising from the group of vulnerable consumers who are the newly arrived migrants with low energy literacy and little or no experience in having a choice of provider. Cost of regulatory compliance is also a significant contributor. Additional costs are arising as a result of individual states implementing derogations from the National Energy Customer Framework[1] (NECF) - for example, Victoria has not joined the NECF and retains its own regulatory framework and licensing process). Divergence and duplication of reporting requirements occurring even within the NECF states like SA, NSW, QLD, TAS and ACT.
- **Customer Acquisition and Retention Costs (CARC)**—includes the costs of acquisition channels (third party comparison websites, door-to-door sales, telemarketing), other marketing spend, retention teams etc.: Increasing cost of acquiring third party channels and commercial comparators, advertising and marketing have pushed up the CARC.

Recommendations by ACCC

- Victoria should join the NECF to streamline regulatory obligations and reduce retailers' costs to serve.
- Future derogations from the NECF should be limited to situations where jurisdiction specific needs cannot be addressed by a NECF-wide rule change.

AER's role in regulating the rising network cost

- AER plays a crucial role in determining the regulated revenues for all electricity network service providers in the NEM and Northern Territory. At the start of each regulatory period, which typically occurs every five years, AER determines the network's revenue allowance for the five year period which is the maximum amount the network can recover from its retail customers through their electricity bills. This is largely based on the annual benchmarking activity that AER undertakes to help customer understand the efficiency of their distribution and transmission network providers. In the 2017 State of the Market Report, AER forecasted that network revenue decisions (informed by benchmarking) would result in a 13.5% decline in network revenues which would in turn reduce the real average residential electricity charges by between 1.9-5% per year over current five-year regulatory periods.
  - **Benchmarking process:** This is based on three top down techniques including Productivity index numbers, Econometric operating expenditure cost function models and Partial performance indicators which analyses relation between inputs and output to determine efficiency.
  - **Revenue determination process:** An electricity network provides the AER with a revenue proposal outlining its forecast expenditures or costs over the five year period, which is then assessed by AER against relevant criteria and tests of the National Electricity Rules. Where a network business' proposed expenditure meets the criteria and tests specified under the NER, the AER accepts the proposal. Where relevant regulatory criteria and tests are not met, the AER does not accept the proposal and estimates an amount it believes reasonably reflects the regulatory requirements. Benchmarking activity helps in determining that threshold level.
- In July 2018, AER released a draft on Rate of Return Guidelines which outlines the approach to setting the allowed rate of return for regulated gas and electricity network service providers. Rate of Return essentially comprises of return on debt and equity and account for about 50% of network providers' allowed revenue. Higher returns attracts over investment from the NSPs, the cost of which is recovered largely through higher customer bills. In order to prevent this, AER announced plans to reduce the return on debt in its new guideline, to ensure a balance between system reliability and efficient network investment that would help keep energy prices down.
- The AER estimates that its draft guideline would result in a 45 basis point reduction in the overall rate of return for network businesses, compared to its previous determination in 2013.
- The AER has tried previously to reign in network costs, but has repeatedly been forced to allow for a compromise after its decisions were appealed or taken to the courts. However, in late 2017, the limited merits review regime, which enables networks to successfully challenge AER determinations on allowable network revenues, was abolished. This will limit the influencing power of the network providers in the regulatory framework and the ACCC recommends limited merits review of AER decisions should not be reinstated in the future as well.

Trends in electricity prices across jurisdictions in NEM

Aligned to the trend in overall NEM, network and wholesale costs account for the largest share of 72-79% of the cost stack across all regions. While there is an increase in the overall cost stack in all states on a cent/kWh basis, the drivers of price changes vary between states

Victoria:

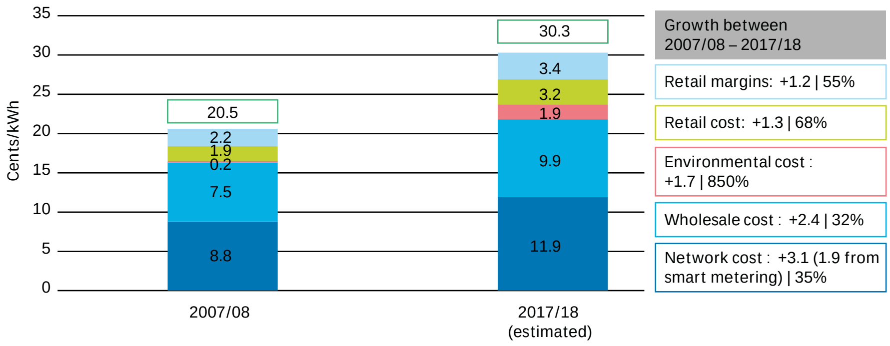
- It recorded the lowest percentage increase in residential effective price of 48% between 2007/08-2017/18.
- Although network cost increased by 35%, it was primarily driven by the costs of the state mandated distributor-led rollout of smart meters that accounted for 1.9 cents/kWh of the 3.1 cents/kWh increase in network cost registered between 2007/08- 2017/18 - the remaining is accounted by distribution and transmission cost.
- If the effect of smart meters is put aside, the largest increase was due to the combined increase in retail costs and margins - Victoria has the highest retail cost and margin of the NEM regions.
- Retailers operating in Victoria incur additional regulatory costs as a result of the state not having joined the NECF - many retailers pointed to the regulatory divergence between Victoria and the rest of the NEM as being a source of additional operating expenditure.
- There were also significant increases in environmental cost arising from schemes like – Victorian Premium FiT scheme and Victorian Energy Efficiency Target that provides monetary benefits and discounts to entities producing renewable energy and ensuring GHG emissions reduction, at the expense of higher prices charged from electricity customers.

NSW:

Network costs are the primary driver of price increases between 2007–08 to 2017–18 in NSW. Imposition of high network reliability standards on distributors, following the outages in 2004, led to higher costs.

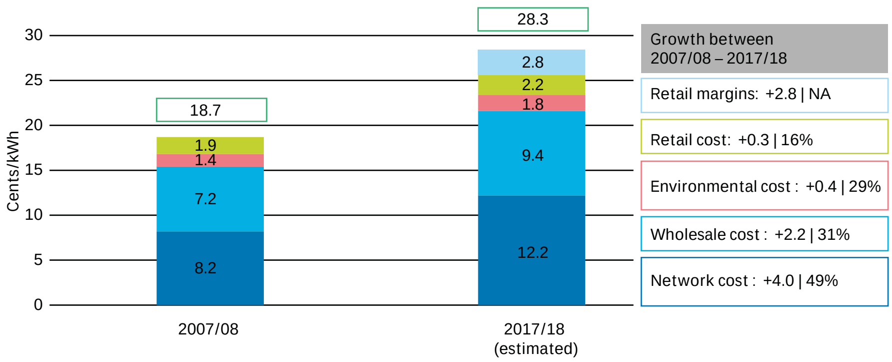
The NSW Government introduced highly prescriptive standards that were deterministic and focused on the input standards that distributors should achieve in planning the network, rather than the outputs of reliability that should be achieved.

Figure 4.4. Change in average Victorian residential effective price (c/kWh) from 2007/08 to 2017/18, NEM-wide, real A$2016/17 (excluding GST)



Source: ACCC, Retail Electricity Pricing Inquiry—Final Report, June 2018

Figure 4.5. Change in average NSW residential effective price (c/kWh) from 2007/08 to 2017/18, NEM-wide, real A$2016/17 (excluding GST)

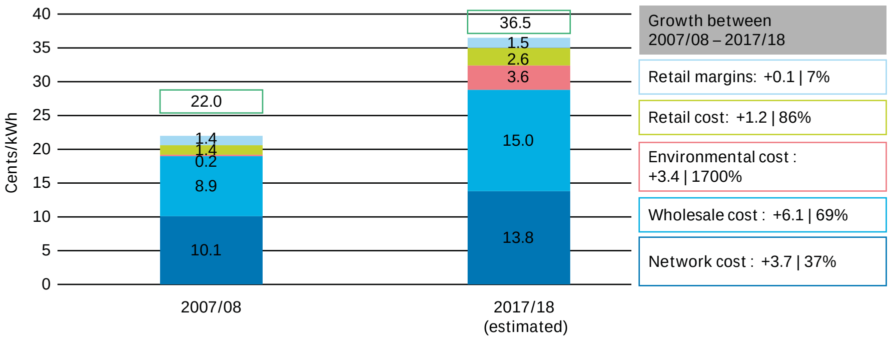


Source: ACCC, Retail Electricity Pricing Inquiry—Final Report, June 2018

South Australia:

- South Australia recorded the highest increase in residential effective prices of 66% between 2007/08-2017/18 and it has amongst the highest electricity prices in the world.
- The primary drivers of cost increases in South Australia have been wholesale costs and environmental costs.
- The state has a very high penetration of solar PV - environmental costs are thus driven by high costs of premium FiT schemes which are recovered through additional network charges from customers that are paid to solar PV households as incentives.
- Since the closure of Alinta's Playford and Northern coal-fired power stations in May 2016, output supply was compensated through more expensive sources like gas-powered-generation which pushed up the wholesale prices significantly:
  - Post May 2016, gas-powered generators have represented about two thirds of dispatched generation in South Australia and set the price 23–53% of the time - additional gas capacity became available during 2017 with the second unit of Pelican Point restarting.
  - Offers in South Australia were revised upwards from prices of A$50–75/MWh in 2015 to A$100–300/MWh in 2016.

Figure 4.6. Change in average South Australian residential effective price (c/kWh) from 2007/08 to 2017/18, NEM-wide, real A$2016/17 (excluding GST)

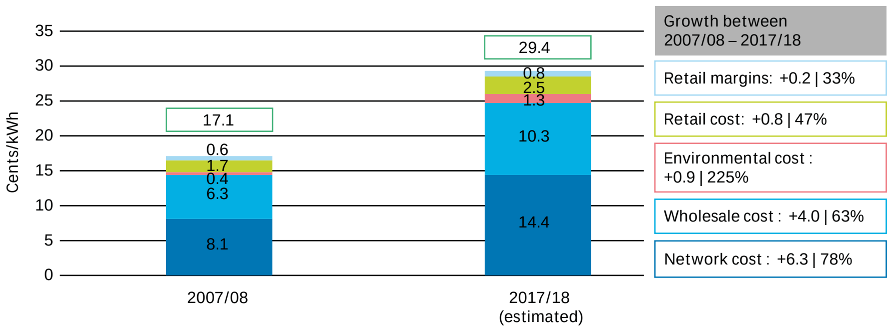


Source: ACCC, Retail Electricity Pricing Inquiry—Final Report, June 2018

South-east Queensland:

- The primary drivers of cost increases in south east Queensland were network costs and wholesale costs.
- In Queensland, reliability standards were set that required incremental improvements in network reliability over time, by reference to a Minimum Service Standard specified in the legislation 313. However, these standards were prescriptive and had a strong focus on inputs rather than outcome.

Figure 4.7. Change in average south east Queensland residential effective price (c/kWh) from 2007/08 to 2017/18, NEM-wide, real A$2016/17 (excluding GST)



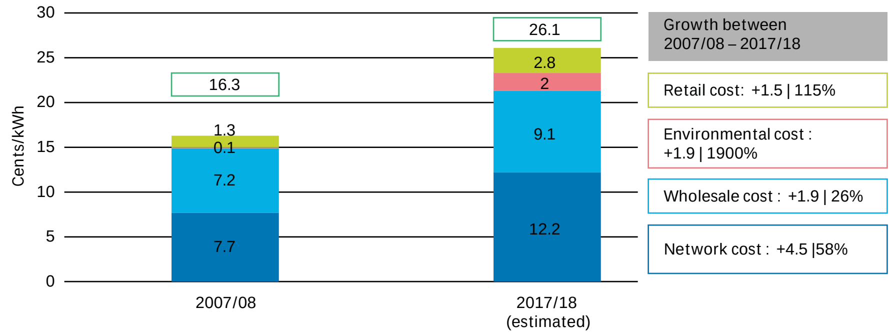
Source: ACCC, Retail Electricity Pricing Inquiry—Final Report, June 2018

- Queensland also experienced relatively high electricity demand in 2015/16 and 2016/17 as temperatures soared above the average. However, due to lack of competition in the market, generators like Stanwell and CS Energy (which together control two-thirds of the state's electricity supply) leveraged this situation and most of this excess demand was met through additional capacity offered by coal-fired Stanwell power plant at higher prices. Market prices are usually determined by generator receiving the price of the lowest priced bid which can satisfy demand, but due to market concentration in Queensland, prices set locally were much higher than usual.
- Additionally, several government-owned coal-fired generators in Queensland retired since 2011 and the reduction in output was then compensated through expensive means of generation like gas and hydro during mid-2014, mid-2016 and early 2017.
- Despite recording an increase of 225% since 2007/08, overall, in 2017/18 south east Queensland recorded the lowest environmental costs - this was largely owing to the removal of premium FiT charges that were recovered through higher network costs.

Tasmania:

- The primary drivers of cost increases in Tasmania were network costs and environmental costs.
- There has been significant over-investment in state-owned networks, driven primarily by excessive reliability standards and a regulatory regime tilted in favor of network owners at the expense of electricity users.
- Funding of environmental schemes like Premium FiT scheme through increased network cost charged from customers is the main driver of environmental cost- these are expected to make up an increasing proportion of a residential electricity consumer's bill going forward.

Figure 4.8. Change in average Tasmanian residential effective price (c/kWh) from 2007/08 to 2017/18, NEM-wide, real A$2016/17 (excluding GST)



Source: ACCC, Retail Electricity Pricing Inquiry—Final Report, June 2018

Measures to improve customer experiences and outcomes

The approach to policy, regulatory design and promotion of competition in electricity sector has not been in favor of consumers in recent past. However, measures are now being gradually adopted to improve the customer outcomes, as revealed by ACCC's final report from the Retail Electricity Pricing Inquiry

Strategies to encourage consumer engagement.

- In August 2017, eight retailers including AGL, Alinta, Energy Australia, Origin, Momentum Energy, Simply Energy, Red Energy and Lumo Energy made a number of commitment to the Prime Minister to encourage consumer switching – this included a commitment to contact all standing offer and expired benefit customers, to encourage them to switch.
- The eight retailers also agreed to support a rule change that would require retailers to contact customers prior to a benefit changing or expiring - on 7 November 2017, the AEMC published this as the final rule.

Improving easy accessibility to electricity consumption and pricing data.

- Majority of households in NSW, Queensland, the ACT, South Australia and Tasmania are still metered using accumulation meters which are manually checked periodically. In contrast, smart meters, which have been rolled out in Victoria, provide richer data, including half-hourly measurements of consumption - as part of the Power of Choice reforms, retailers are now progressively rolling out smart meters in other NEM regions.
- On 9 May 2018, the Australian Government agreed to the Consumer Data Right (CDR) model and ACCC was named as the lead regulator. CDR, which will be implemented in banking sector initially and later extended to energy and telecommunications, will enable consumers to share their transaction, usage and product data with service providers and comparison services. This right will improve the consumer's ability to compare and switch between goods and services on offer.
- The COAG Energy Council has also been developing a framework[1] to enhance the availability of and access to electricity data, and the Energy Security Board is developing a data strategy[2].

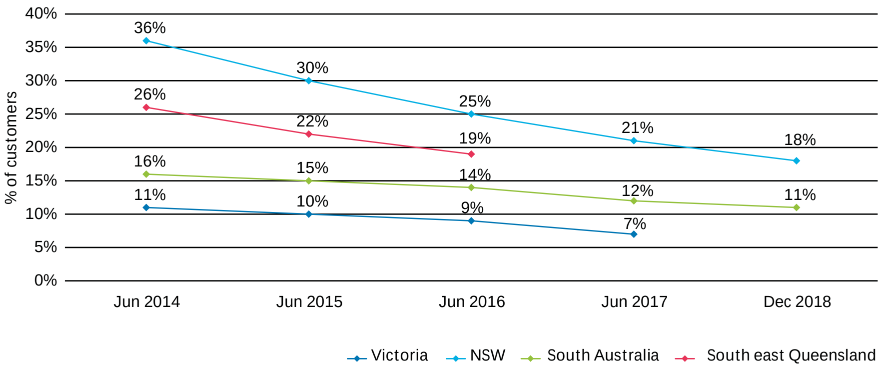
1 The COAG Energy Council initiated a project to streamline the process and facilitate timely access to consumer consumption data. The Department of the Environment and Energy is coordinating this project with the support of consultants

2 The data strategy is focused on principles to guide how data is managed, and mechanisms that identify what data, how it is handled, who should have access and where it can be published.

Tools to assist consumers to choose a retailer and switch.

- In 2017, many residential customers switched electricity retailers or plans- Victoria and south east Queensland had the highest switching rates of 27% and 25% respectively, followed by 19% in NSW and 16% in SA.
- However, for many consumers, switching retailers is not a simple task, and although there are third party intermediaries who can provide this service to consumers seeking switch of retailers, ACCC highlights that they may not always provide recommendations in interest of the consumers. Therefore, their activities require close monitoring and should have penalty provisions for any breaches.

Figure 4.9. Residential customers on standing offers in non-price regulated jurisdictions, 2014–2018



Source: ACCC, Retail Electricity Pricing Inquiry—Final Report, June 2018
Note: Figures for Victoria for December 2017 is not included as it is reported annually and figures for south east Queensland prior to June 2016 are not included as reporting to the AER for Queensland only commenced in the 2015–16 financial year

Consumers are now moving away from standing offers.

- Standing offer: It is the offer to supply electricity in accordance with the standard retail contract at the price set by the retailer. This offer intends to provide additional consumer protection, provided the difference between the lowest market offer and the standing offer is not significantly high.
- Inquiry by ACCC revealed high costs of standing offer and significant difference between the standing offer bill and lowest market price offer bill in regions like ACT and South Australia where there are options of alternate retailers - consumers on standing offers make up the bulk of retailer margins.
- While consumers have been encouraged to participate in the market and choose a competitive offer, some consumers remain on standing offers largely owing to challenges faced when choosing a retailer and offer – like complicated marketing and confusing tariff structure presented by different retailers.
- However, over the past four years, there has been a trend of consumers moving away from standing offers, as they realize that the high price of standing offer bills outweighs its benefits around additional essential consumer protection.
- As an alternate there have been some developments in Australia around automated switching services – According to ACCC, automated switching providers are still a relatively new feature of the electricity market, but if enough consumers start using a service of this kind, it has the potential to place competitive pressure on retailers to provide better offers to customers:
  - CHOICE (Australian Consumers' Association) has launched an automatic switching service – Transformer uses a consumer's bill to determine whether a consumer can save money by switching to a new electricity offer based on an analysis of their previous usage, tariff, rate and discount structure
  - RoboSave: Reads a consumer's bills, scans the market and automatically switches electricity offers on the consumer's behalf
  - Energy Bill Doctor: Provides a free service where consumers can upload a bill and the tool will seek a cheaper power plan for the consumer.

Topic Box 4.1: Drawbacks of the current regulatory framework for consumer protection and the proposed scheme by ACCC

The government currently lacks robust framework and principles by which they can manage and review the overall operation of energy specific consumer protections, especially in the backdrop of market change and technological disruptions. Guidance outlined by ACCC in its Retail Price Inquiry Final Report is expected to lead to regulations that are more clearly aimed at benefiting consumers

Concerns with the current regulatory framework.

- The National Energy Retail Law (NERL) and National Energy retail Rule (NERR) were designed for a retail market where a few retailers operated and offered more or less homogenous products and services. However, the NEM has evolved over the past decade, shifting from a highly centralized retail market with a small number of state-owned retailers, to many retailers and several retail offers. This has resulted in an expanding and increasingly complex body of regulations over time.
- Under the NERL, there is no mechanism for a broad-based review of its effectiveness against its stated objectives.
- Incremental and ad hoc approach employed to address poor retailer behavior and consumer harms, has not benefited consumers in terms of either market efficiency or consumer protections. Since 2012, there have been 10 changes to the retail rules, and there are a further eight open or pending rule change proposals registered with the AEMC. These rule changes along with other associated changes to the electricity rules, AER guidelines, and procedural changes have resulted in the NEM being in a constant state of regulatory change since the introduction of the NERL and NERR. This poses difficulty for the industry and consumer stakeholders to keep pace with the continuous rule changes.
- ACCC also highlighted concerns regarding the ever increasing suite of rules that are more prescriptive in nature than directive, which are increasing costs and largely being circumvented by retailers and some state governments according to their convenience.

ACCC proposes a framework focused on best outcomes for consumers.

- The ACCC suggests NERL and NERR to apply a hybrid approach in policy that balances prescriptive and non-prescriptive elements to ensure that mandates to certain activities are clearly highlighted and state based derogations are limited.
- It also proposes for a more principles-based approach over time that will require a regulatory shift in the NERL and NERR and a change in retailers' approach to regulation. Energy businesses, including retailers, have reportedly indicated a willingness to take steps in this direction.
- In order to signal a strong focus on consumer outcomes, the COAG Energy Council could establish ministerial principles focused on consumer outcomes – these principles should include direction on governments' expectations around regulation to protect vulnerable consumers.
- ACCC also highlights that in addition to implementing its recommendations, a review of the effectiveness of the whole consumer electricity regulatory framework should be conducted within three years after the implementation of the recommendations and no later than June 2022.

5-New Business Models & Services

Boom in Distributed Energy Resources (DER) resulting in a paradigm shift in the NEM, from a centralized structure with few dominant players to a more competitive framework with households and small businesses participating in the national grid

- ARENA has allocated A$12.5 million to fund initiatives that aims to support growth of distributed solar PV and batteries, and thus help distributed energy resources in homes and businesses to contribute to grid reliability.
- In collaboration with Energy Network Australia, AEMO is exploring means to integrate DER with the national grid in a more efficient and holistic manner, to ensure reliability in supply.

Experimentation in wave, bio energy and battery storage technologies is driving growth in innovative renewable generation

- Several research projects are being explored to harness the power of the tides, this includes - an online web atlas of Australia's national wave energy resource, a hydrodynamic tidal model to map the scale and distribution of the nation's tidal energy resources, as well as prototype that will leverage wave energy to generate hydro electricity.
- Local governments (like South Australian government) are inviting tenders for investing in bio energy projects.
- South Australia also witnessed the successful implementation of the Tesla battery storage project and in addition to that, several other large-scale battery projects are also in pipeline across states of South Australia and Queensland.

Blockchain technology and its application in energy trading is gaining traction

- With the electricity market decentralized and electrical energy becoming an asset on a blockchain, consumers are gradually trading electricity within a peer-to-peer market.
- Australian blockchain-based energy companies like PowerLedger is working to implement peer to peer trading platform to facilitate solar trading between residents of Yolk Property Group in Western Australia.

Big data, analytics and IoT are being leveraged by city councils and businesses to improve energy efficiency, facilitate smart city development and ensure consumer retention

- As a part of the Smart Cities and Suburbs Program, city councils are investing in smart technologies to facilitate programs like smart meters, smart lighting, smart environment monitoring that will improve livability and energy efficiency of the metropolitan cities.
- Major utilities players like Energy Australia is investing in big data, cloud and Hadoop to provide customers with real time data and improve customer engagement.

Fast paced technological changes are rapidly reshaping Australia's energy market – electricity market has transformed from a centralized system dominated by few players to a decentralized system with several participants.

Rapid growth in DER, driven by increased consumer awareness and consumer uptake, is paving way for a new decentralized business model in Australia's NEM

DER driving more participation in the national electricity grid.

- Growth in DER is shaping Australia's electricity market transition from a centralized system of generation, transmission and distribution dominated by few players to a decentralized system with several participants in the energy system.
- As deployment of rooftop solar PV and battery storage technology increases rapidly, customers are more proactively connecting to the grids and energy markets - generation and storage at home is very appealing in countries with low population density and/or high solar radiation and Australia tops the ranking of current deployment.

ARENA allocating A$12.5 million to activities focused on DER.

- Touted as ARENA's first targeted funding initiative, a portion of it i.e. A$7.5 million has been allocated to pilot projects focused on increasing network hosting capacity through advanced monitoring and control schemes to manage power flow, voltage fluctuations and other system requirements in real time to ensure secure operation of the grid and system; the rest i.e. A$5 million has been allocated for desktop studies, feasibility studies or modelling to investigate how to successfully integrate high penetrations of DER.
- The funding initiative aims to support increasing shares of distributed solar PV and batteries, and help distributed energy resources in homes and businesses to contribute to grid reliability.
- ARENA CEO Ivor Frischknech highlighted that by 2022, it aims to ensure that the entire electricity system operates securely and reliably with 100% of demand met from behind-the-meter assets in combination with rooftop solar, batteries and other demand management options within homes and businesses.

AEMO's partnership with Energy Network Australia to explore means of integrating DER with the national grid in a better way.

- Despite the robust growth of DER, connecting it to the grid can, in technical terms, be quite complex. Australia's electricity system was originally designed to deliver large-scale centralized generation to customers with traditional one way power flow from transmission systems through distribution networks to end customers.
- The rise in distributed generation is leading to periods during which power is being exported from distribution networks onto the transmission system resulting in a two way power flow - this is not only impacting the quality of power in some occasions but also imposing strains on network leading to reliability and safety issues.
- In order to ensure a better integration of this two-way system, AEMO has proposed a central platform which can interface with aggregators, transmission and distribution network providers simultaneously. Three ways have been explored by which the central platform may be designed and delivered :
  - **Single Integrated Platform (SIP):** It will be a regulated entity and serve as a one-stop-shop that provides market participants the opportunity to participate anywhere in the NEM without having to develop separate systems or tools to integrate with the various individual distribution platforms. This will operate on a set of agreed standard interfaces to support the participation by retailers, aggregators and VPP platform companies. Distribution business will be linked to the platform and they will provide information on local constraints to AEMO. AEMO would consider this information and economically dispatch these resources. This entire process will help the SIP to simultaneously solve local security constraints and support wholesale market entry.
  - **Two Step Tiered Regulated Platform:** This model would include two platforms – firstly a distribution level platform interface operated by local distribution network which will help them liaise with the DER providers/participants and secondly an interface between the distribution network's platform and AEMO. Using this model, participants can communicate directly with the distribution level platform for the local constraint issues and the distribution network would optimize these resources by coordinating with the aggregators servicing the area. As a next step, distribution networks would provide an aggregated view of each transmission connection point to AEMO, which will then leverage this information to determine the overall system security and economic dispatch.
  - **Independent Distribution System Operator (DSO):** Under this model the independent DSO (which is a separate entity from AEMO) would work with the distribution utility to optimise the dispatch of the DER based upon local system constraints that are provided by the network business, provide the aggregated bids to AEMO for incorporation into the larger dispatch. This option will be more complex than the others and may be significantly more costly.

Innovation in renewable generation increasingly gaining traction

Wave technology: Despite being an underutilized resource currently, wave technology has the potential to be a game changer and a leading source of renewable power generation in future – several projects are underway to harness the power of tide

The Australian Wave Energy Atlas

- It is an initiative by CSIRO which was completed in 2017 and had also attracted funding of A$1.32 million from ARENA.
- The project delivered a searchable, free and publicly available online web atlas of Australia's national wave energy resource and marine management uses.
- It also provides best practice guidelines on physical impact assessments for wave energy developments in Australia's marine domain.

Other developments

- **Initiatives by Perth-based Carnegie Clean Energy:** The company has been long at the forefront of wave energy, and in the latter half of 2017, it announced plans for a new wave energy project as well as a National Wave Energy Research Centre at Albany, on the Western Australian coast. It also unveiled an upgraded version of its trademark product. CETO – a fully submerged buoy which uses wave technology to convert kinetic energy from ocean swell into electrical power. Carnegie will design, manufacture and install an updated CETO unit (named CETO-6) offshore from Albany during the 2019/2020 summer and this is expected to generate far more electricity than its predecessors.
- **Tidal Energy in Australia:** This is a joint research project of CSIRO, the Australian Maritime College at the University of Tasmania, the University of Queensland and industry partners, which will focus on developing a hydrodynamic tidal model to map the scale and distribution of the nation's tidal energy resources.
- **Prototype by Sydney based company Wave Swell Energy:** This will harness the power of waves to create an artificial blowhole. The company will build a A$7 million large-scale unit on the seabed near the coast of King Island that will feed into Hydro Tasmania's grid, and at peak times will provide up to half the island's power.

Bioenergy: Bioenergy power plants accounted for almost 10% of Australia's clean energy and 1.7% of total electricity generated in 2017

- According to the Federal Government's Australian Energy Statistics, Queensland produced the most bioenergy of any state in 2016/17, primarily due to the large number of bagasse cogeneration plants associated with the sugar industry in the northern and central coastal region. In August 2017, South Australian government invited tender for investing in bio energy projects which are expected to have storage facilities as well.
- Other key bio energy projects include:
  - **Worsley Multi-Fuel Cogeneration Plant:** This is the largest project completed in 2017 and is expected to supply electricity and heat for alumina refining at Collie, 189 km south-east of Perth
  - **2.4 MW combined solar and methane plant by The Northern Adelaide Waste Management:** The two fuel sources use a shared turbine interconnector to feed electricity back into the South Australian grid. Combining solar and landfill gas to generate electricity is considered to be a first of a kind initiative in Australia
  - **MSF Sugar's 24 MW Green Energy Power Plant at Tableland Mill:** This was one of the few major new bioenergy projects at an advanced stage of development in 2017. The A$75 million plant will use bagasse from local sugar operations to produce power when it is completed in mid-2018
  - **40 MW waste-to-energy power plant at Kwinana in Western Australia:** Construction of this A$400 million plant is scheduled to begin in second quarter of 2018 and the project is being led by Phoenix Energy and co-sponsored by Macquarie Capital. Spanish infrastructure and renewable energy company ACCIONA and waste management company Veolia are also involved.

Bulk Energy Storage: Australia has slowly yet steadily started to become a more significant player in large-scale battery storage

- Declining lithium ion prices have also provided further impetus to this technology. Apart from the much talked about Tesla battery in South Australia, (touted as the largest battery in the world) there are a number of other large-scale battery projects in the pipeline. This includes:
  - World's second biggest lithium-ion battery, the ESCRI project to be located in South Australia
  - 4,000 MWh lithium-ion battery storage facility attached to SolarQ's solar farm in Queensland and a large-scale battery proposed for Neoen's site south of Cairns in Queensland.

Advancements in emerging technologies like blockchain, IoT, big data and cloud are resulting in innovative services like blockchain powered trading platform, low-cost and low energy consumption based IoT network, smart lighting and smart environment monitoring services

Increased potential for blockchain technology in Australia's energy sector

Blockchain application in energy trading

- Utilities firms are increasingly facing compliance requirements for reporting, transparency, and dissemination of data. Costs have gone up and revenues have gone down and therefore blockchain technology is helping to address these issues by providing a transactional platform that is highly secure, reliable, low cost, and fast.
- Origin Energy is working with the Australian blockchain startup Power Ledger to test a new energy trading platform. Origin works in various fields of energy, ranging from power plant operation, natural gas processing and both commercial and domestic power delivery - as a part of the project, the company will use the trial trading platform to connect customers who want to either buy or sell excess energy, with blockchain creating a robust record of energy allocation.
- In 2018, PowerLedger also initiated a peer to peer trading project with Yolk Property Group at White Gum Valley – this project will enable solar energy trading between residents leveraging a blockchain platform which will serve as a secured transactional layer.

Blockchain based operations are expected to be more attractive, driven by 'behind the meter' deployment.

- Blockchain processes require very high computing power and energy to operate, and given the high energy costs in Australia, blockchain specialist were not too keen on investing in this domain till date.
- However, in April 2018, IOT Group struck a landmark deal with Hunter Energy of NSW to build a blockchain center inside the Redbank coal-fired power station, which will provide the center a direct access to wholesale prices and help avoid additional costs from retailers and transmission. Power at wholesale cost is expected to make blockchain related operations more attractive in the energy sector and drive its adoption in near future.

State councils and businesses are leveraging big data, analytics and IoT to ensure energy efficiency, development of smart cities and improve competitiveness in the electricity market

Australian business harnessing big data to improve customer experience and remain ahead of competition.

- In the backdrop of spiraling energy prices and influx of multiple participants in the electricity market, customer satisfaction is emerging as a major battleground for Australian utilities.
- In order to combat the customer churn rate and drive more business value, utilities companies are investing a lot of stake in IoT platform, Business Intelligence and big data tools to get detailed customer insights, their preferences and consumption pattern that help them to design lucrative tariff and offer plans.
- For example – Energy Australia is using Oracle Big Data Cloud and Oracle R for Hadoop to analyze and improve the way they engage with their customers. Oracle's Big Data solution is enabling the company to identify customer trends, draw insights and provide a better, more seamless experience for their customers along with an improved call center flow to boost customer loyalty.

IoT is being increasingly leveraged by Australian cities and councils to facilitate the development of smart cities.

- The Australian government has invested A$50 million through the Smart Cities and Suburbs Program that aims at supporting those projects which apply smart technology to improve the livability of metropolitan cities.
- NBN Co, the Australian National Broadband Network has also expressed interest in supporting smart initiatives especially the IoT network through a collaboration of cities and councils.
- The city of Adelaide is planning a network rollout of 10 gigabit starting 2018 to facilitate smart programs such as smart city lighting with Cisco, smart environment monitoring, along with other programs like smart waste bins, smart parking.
- In partnership with Cisco and Telstra, Sunshine Coast created the Smart City Framework - a portfolio of 13 services which includes programs related to smart power, smart lighting as well as other areas like smart water, smart waste management, smart transport etc.
- The Wyndham City Council in Victoria is using "temperature sensors built into LED streetlights to generate a real-time

high-resolution heat map" for their community.

- City of Gold Coast initiated a large scale roll out of smart meter and connected street lighting in early 2018 which helped to test varying levels of energy consumption via metered and unmetered streetlights.
- The City of Ipswich is using sensor networks to support its smart city plans - the sensor networks lay the platform for testing technology in the areas of lighting management, solar energy, water and waste management, precinct maintenance, traffic management etc.

In an effort cut energy use, Australian company Thinxtra launched the Sigfox Low Powered Wide Area Network (LPWAN) technology to provide a low-cost operating framework for Internet of Things Technologies.

- Thinxtra's LPWAN technology requires far less power and provides much longer battery life for devices that require transmission of small amount of data and intermittent internet connectivity.
- More than 150 local businesses have already partnered with Thinxtra to leverage its network technology, which includes - smart water meter service companies that enable large water users to detect leaks and smart logistics solution providers with cold chain monitoring trackers to increase traceability of food and reduce wastage.
- Thinxtra's IoT network provides connectivity to cloud at lowest level of energy consumption and is complementary to RFID and Wi-Fi technologies.
- The CEFC has committed up to A$10 million to assist the expansion of Thinxtra, through the Clean Energy Innovation Fund.

Mandates from regulatory body to improve flexibility and efficiency, coupled with other factors like ageing infrastructure and tight emissions reductions targets are driving the utilities toward cloud solutions

Cloud has the potential to address a number of challenges in the utilities sector and energy providers are seeing the benefits of cloud, such as significantly shorter application development cycles and faster IT services and infrastructure at lower cost.

- In June 2018, Endeavor Energy roped in Cognizant to help them transform and automate their customer experience, energy market and business processes.
- As part of the engagement, Cognizant will digitally transform Endeavour Energy's procurement and supplier management, human resources and finance systems using the SAP S/4HANA suite and a range of SAP Cloud solutions such as SuccessFactors, Ariba and Concur, as well as the SAP Industry Solution for Utilities.
- Some companies are also leveraging cloud technology to digitize their field workers by providing real time data during field explorations, which in turn is pushing up their productivity levels.
- In 2017, A$2 million was invested from the Clean Energy Innovation Fund in clean-tech company Wattwatchers, to expand production of its measurement technology that helps better manage energy use and costs - Wattwatchers leverages internet devices, advanced control analytics and cloud-hosted management interface to provide real time data showing where and when energy is being consumed. The multi-channel auditor device can be used to inform customers of energy usage and identify energy waste or poor performance.

In its 2018 update to the 'Sector Competitiveness Plan', National Energy Resources Australia (NERA) highlighted that that despite the challenges, Australia's energy resources sector remains one of the principal sources of revenue underpinning the nation's economy. However, it emphasizes the need for more advancements to improve the sector's competitiveness when compared with global peers. NERA further highlights how automation and digital technologies – whether leveraged through smart networked assets, autonomous sensors, artificial intelligence, robotics, drones or remote operating vehicles – can deliver opportunities for the industry and help it in cost management, efficiency, safety and productivity improvement.

Topic Box 5.1: Carbon Capture and Storage (CSS) to play a pivotal role in CSIRO Low Emissions Technology Roadmap

The Australian Government released a Low Emissions Technology Roadmap in June 2017, developed by CSIRO, which explores the scope for new technology to reduce greenhouse gas emissions from the energy sector. The country is taking keen interest in four technology areas specifically, which includes carbon capture and storage along with other three key areas - smart grid, energy storage and affordable heating and cooling of buildings. In 2017, government also completed development of an industry-led roadmap for CSS, which confirmed the viability of CCS technology in Australia and presented a comprehensive plan for its deployment.

- Government programmes are targeting four priority areas for CCS technology development: i) improving the knowledge base of Australia's CCS resource; ii) demonstrating domestic low emission technology capacities and capabilities; iii) building Australian skills and capacity and iv) strategic partnering with ARENA and clean energy R&D community for funding.
- Over the last five years, there has been good progress in Australia's delivery of CCS projects, driven by support from the government and private sector activities in CSS R&D. Some of the notable projects include:
  - **Chevron's Gorgon project (Western Australia):** Touted as world's largest CSS facility, this commercial-scale project is expected to commence capturing carbon dioxide from its natural gas field in 2018. Each year three to four million tons of carbon dioxide will be injected into undersea storage, reducing emissions from the facility by 40%.
  - **The CarbonNet Project:** This is investigating the potential for a commercial scale CCS network in the Gippsland region of Victoria. The network could integrate multiple carbon dioxide capture projects in the Latrobe Valley, transporting carbon dioxide via a common-use pipeline and injecting it deep beneath the Gippsland Basin to be securely stored within suitable geological formations. If proved viable, CarbonNet could enable innovative new industries in Gippsland securing jobs, boosting skills and attracting investment while strengthening Victoria's energy security.
  - **The Cooperative Research Centre for Greenhouse Gas Technologies Otway:** This research facility is Australia's first demonstration of the deep geological storage of carbon dioxide, which provides technical information on the injection, storage and monitoring of carbon. This storage research programme has successfully injected more than 80,000 tons of carbon dioxide into geological storage facilities in Victoria's Otway Basin and is investing a further AUD 41 million (including private capital) between 2016 and 2020 to reduce the cost of carbon dioxide storage monitoring.
  - **The National Geosequestration Laboratory** delivers innovative research solutions to support Australia's carbon storage, energy and resources industries. For example, it is the lead research partner for the South West Hub CCS project in Western Australia.
- Funding of CSS projects:
  - The CCS Research Development and Demonstration Fund: This provides funding for carbon capture and storage projects and supports the Australian Government's commitment to reduce the technical and commercial barriers to the deployment of large-scale CCS projects.
  - The Australian Government has also introduced to Parliament proposed changes to the Clean Energy Finance Corporation Act 2012 to allow the Clean Energy Finance Corporation to invest in CCS.

6-Financials

Despite growing competition, the generation market continues to be dominated by AGL, while the retail market is largely catered by Origin Energy along with AGL and Energy Australia

- In 2017, AGL accounted for the largest market share in generation capacity across regions of Victoria, South Australia and NSW - streamlined cost reduction programs and rising wholesale electricity prices helped AGL improve its bottom-line.
- Origin Energy continued to dominate the electricity and gas retail market across Queensland, South Australia and NSW, along with AGL.
- Energy Australia is also quite dominant in electricity and gas retail market of NSW.

For the current regulatory period of 2016/17-2021/22, AER forecasts reduction in electricity and gas network revenues

- According to the current round of AER decisions, regulated electricity and gas network revenues are forecast to fall by an average 13.5% and 12% respectively, from the previous regulatory period.
- Improvement in financial environment and reduction in borrowing and equity costs have reduced the forecast revenue requirements for most network businesses.
- With respect to operating expenditure, AER forecasts an increase for both gas transmission as well as distribution network providers - largest rise is forecasted for Victoria's AGN network. However for electricity networks, AER's decision forecasts a reduction in operating cost for some companies due to inefficiencies reflected in the previous regulatory period and increase for some companies driven by regulatory changes.

AER decisions in the current regulatory period have lowered total network revenues of electricity and gas, reflecting more stable financial markets and reduced capital expenditure.

Generation capacity

AGL Energy is a dominant player in generation market, across most of the regions in NEM

Victoria

- In Victoria, AGL Energy, EnergyAustralia and SnowyHydro together account for the major share of 78% in capacity generated.
- Engie controlled 23% of the market until decommissioning its Hazelwood plant in March 2017, post which its market share dropped to 10%.

South Australia

- AGL Energy is the dominant generator, with 42% capacity.
- Other significant entities are Origin Energy, Engie and EnergyAustralia and they together account for 39% of the capacity share.
- Before retiring its Playford power station in 2012 and Northern power station in 2016, Alinta had an 18% market share in South Australia.

NSW

- Privatization of state owned generation completed in 2015.
- EnergyAustralia, Origin Energy, AGL, Snowy Hydro and Sunset Power were the successful bidders.
- AGL, Origin Energy and Snowy Hydro emerged as the state's leading generators with 71% market share in the region.

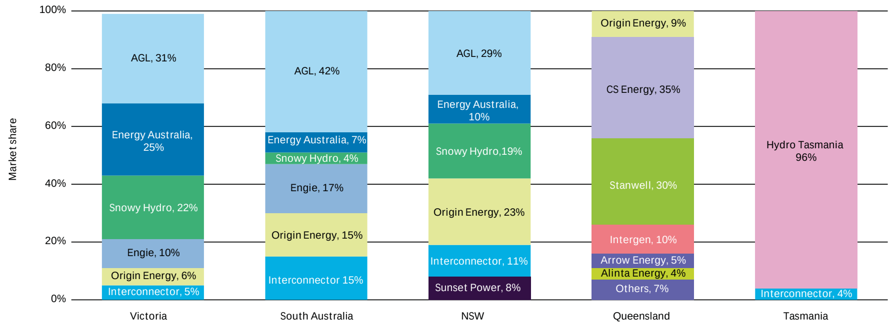
Queensland

- In Queensland, state owned corporations Stanwell and CS Energy control 65% of generation capacity, including power purchase agreements over privately owned capacity.
- The most significant private operators are InterGen and Origin Energy.
- The degree of market concentration increased in 2011, when the Queensland Government dissolved state owned generation businesses Tarong Energy and re-allocated its capacity to the remaining two state owned entities – Stanwell and CS Energy.

Tasmania

- The state owned Hydro Tasmania owns nearly all generation capacity.
- To encourage competition in the retail market, the Office of the Tasmanian Economic Regulator regulates the price at which Hydro Tasmaniacan offer contract products, and it ensures adequate volumes of these products are available.

Figure 6.1. Market shares in generation capacity across regions, 2017



Source: State of the Energy Market, May 2017 (updated Aug 2018)

Electricity Retail Market

Australia's electricity retail market continues to be dominated by the key players- AGL, Energy Australia and Origin Energy

Queensland

- **Origin Energy** dominates the electricity retail market in the state, both from residential and small customers perspective.
- In total, 25 retailers supply electricity to small customers in the Queensland electricity market, which is split between South East Queensland, and the rest of Queensland, where the supplier is Ergon Energy.
- Origin and AGL together supply over half i.e. 53% of Queensland customers.

South Australia

- Majority of the electricity supply in the state is accounted by **AGL**, for both residential and small customers.
- While a total of 21 retailers supply electricity to small customers in South Australia, the 'big three' retailers - AGL (43%), Origin Energy (23%) and EnergyAustralia (10%) supplied around 76% of that market.

NSW

- **Origin Energy** is the largest supplier in NSW, to both residential and small business customers.
- 30 retailers supply electricity to small customers in New South Wales - around 86% of these customers are supplied by AGL (23%), Origin Energy (34%) and EnergyAustralia (29%).

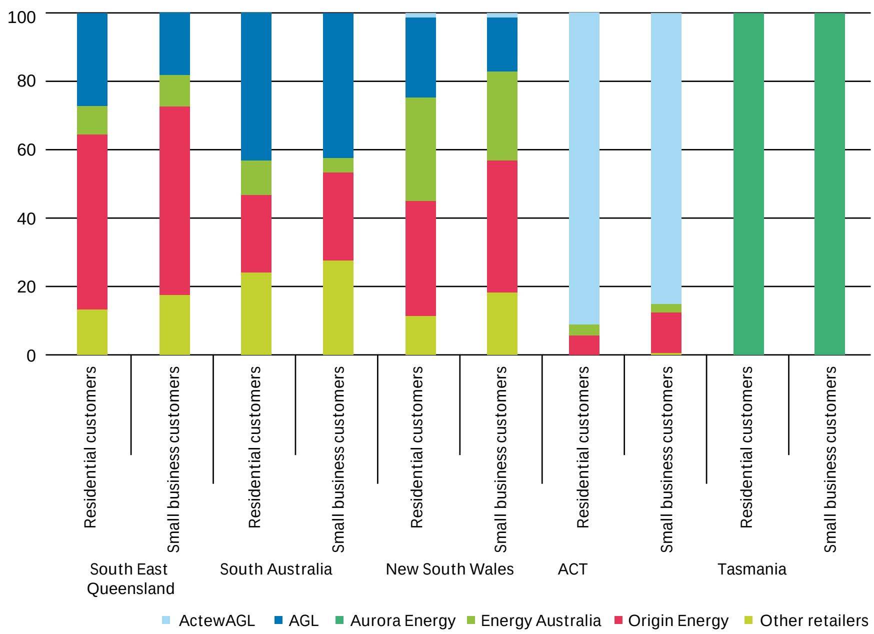
ACT

- **ActewAGL** remains the dominant retailer for both residential and small customers in the ACT – it caters to 91% of small customers.
- Despite signs of decreasing market concentration in previous years following Origin Energy entering the market in September 2014, ActewAGL's market share fell by just 1 per cent in 2016–17.

Tasmania

- The Tasmanian Government-owned incumbent, **Aurora Energy**, sells electricity to all residential customers and almost all small business customers in the state.
- Electricity prices remain regulated in the ACT and Tasmania.

Figure 6.2. Electricity retail market share across regions, 2017



Source: Annual Report on Compliance and Performance of the Retail Energy Market, November 2017

Gas Retail Market

The availability and uptake of gas varies across jurisdictions. In the ACT, 70% of households are supplied with gas, followed by 55% of households in South Australia and 42% in New South Wales are supplied with gas

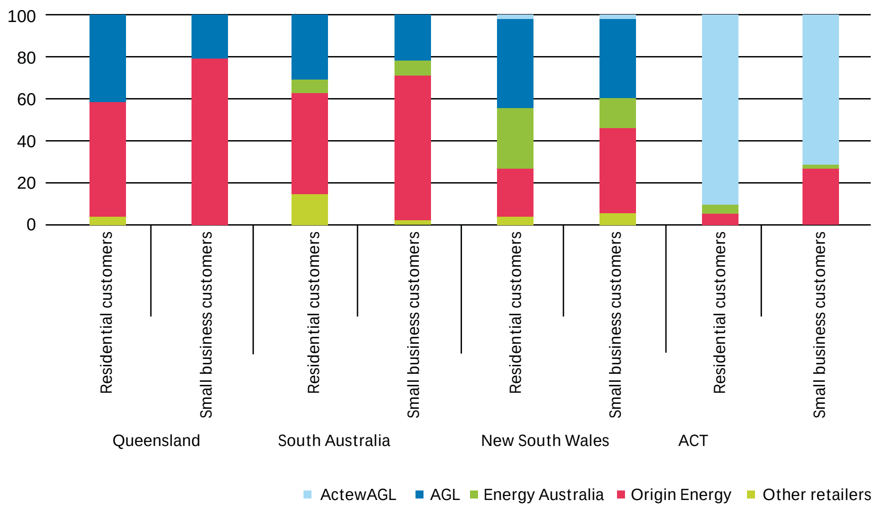
Queensland

- In total, four retailers supply gas to small customers in Queensland, and of these, two big retailers supply almost all customers- these are Origin Energy and AGL with approximately 80% and 20% market share respectively.

South Australia

- Seven retailers supply gas to small customers in South Australia.
- Around 88% of customers are supplied by the 'big three' retailers –Origin Enery, AGL and EnergyAustralia with the remaining 12% supplied by Alinta Energy, Simply Energy and Savant Energy Power Networks.

Figure 6.3. Gas retail market share across regions, 2017



Source: Annual Report on Compliance and Performance of the Retail Energy Market, November 2017

NSW

- Eleven retailers supply gas to small customers in New South Wales.
- Despite the number of retailers, the big three retailers i.e. AGL, Energy Australia and Origin collectively supply 94% of all small customers, a 2% decrease from 2015/16.

ACT

- Following the trend in the electricity retail market, ActewAGL is the main retailer in the gas market as well.

Earnings performance of AGL and Origin Energy

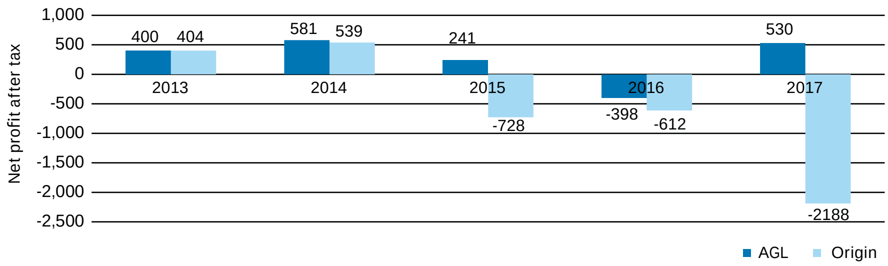
AGL's earnings rebounded in 2017 after two consecutive years of declining profits.

- During 2015 and 2016, AGL registered significant decline in its net profit after tax (NPAT), owing to exit of gas exploration and production assets, which impacted the company's gas revenue and margins.
- However, in 2017, profits bounced back primarily as a result of strengthening wholesale electricity prices and the ongoing delivery of AGL's cost reduction programs, which offset the decline in gas margins.

Origin Energy registered a cumulative loss of around A$3.5 billion since 2015, primarily owing to LNG dominated write-downs.

- In August 2017, Origin announced a A$1.2 billion of impairment charges against its stake in the Australia Pacific LNG project (APLNG), which followed the A$1 billion worth of impairment charge on APLNG announced by Origin in the beginning of the year.
- In addition, some of its traditional oil and gas assets worth A$170 million have been bundled together to be spun-off as Lattice Energy.
- The other impairments include A$578 million on the Browse Basin project, it purchased from Karoon Gas in 2014 for A$860 million.

Figure 6.4. Five year earnings performance of AGL and Origin Energy, 2013-2017 (A$ million)



Source: Thomson Reuters

Benchmarking of Regulated Electricity Network Revenue and Costs

According to the current round of AER decisions, regulated electricity network revenues are forecast to fall by an average 13.5%.

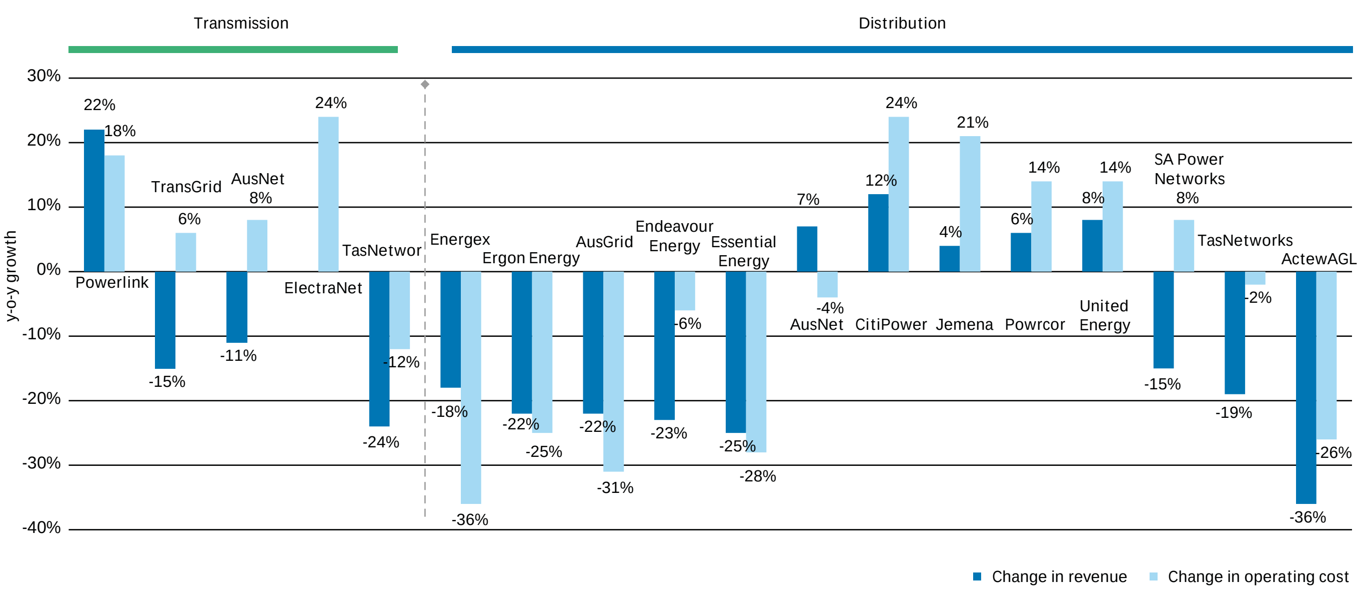
Electricity network revenues are forecast to total A$12 billion annually in the current regulatory cycle, of which distribution networks is expected to account for almost 80%.

- The previous round of regulatory determinations between 2012/13-2016/17 was made amid rising network cost to replace ageing assets, meet stricter reliability and bushfire safety standards, and respond to forecasts made at the time of rising peak demand. Further, instability in global financial markets exerted upward pressure on the costs of funding investment.
- The financial environment has improved in current times, and borrowing and equity costs have eased accordingly. Lower financing costs along with declining energy demand in recent years, have reduced the forecast revenue requirements for most network businesses.

The AER assesses a network's efficient operating and maintenance cost requirements as part of the revenue determination process.

- In the current regulatory cycle, electricity transmission networks on an average are allowed to spend over 10% higher than the previous period and distribution networks are mandated ti spend 17% lower than previous period on operating and maintenance costs per year.
  - Cost reductions for distribution networks reflect the use of AER benchmarking in regulatory assessments, which identified operating inefficiencies in some distribution networks and hence determined lower maintenance spend for them, to avoid the impact on customer bill.
  - However, AER also determined rising operating costs for some distribution companies driven by new regulatory obligations on the businesses, including new regulatory information reporting processes, changes to the connections charging framework, and Power of choice requirement.
  - Electricity network revenues primarily comprises of return on capital, depreciation and operating expenditure/cost. Operating cost or network costs are paid by the electricity consumers through network charges in their bill. Therefore an increase in operating cost is expected to have a positive impact on revenue determination and vice versa.
  - However, for some network providers like Transgrid, AusNet (Transmission) and SA Power Networks, AER has reduced the allowed revenues in the current regulatory period, despite determining an increase in operating cost. This may be attributed to the lower allowed rate of return in AER decision, amidst improved financial market conditions, which is expected to offset the impact of rising operating expenditure on revenue.

Figure 6.5. Change in electricity transmission and distribution network revenues and operating cost – previous (2012/13 – 2016/17) vs. current (2017/18-2021/22) regulatory period



Source: State of the Energy Market, May 2017 (updated Aug 2018)

Benchmarking of Gas Network Revenue and Costs

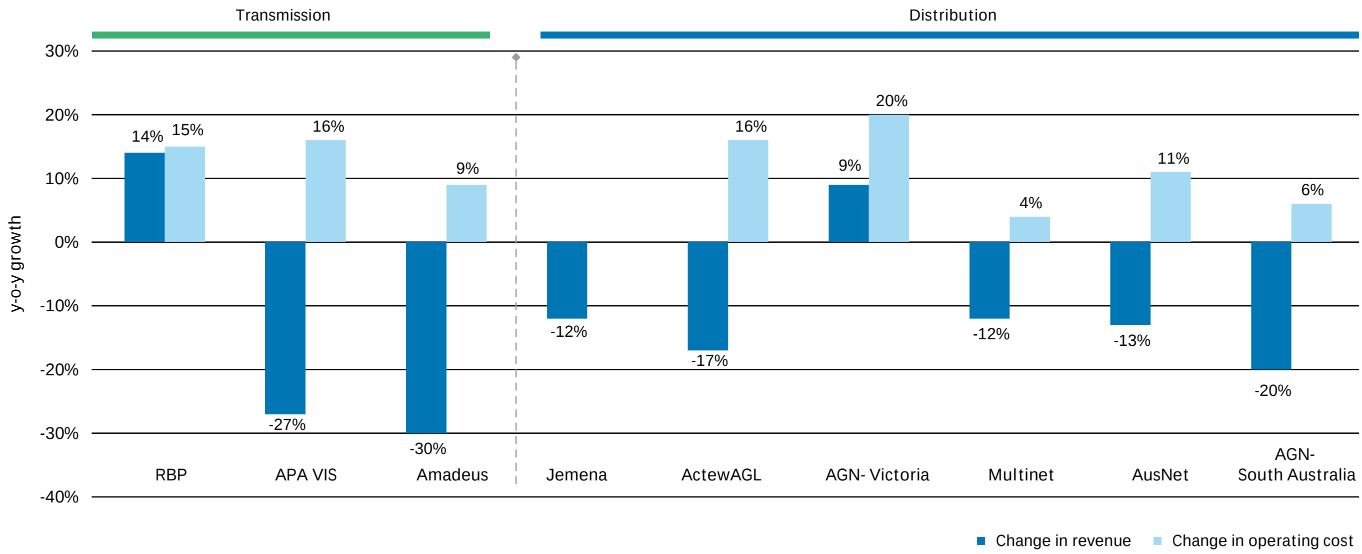
AER's decision for the current regulatory period, forecasts an average 12% decline in regulated gas network revenue, compared to the previous period - revenues are forecasted at A$1.4 billion per year in the current cycle.

- Decrease in revenue forecast by AER is largely driven by the improving global financial condition, which is reducing the cost of funding investments and therefore requirement for higher revenues might not be necessary to recover the investment cost.

In the current regulatory period, AER forecasts increase in operating expenditure for both gas transmission as well as distribution network providers.

- Gas transmission networks are forecast to spend around A$59 million per year on operating expenses and gas distribution networks are forecast to spend over A$460 million annually on these costs – largest rise is forecasted for Victoria's AGN network.
- AER's decision on the forecast operating expenditure for South Australia's AGN distribution network, involved a 6% increase in the current regulatory period compared to the previous one- The AER found the network had operated efficiently in the past, so its decision maintained base levels of expenditure, with increases to cover higher costs in some areas.
- Operating costs for the ACT's ActewAGL network are forecast to rise by 16% over the same period mainly owing to compliance issues and business-to-business harmonization.

Figure 6.6. Change in gas transmission and distribution network revenues and operating cost – previous (2012/13 – 2016/17) vs. current (2017/18-2021/22) regulatory period



Source: State of the Energy Market, May 2017 (updated Aug 2018)

Earnings performance of Citipower, Powercor and AusNet

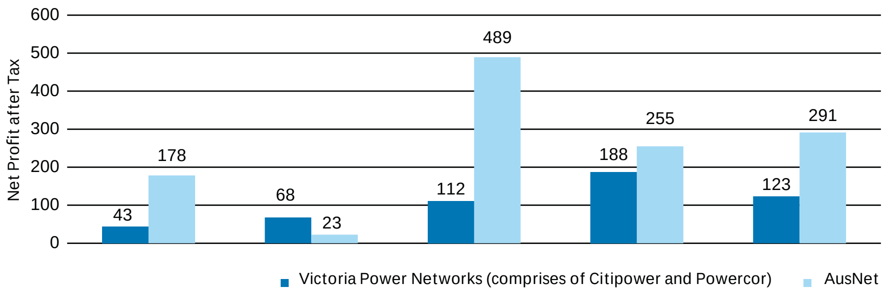
AusNet's earnings rebounded in 2017/18, after registering a nearly 50% decline a year ago.

- Net profit after tax (NPAT) increased significantly in 2015/16 a result of one-off income tax benefits in that year, after which NPAT declined as the benefits expired, resulting in lower profits in 2016/17.
- NPAT was also affected by redundancy and restructuring cost, IT asset write off, costs relating to the 2014 bushfires at Yarram and Mickleham and lower revenues associated with the new Electricity Distribution Price Review period (2016-20).
- However, in 2017/18, disciplined cost management measures undertaken by the management resulted in strong operating cost performance and improved the NPAT.

Victoria Power Networks has been recording steady growth in its earnings over the last few years

- In 2016/17, it completed its efficiency program, delivering over A$150 million in annual savings across both operational and capital expenditure.
- In 2017/18, continuous improvement programs have delivered a further A$17 million in annual savings through additional productivity gains throughout its operations and corporate/IT functions. However, this has been offset by reduced EBITDA margins of its unregulated subsidiary Beon Energy Solutions, resulting in overall reduction in net profit fro the year.
- AusNet's NPAT, takes into account earnings from both gas and electricity distribution as well as electricity transmission, while NPAT of Victoria Power Network takes into account earnings from electricity distribution business only.

Figure 6.7. Five year earnings performance of Citipower, Powercor and AusNet, 2013-2017 (A$ million)

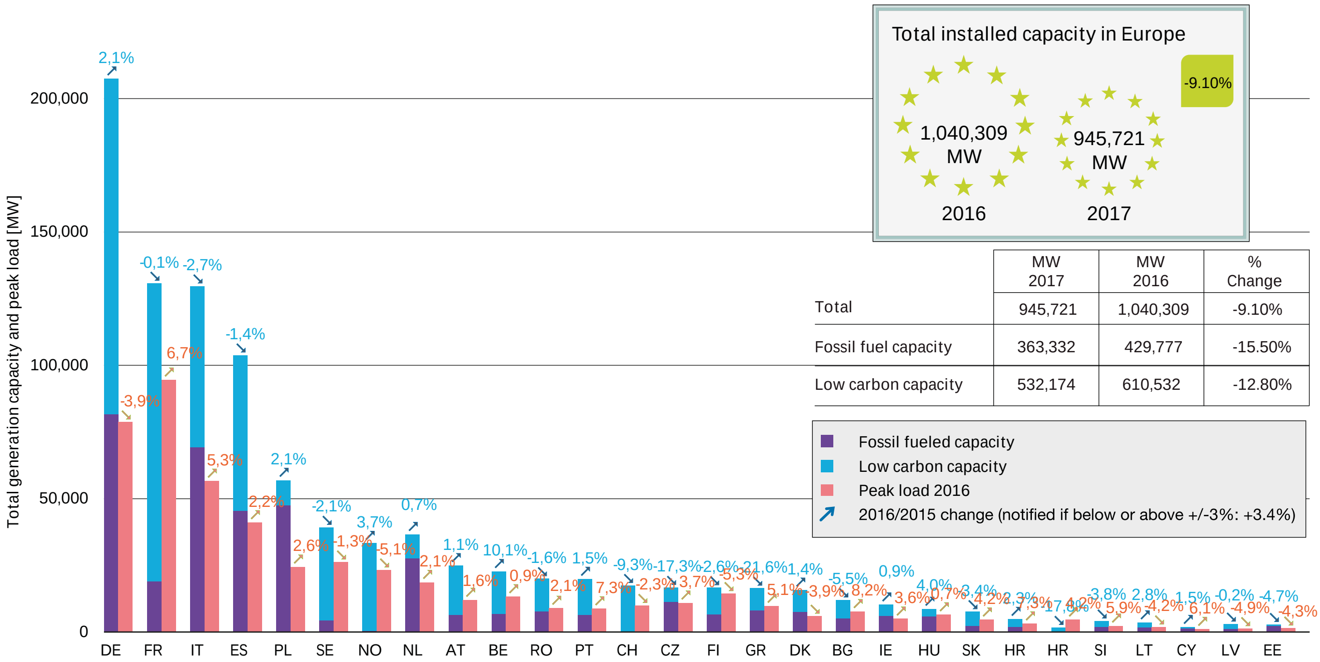


Source: Annual Reports

Australia

Appendix Figures

Figure A.1 Peak load, generation capacity and electricity mix (2017)



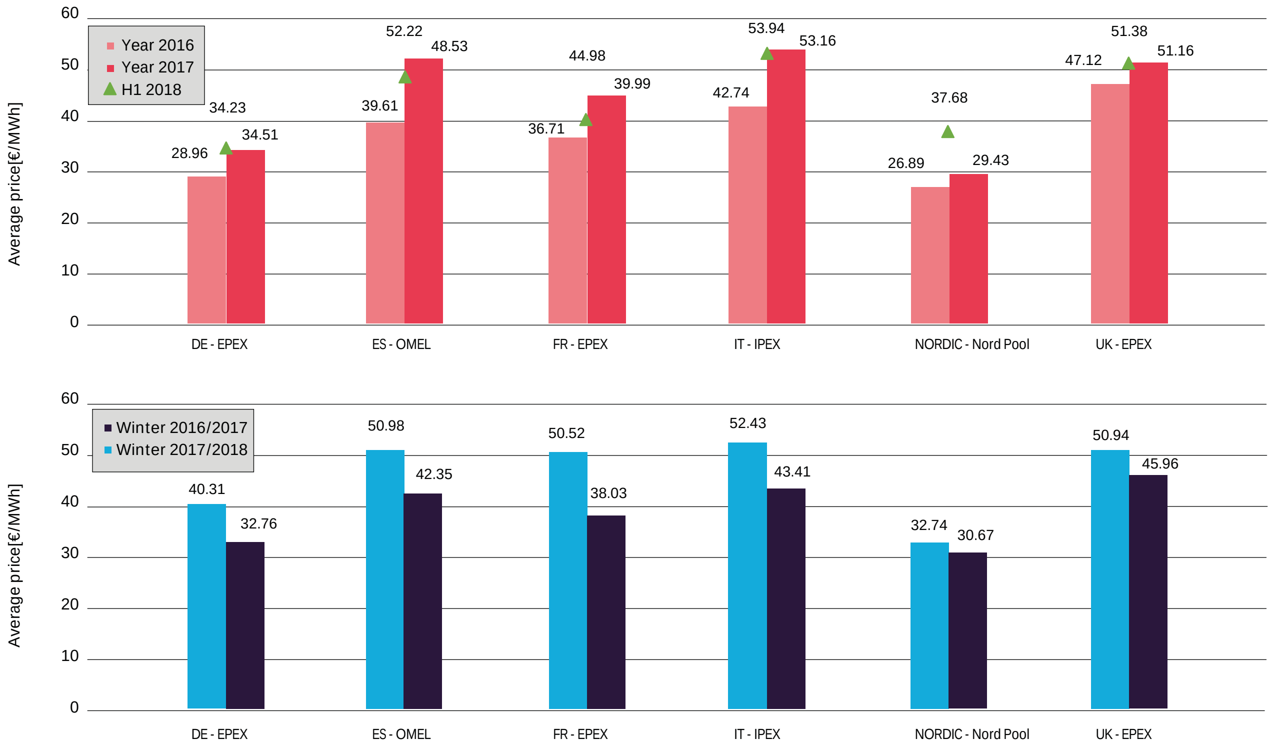
Source: ENTSO-E database – Capgemini analysis, WEMO2018

Figure A.2 Share of renewable generation capacity by country (2017)

Country	Code	Total generation capacity	Renewable generation	Share of renewables in generation capacity
Austria	AT	25,032	4,356	17%
Belgium	BE	21,579	6,993	32%
Bulgaria	BG	12,073	1,825	15%
Switzerland	CH	17,616	1,912	11%
Cyprus	CY	1,757	279	16%
Czech Republic	CZ	20,845	3,148	15%
Germany	DE	208,229	105,708	51%
Denmark	DK	15,784	8,124	51%
Estonia	EE	2,831	444	16%
Spain	ES	104,526	30,847	30%
Finland	FI	16,730	3,978	24%
France	FR	130,729	25,104	19%
Greece	GR	16,392	4,821	29%
Croatia	HR	4,778	670	14%
Hungary	HU	8,569	755	9%
Ireland	IE	10,510	3,458	33%
Italy	IT	133,132	33,846	25%
Lithuania	LT	3,509	694	20%
Luxembourg	LU	1,738	259	15%
Latvia	LV	2,929	217	7%
Netherlands	NL	31,976	8,388	26%
Norway	NO	33,329	1,149	3%
Poland	PL	39,389	7,112	18%
Portugal	PT	19,799	6,204	31%
Romania	RO	19,957	4,381	22%
Sweden	SE	39,037	9,836	25%
Slovenia	SI	3,816	329	9%
Slovakia	SK	7,721	875	11%
EU 28		**936,696**	**273,800**	**29%**

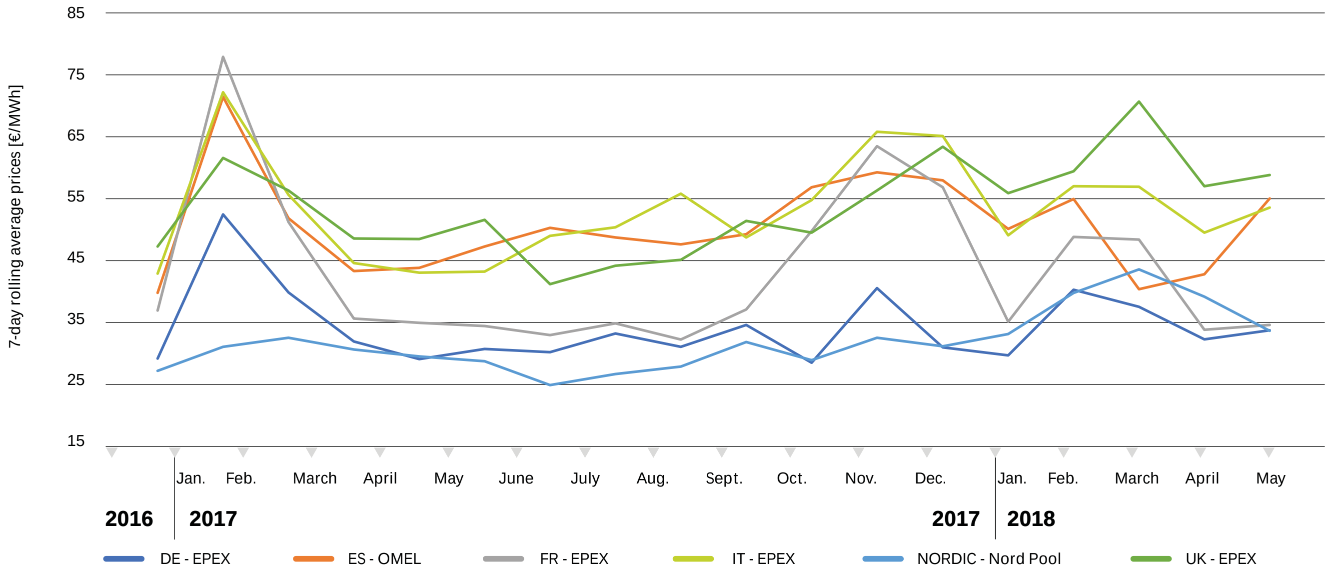
Source: Capgemini analysis, WEMO2018

Figure A.3 Yearly (2017 and 2018) and winter (2016/2017 and 2017/2018) average electricity spot prices



Source: Power Exchange websites – Capgemini analysis, WEMO2018

Figure A.4 Electricity spot prices on the main European markets (2017 and H1 2018)



Source: Power Exchange websites – Capgemini analysis, WEMO2018

Figure A.5 Status of electricity price regimes (2017)

Country	Existenceof regulated prices of (year of price control removal)	
	Households	Non-households
AT	No (2001)	No
BE	No	No
BG	Yes	Yes
CZ	No (2006)	No
DK	Yes	Yes
EE	No (2013)	No
FI	No	No
FR	Yes	No
DE	No (2007)	No
GR	No (2013)	No
HR	No	No
HU	Yes	Yes
IE	No (2011)	No
IT	No	No
LV	No	No
LT	Yes	No
LU	No (2007)	No
NL	No	No
PL	Yes	No
PT	Yes	Yes
RO	Yes	No
SK	No	No
SI	No (2007)	No
ES	No (2014)	No
SE	No	No
UK	No	No

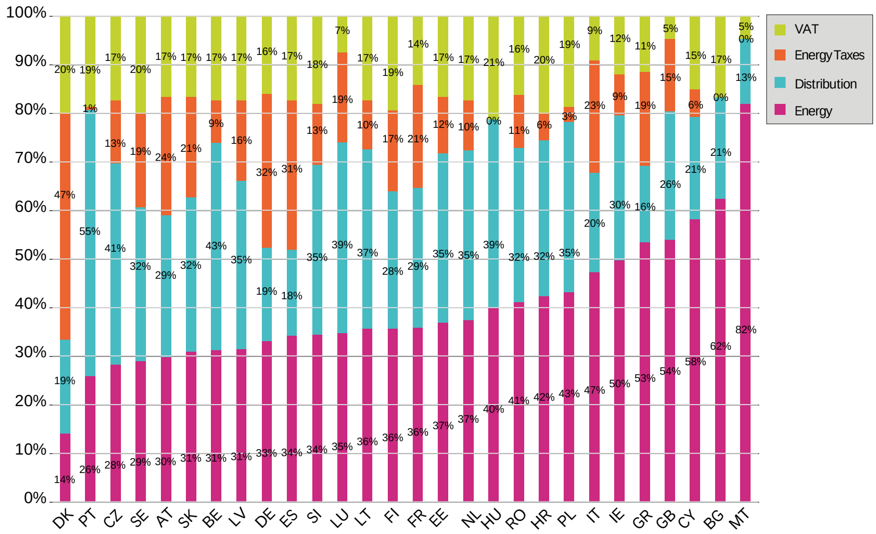
Source: CEER-ACER, National regulators – Capgemini analysis, WEMO2018

Figure A.6 Electricity retail market size (2017)

Country	Number of electricity customers (in thousands)
AT	6,076
BE	5,860
BG	4,839
CZ	5,901
DE	50,200
DK	2,800
EE	561
ES	28,825
FI	3,600
FR	36,865
GR	7,425
HR	2,372
HU	5,347
IE	2,236
IT	37,131
LT	1,656
LU	286
LV	1,125
NL	7,743
NO	2,900
PL	16,936
PT	6,076
RO	9,157
SE	5,346
SI	937
SK	2,454
UK	30,115

Source: Eurogas – Capgemini analysis, WEMO 2018

Figure A.7 Residential electricity price breakdown (as of June 2018)



Source: HEPI by E-Control Austria, MEKH and VaasaETT, 2017; AER; EA, analysis by VaasaETT - WEMO2018

Figure A.8 Status of gas price regimes (2017)

Country	Existence of regulated prices (year of price control removal)	
	Households	Non-households
AT	No (2002)	No
BE	No	No
BG	Yes	Yes
CZ	No (2007)	No
DK	Yes	Yes
EE	No	No
FI	No	No
FR	Yes but on going discussions)	Yes
DE	No (2007)	No
GR	Yes	Yes
HR	Yes	No
HU	Yes	Yes
IE	No	No
IT	No	No
LV	Yes	Yes
LT	Yes	No
LU	No (2007)	No
NL	No	No
PL	Yes	Yes
PT	Yes	Yes
RO	Yes	No
SK	Yes	No
SI	No (2007)	No
ES	No (2014)	No
SE	No (2007)	No
UK	No	No

Source: CEER-ACER, National regulators – Capgemini analysis, WEMO2018

Table A.9 Gas retail market size (2017)

Country	Number of gas customers (in thousands)
AT	1,346
BE	3,268
BG	87
CZ	2,844
DE	21,179
DK	420
EE	52
ES	7,556
FI	31
FR	11,311
GR	325
HR	647
HU	3,468
IE	661
IT	23,203
LT	562
LU	86
LV	443
NL	7,152
NO	Not developed market
PL	6,852
PT	1,382
RO	3,282
SE	37
SI	136
SK	1,506
UK	2,302

Source: Eurogas – Capgemini analysis, WEMO 2018

Figure A.10 Residential gas price breakdown (as of June 2017)

Source: HEPI by E-Control Austria, MEKH and VaasaETT, 2017; AER, EA, analysis by VaasaETT - WEMO2017

Glossary

ACER
Agency for the Cooperation of Energy Regulators, created under the EU Third Legislative Package, adopted in April 2009

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

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)

CAPEX
Capital Expenditure, funds used by a company to acquire or upgrade physical assets

CCS
Carbon Capture and Storage. Technologies used for isolating carbon dioxide from flue 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

Churn/Switch
Free (by choice) movement of a customer from one supplier to another

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

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

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)

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

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

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

Eligible customer
Electricity or gas consumer authorised to turn to one or more electricity or gas suppliers of his choice

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

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

EWEA
European Wind Energy Association

FID
Final Investment Decision

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

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 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

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

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

Installed capacity
The installed capacity represents the maximum potential net generating capacity of electric utility companies and auto-producers in the countries concerned

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

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. It entered into force in February 2005 and ends in 2012. 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).

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

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

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

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

Metering
Measurement of the various characteristics of electricity or gas in order to determine the amount of energy produced or consumed

NAP
National Allocation Plan. List of selected industrial and power installations with their specific emissions allowance (under the ETS system)

NEEAPs
National Energy Efficient Action Plans, plans providing detailed roadmaps of how each Member State expects to reach its energy efficiency target by 2020

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

Nomination
A request for a physical quantity of gas under a specific purchase or transportation agreement

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

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

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

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

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

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

Take-or-pay contract
Contract whereby the agreed consumption has to be paid for, irrespective of whether the consumption has actually taken place

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

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

List of Acronyms

1. ACCC: Australia Competition and Consumer Commission
2. ACEEE: American Council for an Energy Efficient Economy
3. ACT: Australian Capital Territory
4. ADIT: Accumulated Deferred Income Tax
5. AEMC: Australian Energy Market Commission
6. AER: Australian Energy Regulator
7. AGA: Advanced Grid Analytics
8. AMI: Advanced Metering Infrastructure
9. APEC: Asia-Pacific Economic Cooperation
10. APGCC: ASEAN Power Grid Consultative Committee
11. ARENA: Australian Renewable Energy Agency
12. ARFVTP: Alternative and Renewable Fuel and Vehicle Technology Program
13. ARRA: American Recovery and Reinvestment Act
14. ASEAN: Association of Southeast Asian Nations
15. BAU: Business-as-usual
16. Bcm: Billion cubic meters
17. BNEF: Bloomberg New Energy Finance
18. CAFÉ: Corporate Average Fuel Economy
19. CapEx: Capital Expenditure
20. CC: Contestable Consumers
21. CCA: Climate Council Authority
22. CCC: Climate Change Commission
23. CEVS: Carbon Emissions-Based Vehicle Scheme
24. CO_2: Carbon dioxide
25. CO_2e: Carbon dioxide Equivalent
26. COAG: Council of Australian Governments
27. COP22: 22nd Conference of the Parties
28. CPP: Clean Power Plan
29. CREZ: Competitive Renewable Energy Zones
30. CRI: Climate Risk Index
31. CRM: Customer relationship management
32. CSI: California Solar Initiative
33. CSIRO: Commonwealth Scientific and Industrial Research Organization
34. DER: Distributed Energy Resource
35. DES: Distributed Electricity and Storage
36. DfE: Design for Efficiency
37. DOE: Department of Energy
38. DSO: Distribution System Operator
39. DSM: Demand-side Management
40. EASe: Energy Efficiency Improvement Assistance Scheme
41. EBITA: Earnings before Interest, Taxes, and Amortization
42. EBITDA: Earnings before Interest, Tax, Depreciation and Amortization
43. EC: Energy Commission
44. ECF: Equity Crowd Funding
45. EE: Energy Efficiency
46. EERS: Energy Efficiency Resource Standards
47. EIA: Energy Information Administration
48. EMA: Electricity Market Authority
49. EPA: Environmental Protection Agency
50. EPS: Earnings per Share
51. ERCOT: The Electric Reliability Council of Texas
52. ETS: Emissions Trading Scheme
53. EV: Electric Vehicle
54. FERC: The Federal Energy Regulatory Commission
55. FFO: Funds from Operation
56. FFR: Fast Frequency Response
57. FPSS: Future Power System Security
58. FPA: Federal Power Act
59. FRC: Full Retail Contestability
60. GCF: Green Climate Fund
61. GDP: Gross Domestic Product
62. GHG: Greenhouse Gas
63. GIS: Geographic Information System
64. GJ: Gigajoules
65. GMI: Grid Modernization Initiative
66. GMLC: Grid Modernization Lab Consortium
67. GREET: Grant for Energy Efficient Technologies
68. GTFS: Green Technology Financing Scheme
69. GW: Gigawatt
70. HEV: Hybrid Electric Vehicle
71. IA: Investment Allowance
72. IBR: Incentive Based Regulation
73. ICT: Information and Communication Technologies
74. IEA: International Energy Agency
75. IEC: International Energy Consultants
76. IFC: The International Finance Corp
77. INDC: Intended Nationally Determined Contribution
78. IoT: Internet of Things
79. IPP: Independent Power Producer
80. IPv6: Internet Protocol version 6
81. ISO: International Organization for Standardization
82. IVR: Interactive Voice Response
83. kgoe: Kilograms of oil equivalent
84. KW: Kilowatt
85. KWh: Kilowatt-hours
86. LCOE: Levelized Cost of Energy
87. LNG: Liquefied Natural Gas
88. LPG: Liquefied Petroleum Gas
89. LRET: Large-scale Renewable Energy Target
90. LSS: Large Solar Scale
91. M2M: Machine to Machine
92. MDM: Meter Data Management
93. MIDA: Malaysian Investment Development Authority
94. MMBTU: Million Metric British Thermal Units
95. MMT: Million Metric Tonnes
96. MMTPA: Million Metric Tonnes Per Annum
97. MNCAA: The Mayors National Climate Action Agenda
98. MOU: Memorandum of Understanding
99. MSCI: Morgan Stanley Capital International
100. Mtoe: Million Tonnes of Oil Equivalent
101. MW: Megawatts
102. MWh: Megawatt-hours
103. NAFTA: North American Free Trade Agreement

104. NDC: Nationally Determined Contributions
105. NEA: National Environment Agency
106. NEB: National Energy Board
107. NECF: National Energy Customer Framework
108. NEPA: National Environmental Policy Act
109. NEM: National Electricity Market
110. NEMS: National Energy Modeling System
111. NGV: Natural Gas Vehicle
112. NIA: National Irrigation Administration
113. NIC: Network Interface Card
114. NOL: Net Operating Loss
115. NREP: National Renewable Energy Program
116. NSPS: New Source Performance Standards
117. NSW: New South Wales
118. OECD: Organization for Economic Co-operation and Development
119. PACE: Property Assessed Clean Energy
120. PHEV: Plug-in Hybrid Electric Vehicle
121. PEV: Plug-in Electric Vehicle
122. PBR: Performance-Based Ratemaking
123. PPAs: Power Purchasing Agreements
124. PPP: Public Private Partnership
125. PV: Photovoltaic
126. RGGI: Regional Greenhouse Gas Initiative
127. RE: Renewable Energy
128. REP: Retail Electric Provider
129. RES: Renewable Energy Sources
130. RET: The Renewable Energy Target
131. RIT-T: Regulatory Investment Test for Transmission
132. RPS: Renewable Portfolio Standards
133. RRO: Regional Reliability Organizations
134. RTO: Regional Transmission Organization
135. SCA: Scheme of Control Agreement
136. SCC: Social Cost of Carbon
137. SCEM: Singapore Certified Energy Manager
138. SEA: Southeast Asia
139. SGER: Specified Gas Emitters Regulation
140. SMOC: Streaming Media Online Charging System
141. SoC: Scheme of Control
142. SRES: Small-scale Renewable Energy Scheme
143. SSR: Summer Saver Rebate
144. S&P: Standard & Poor's
145. TCF: Trillion cubic feet
146. ToU: Time-of-Use
147. TWh: Terawatt Hours
148. T&D: Transmission and Distribution
149. UNCED: United Nations' Conference on Environment and Development
150. UNFCCC: United Nations Framework Convention on Climate Change
151. USTDA: United States Trade and Development Agency
152. UTP: Uniform Tariff Policy
153. VES: Vehicular Emissions Scheme
154. VPP: Virtual Power Plant
155. VRE: Variable Renewable Electricity
156. VWEM: Vietnam Competitive Wholesale Electricity Market
157. WSD: Water Supplies Department
158. WTE: Waste-to-Energy
159. WTO: The World Trade Organization
160. YTD: Year to date
161. 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	Federal Environment Ministry: www.bmu.de/ Energy Agency: www.dena.de/ Competition Authority: www.bundeskartellamt.de/
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	Electrical and Mechanical Services Department: www.emsd.gov.hk Environment Bureau: http://www.enb.gov.hk/en/
Ireland	IE	CER (Republic of Ireland) NIAUR (Northern Ireland)	Department of Communications, Energy & Natural Resources: www.dcenr.gov.ie/Energy/
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	Energy Commission : www.st.gov.my
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/
Philippines	PH	ERC	Energy Regulatory Commission: www.erc.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	Energy Market Authority: www.ema.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	Federal Department of Environment, Transport, Energy and Communications: www.uvek.admin.ch/ Competition Authority: www.weko.admin.ch/
Taiwan	TW	BOE	Bureau of Energy, Ministry of Economic Affairs: www.moeaboe.gov.tw
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	U.S. Department of Energy (DoE): https://www.energy.gov/
Vietnam	VN	MOIT	Ministry of Industry and Trade: www.moit.gov.vn

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