Capgemini

World Energy Markets Observatory

November 2017 | 19th Edition

In collaboration with:

vaasaETT

I4CE INSTITUTE FOR CLIMATE ECONOMICS

DE PARDIEU BROCAS MAFFEI AVOCATS

Contents

Figures

North America

Europe

Southeast Asia

Australia

Appendix Figures

Topic Box

North America

Europe

Southeast Asia

Australia

Energy Transition in the World

Editorial by Colette Lewiner

> In 2015, nearly all countries in the world committed to the Paris Agreement, which aims to restrict the increase in global temperature to 2°C (or less) by 2050

Energy Transition

Energy transition objectives and implementation differ from country to country.

Although the true objective is to decrease GHG[1] emissions, the USA, which had committed to reducing its GHG emissions, has changed its policy and is withdrawing from the Paris Agreement.
Also, in 2011 Germany closed half its nuclear plants (which don't emit CO_2) and since, Germany's lignite and coal generation plants caused emissions to rise, despite renewables development.

For many years, the IPCC[2] has warned about the consequences of GHG increases on the climate.

In 2015, nearly all countries in the world committed to the Paris Agreement, which aims to restrict the increase in global temperature to 2°C (or less) by 2050.
There are basically three ways to limit GHG emissions: energy conservation, carbon pricing, and development of renewable energy sources.
The first is complex to achieve because of cultural habits and also the very local level at which decisions are taken. For example, energy savings in existing buildings, which are equivalent to the total consumption in the transportation system, are difficult to implement, particularly because of the multiplicity of parties involved and their divergent interests. So energy efficiency, while the cheapest way to achieve GHG emissions reduction, is progressing slowly, handicapped also by the present low energy prices that give a poor return on investment in related projects.

The second way would be to establish a high enough carbon price in order to increase the cost of carbon-rich usage and discourage investors.

In order not to add a new tax while combating global warming, in 2005 the EU[3] launched the ETS[4] but unfortunately it doesn't deliver the right price signal. Due to the 2008 economic crisis that has created an emissions rights surplus and the EU's inability to reform the ETS, the carbon price is down at meaninglessly low levels. Other regions and countries have also created carbon markets (but these are not having yet an impact on the global position). The UK has a

1 GHG: Greenhouse Gas
2 IPCC: Intergovernmental Panel on Climate Change
3 EU: European Union
4 ETS: Emissions Trading System

carbon floor price, which should inspire others.

Despite cost decreases, the third, and more onerous, way is renewables development.

Photovoltaic cells and wind turbines still generate only 7% of the world's electricity. They are now growing faster than any other energy source and their falling costs are making them more competitive. However, they still need financial help: Europe, the USA, and other regions have massively subsidized their development, which means that, once again, the end customer is paying for it.

These huge public subsidies, of about $800 billion worldwide since 2008, have distorted the market. They have hit just as electricity consumption in the developed world was stagnating because of growing energy efficiency and the financial crisis. The result was a glut of power-generating capacity that has pushed wholesale prices down to very low levels and slashed revenue for the Utilities. The latter have suffered a "lost decade" of falling returns, stranded assets, and political disruption. Last year, Germany's two biggest electricity providers, E.ON and RWE, both split in half. In renewables-rich parts of America, power providers struggle to find investors.

The bigger task is to redesign electricity, capacity and carbon markets in a coherent way in order to reflect the new need for flexible supply and demand, and to provide relevant price signals that will incentivize investors. Policymakers need to remedy the out-of-date method of electricity pricing.

Unfortunately, the Clean Energy package, now to be adopted in Europe, is not really tackling this problem.

As will be discussed later, the good news is that new technologies can help fix the problem. Price cuts in renewables and electricity storage, combined with digitalization, will decrease the cost of reliable green electricity and help cope with intermittent supply.

Climate Change

2016 was the third year in a row where global energy-related CO_2 emissions from fossil fuels and industry remained stable despite 3% growth in the global economy and increased demand for energy. This can be attributed primarily to the decline in coal consumption, but also to the growth in renewable energy capacity and to improvements in energy efficiency. Decoupling economic growth and CO_2 emissions is an important first step towards achieving the decline in emissions necessary to keep the global temperature rise below 2°C.

The Paris Agreement signed in December 2015 by 197 nations was a big diplomatic success. It commits governments collectively to keep the global temperature rise well below 2°C compared with pre-industrial levels, with the aim of holding it at 1.5°C.

During 2016, 117 countries adopted NDCs[5], 55 of which featured renewable energy targets and 107 of which featured energy efficiency targets. Yet the sum total of national pledges would take the temperature well over the 2°C threshold, with best estimates ranging between 2.3°C and 3.5°C.

The USA is the second biggest GHG emitter (14% of the total) after China (28.6%). In November 2011, China's President Xi Jinping and USA President Barack Obama committed to curb their GHG emissions. The USA committed to a 26-28% reduction of GHG emissions by 2025 compared to 2005. China pledged to reach peak carbon emissions by 2030, if not sooner.

President Obama ratified the Paris Agreement during COP22 (after Donald Trump was elected). President Trump announced on June 1, 2017 that he had decided to withdraw from the Paris Agreement as he felt it did not serve the American people well. He has also abandoned the Clean Power Act, which would have been one enabler to reach USA objectives.
In addition, the Environmental Protection Agency budget was significantly reduced.
However, the USA cannot withdraw immediately. According to article 28, it can either denounce the Agreement, which would be a long and complex procedure ending in 2020 (the next election year); or it can denounce the United Nations Framework Convention in which the Paris Agreement is embedded, which would take only one year but would have to be validated by Congress.

This withdrawal decision will have significant consequences:

- Political: other countries could follow the USA
- More effort required from other countries: the USA not respecting its commitment[6] will lead to an increase in emissions of 3 billion tonnes of carbon per year until 2030 or an estimated global temperature increase of 0.3°C. This will have to be compensated for by lower emissions from other countries.

5 NDCs: Nationally Determined Contributions
6 According to Climate interactive projections

- Financial: the USA will cut $15 million from the management expenses of CCNUCC[7](25% of its budget). In addition, the USA had committed to finance the green fund[8] up to $3 billion but will no longer do so. And it will probably stop financing the IPCC[9] (the USA has paid 40% of the budget since 1998).
- However, if other countries do not follow Donald Trump's withdrawal decision, the Paris Agreement can continue to be a good way to prevent global warming reaching dangerous levels.

Carbon pricing

In addition to NDCs, sufficiently high carbon prices that increase over time would be a meaningful climate policy instrument because they render high-emission forms of energy (such as coal power) unprofitable over the long term, and low-emission technologies (such as wind and solar) more competitive.

Economists say that the cost of emitting carbon dioxide must rise to $40-80/t by 2020 and to $50-100/t in the following decade, if countries are to meet climate pledges made under the Paris Agreement.
Until now, 40 countries, more than 20 cities, and some other areas, have priced carbon emissions using taxes or forms of ETS. But these schemes only cover about 15% of global GHG emissions and need to be extended worldwide.

Europe's ETS is delivering a very low price signal that has no impact on investment decisions towards de-carbonized technologies. The EU is attempting to reform the system in order to make it more flexible and to withdraw excessive rights. The MSR[11] was adopted in September 2015 and should start to be effective in January 2019. Prices in Europe's ETS are now around €7/t and are forecast to average just over €16/t from 2021-2030.

To push for GHG emissions reductions, in 2011 the UK adopted a Climate Change Levy with a target price of £30/t of carbon dioxide in 2020, and a start price in 2013 of around £16 per tonne. Later, the Government decided to cap the floor price at £18/t to limit the competitive disadvantage faced by businesses and energy bill increases for consumers. The difference between this carbon price floor and the ETS price is de facto a tax.

Carbon pricing needs to be combined with policies to promote energy efficiency, renewable energies, and innovation.

Energy Efficiency

Measures implemented over the last 25 years have saved an amount of energy equivalent to the total current demand of China, India and Europe combined. By 2015, energy intensity was more than 30% lower than it was in 1990. In 2015, global primary energy intensity improved by 2.6% on the previous year, bringing the average annual rate of improvement between 2010 and 2015 to 2.1%. This was an important achievement, but energy intensity will need to be improved by 2.6% annually (on average) starting in 2017 if the energy efficiency goals[12] are to be met.

Coal

One positive consequence of the Paris Agreement was the commitment by utilities, industry and financial institutions to stop investing in coal. Global demand for coal has fallen for the second consecutive year[13], helped by consumption decreases in the USA (-9%), the EU (-8%), and China (-4.7%). In the USA, coal has been replaced in power generation by cheaper, cleaner gas from the shale boom. In Europe, uneconomic coal-fired generation plants have been closed or pushed to shorter utilization periods by renewables development.
Coal consumption in China has now been declining for three years, as the country's growth is shifting from energy-intensive sectors such as iron, steel and cement to services.
In 2016 overall, coal's global energy market share fell to 28.1%, its lowest level since 2004.
Coal prices have decreased steadily since 2012 to around $48/t. After a surge in coal prices in the second half of 2016 to $139/t on the back of mining curbs imposed by China, coal prices declined sharply in early 2017 before increasing to around $95/t by mid-August 2017.

Carbon Capture and Storage (CCS)

CCS is a way to reduce GHG emissions from fossil fuel (oil, gas and coal) fired plants. Many of the world's largest oil and gas companies recently invested $1 billion in CCS research mainly in industrial pilots. Recent analysis[14] shows that USA coal plants equipped

7 Convention Cadre Nations Unies sur le Changement Climatique
8 Helping developing countries to implement mitigation measures
9 IPCC: International Panel on Climate Change
10 The Commission on Carbon Prices, a group of 13 leading economists supported by the World Bank, http://www.reuters.com/article/us-climatechange-carbon-prices-idUSKBN18P0PN
11 MSR: Market Stability Reserve
12 www.se4all.org/
13 66th edition of BP's annual statistical review of energy
14 www.forbes.com/sites/energyinnovation/2017/05/03/carbon-capture-and-storage-an-expensive-option-for-reducing-u-s-co2-emissions/#36005af06482

with CCS are nearly three times more expensive than onshore wind power and more than twice as expensive as solar photovoltaic. Although these costs will decline with research and development, the potential for cost improvement is limited by the laws of physics.
More research is needed on other processes to eliminate carbon dioxide emissions.

Progress in sector-related technologies: important enablers for successful energy transition

A. Shale oil and shale gas

Technology advances

New technology advances are more often thought of in the renewables sector. However, in the more traditional oil and gas sector, the USA-led "shale revolution" has dramatically changed the world energy outlook and is establishing a new order.
Starting in the 1970s, declining production from conventional gas deposits in the USA prompted the federal government to invest in R&D projects to try to boost USA resource exploitation. But it was not until 1991 that Mitchell Energy's first horizontal drill in the Barnett Shale in north Texas took place. Mitchell used new technologies, such as micro-seismic imaging, to achieve the first economic shale fracture in 1998 with the execution of a slickwater completion.
Drilling innovations generated a spectacular reduction in the cost of pumping oil from shale formations across the USA, triggering an energy revolution and a production boom. A few years later, the USA became the leading gas producer, ahead of Russia (in 2011), and the leading oil producer, ahead of Saudi Arabia (2013).[15]
That boom ended with the two-year global price war in 2014. The industry experienced scores of bankruptcies and thousands of layoffs.
Shale producers responded with deeper cost cuts. Since 2013, the average wellhead breakeven price (BEP) for key shale plays has decreased from $80/bl to $35/bl. This represents an average decrease of more than 55%[16]. There are several reasons behind this drop. Part of it is attributable to structural changes, such as improved well performance (which can be measured by improvements in the EUR[17]) and improved efficiency gains (which can be measured by lower drilling and completion costs, a result of more effective operations). Another set of drivers behind the falling BEP relates to reduced prices in oil services (e.g. rigs, crew supply, technology expertise) linked to drops in oil prices. But in 2017, for the first time since 2012, shale producers will see a rise in BEP costs, according to data from Rystad Energy[18].
Between half and two-thirds of the cost savings achieved during the oil price slump are likely to become permanent even if oil prices increase, according to industry experts and company estimates. This resilient and rapid adaptation has allowed the USA to resume shale oil production.

In 2017, forecasters are estimating the increase in production (compared to 2016) at 600,000-700,000 bpd[19] . They believe this is likely to continue in 2018; and because this form of production is far less capital intensive than conventional methods, it is much more flexible.[20]

Shale is a worldwide game changer

In an attempt to boost prices, OPEC and non-OPEC countries, led by Russia, agreed in May 2017 to extend the crude oil output curbs by nine months to March 2018, keeping roughly 1.8 million barrels per day off the market.
However, the June 2017 Energy Information Administration (EIA) forecast shows that USA oil production growth has the ability to offset much of that[21] – potentially derailing the group's efforts to rebalance supply and demand worldwide.
Also, OPEC needs to realize that supply cuts and higher prices only make it easier for the shale industry to deliver higher profits after it found ways of slashing costs when Saudi Arabia turned up the taps in 2014.
Shale oil will fundamentally change the length of oil price cycles.

Oil prices

In December 2016, OPEC and non-OPEC producers reached their first deal since 2001 to jointly curtail oil output and ease the global production glut after more than two years of low prices. That agreement pushed prices up to $50/bl and more.

---

15 https://www.eia.gov/todayinenergy/detail.php?id=26352

16 http://www.worldoil.com/news/2017/2/28/rystad-examines-what-to-expect-from-us-shale-break-even-prices-in-2017

17 Estimated Ultimate Recovery (EUR) is an approximation of the quantity of oil or gas that is potentially recoverable or has already been recovered from a reserve or well.

18 http://www.worldoil.com/news/2017/2/28/rystad-examines-what-to-expect-from-us-shale-break-even-prices-in-2017

19 bpd: barrels per day

20 An unconventional well seeks investment of less than $10 million in some cases.

21 USA crude oil production averaged an estimated 8.9 million bpd in 2016 and is forecast to average 9.3 million bpd in 2017. EIA forecasts crude oil production to average 9.9 million bpd in 2018 (1 million bpd rise over two years), which would mark the highest annual average production in USA history,

In May 2017, OPEC and non-OPEC producers extended this agreement for nine months until March 2018.

North Sea Brent crude oil spot prices averaged $48/bl in July 2017, almost $4/bl higher than in July 2016.

The EIA[22] forecasts Brent spot prices will average $51/bl in 2017 and $52/bl in 2018. Other agencies[23] forecast a more bearish price direction (25-30$/bl in H1 2018) resting on three core perceptions and assumptions:
1) global oil fundamentals remain much looser (no big stock draws in H2 2017) than implied by the consensus;
2) the Vienna Group will not make sufficient incremental collective cuts at the November 30, 2017 OPEC meeting, and unity should disintegrate by the end of Q1 2018; and
3) Riyadh will continue to refuse to implement cuts unilaterally.

Gas

Gas-fired plants and factories emit less GHG than coal ones and are less polluting in general.
In the long term, gas consumption should benefit from the Paris Agreement on climate change as companies and investment funds commit to abandon coal.
As with oil, fracking technologies have unleashed abundant cheap gas. The average dry natural gas production rate is forecast to reach 73.1 tcf/d[24] in 2017, the second highest on record.
Spot prices on the Henry Hub exchange decreased to about $2/MBTU[25] in April 2012. They have since rallied to around $3/MBTU (still much cheaper than European and Japanese gas).
For a few years, cheap gas replaced coal in many USA electrical plants, contributing to the GHG emissions decrease. As a consequence, surplus USA coal was sent to worldwide markets triggering a coal price decrease starting in 2012[26].
In contrast, cheap coal arriving in Europe combined with ridiculously low carbon pricing has contributed to the closure of many brand new gas-fired plants that were important for security of supply.
The USA natural gas glut, provoked by abundant shale gas, is now expanding to global markets, with large amounts of supply coming online in the next few years, even though prices remain depressed.
Global demand for an LNG[27] increase[28] is being outpaced by faster production increase from a number of areas[29] thus exacerbating the glut.[30]
After opposition from USA leaders of energy intensive industries, many USA liquefaction projects got permission from the Federal Energy Regulatory Commission (FERC) to export LNG. The first one, Sabine Pass, loaded its first cargo in February 2016.
In April 2017, approval for the Golden Pass LNG terminal brought total authorized exports to 19.3 bcf/d[31].
The USA Department of Energy (DOE) says that studies have shown positive benefits to the USA economy with LNG exports up to 28 bcf/d.
Regasification terminals built on land encounter significant local opposition, slowing down construction and increasing costs.
Advanced technologies have enabled the construction of Floating Storage and Regasification Units (FSRUs) whose costs are half those of traditional terminals, and construction time is also halved. They also allow much more flexibility in the way they function. They have been in operation for little more than 10 years, but have moved quickly from being a specialist niche to a mainstream solution for potential new regasification terminals. FSRUs have helped open up new markets, notably linked to the need to deliver LNG to remote locations.
Today, a number of integrated LNG-to-power projects that use re-gasified LNG to fuel power generation are opting to utilize FSU[32] or FSRU technology[33] as it allows development of flexible small and mid-size infrastructure with lower capital costs and shorter lead times.

The rise of LNG[34] will make natural gas trading much more like oil. Today, the main trade is through regional pipelines. As a consequence, there is no global gas price, only regional prices.

In 2011, the Fukushima accident and consequent nuclear plant closures triggered high Japanese demand for LNG, pushing Asia prices high (around seven times Henry Hub prices). With the return of a few nuclear plants into

22 August 7, 2017 report
23 The Rapidan Group
24 Tcf./d: trillion cubic feet per day
25 MBTU: Million British Thermal Units
26 Coal prices have rebounded since
27 LNG: Liquefied Natural Gas
28 LNG demand is expected to rise at 4-5%/year, between 2015 and 2030, according to Royal Dutch Shell PLC's first LNG Outlook.
29 With a total LNG production increase of 44% from 2015 to 2020
30 https://www.forbes.com/sites/michaellynch/2017/03/16/the-glutted-world-gas-market/#51d0e5b154cc
31 bcf/d: billion cubic feet per day
32 FSU Floating Storage Unit
33 http://world.cwclng.com/lng-to-power-key-bankability-considerations-for-fsru-to-ipp-project-structures/
34 50% between 2015 and 2020 www.woodmac.com/reports/lng-global-lng-fsru-overview-2016-35539602

operation in Japan and the abundant LNG supply in Asia/Australia, these discrepancies have decreased: at the end of 2016, Asia prices were "only" three times USA ones. European price gaps also narrowed from more than three times USA ones in 2012 to around twice at the end of 2016.
In June 2017, a first cargo of USA LNG reached Poland and in August 2017 another was supplied to Lithuania. Calculations[35] of the price for USA LNG bound for Europe suggest that it is about $1-2 above northwestern European benchmark gas prices. However, countries formerly belonging to the Soviet Bloc, like Poland or Lithuania, which are heavily dependent on Russia for their supplies, are ready to pay this price premium in order to increase their energy independence.
More generally, Europe, which imports 30% of its total gas needs from Russia, is willing to diversify its sources of supply.
This explains EU[36] opposition to the extension of the Nord Stream pipeline (Nord Stream 2) that brings gas from Russia to Germany without passing through Ukraine.
Shortcutting Ukraine will avoid repetition of past incidents such as in January 2009 when a dispute between Russia and Ukraine deprived Europe of Russian gas supplies. Some countries, especially in the eastern part of Europe, had no gas and sometimes no heating during three weeks of a very cold winter. At that time, 80% of Russian gas supplies went through Ukraine.
Despite this security of supply improvement, the pipeline extension will strengthen Russia's position in Europe, contrary to EU objectives.

Outlook

With low oil and gas prices, FID[37] investments in large conventional oil or gas fields are being pushed forward. This could create a shock in oil prices in a few years' time. However, with the 2°C global temperature increase limitation, sustained and significant carbon pricing, and the use of more renewable energy sources (with declining costs), the competitiveness of oil, gas and coal will change, slowing down production of these fossil fuels. According to an IEA/IRENE study, if the 2°C commitment is implemented, 80% of coal reserves will stay in the ground, along with 50% of oil and 40% of gas.

B. Renewables

General considerations

Renewables are considered the main component of energy transition as they do not generate GHG emissions. However, this is not entirely accurate if one considers first-generation biofuels, for example. In addition, other technologies such as nuclear do not emit GHG.
Except for hydropower, renewables are not yet mature technologies and there is significant potential for improvements and cost decrease.

The main drivers for renewable energy deployment are mitigation of climate change and, in many countries, notably China, reducing local air pollution and the health problems that it causes.
Also, as renewables are domestic energy sources, security of supply is another important driver.

Technology considerations

Renewables are a dispersed form of energy occupying a significant amount of land surface. For example, replacing a 1,000 MW nuclear reactor with photovoltaic farms would require to cover a surface area equivalent to Paris.

Renewables belong in two main categories: renewables with storage (hydropower, biomass, concentrated solar power – CSP) and those without (mainly photovoltaic solar and wind). The latter are variable by nature and thus need backup (storage, other generation sources). In the absence of competitive mass storage their share of the electricity mix is limited (around 40%). Their non-dispatch nature creates grid disturbances (balancing problems, grid overhaul), leading to extra cost (depending on grid structure, around 30%)[38 39].

For example, in 2014, the South Australian Government set a target of 50% of the state's energy to be supplied by renewable sources by 2025, aiming to be carbon neutral by mid-century, which meant moving to 100% renewable electricity over the next 15-20 years.
In 2016, around 50% of its electricity came from sun- and wind-based sources. However, this level was not sustainable as the state experienced several blackouts and load shedding. Following these events, in March 2017, the Government announced it would spend more than A$550 million (€333 million) to build a new gas-fired power plant and Australia's largest battery in order to secure the state's energy supply. In July 2017, the Prime Minister announced that the world's largest lithium ion battery (100 MW capacity) would be built by Tesla

35 http://oilprice.com/Energy/Natural-Gas/Can-US-LNG-Challenge-Gazprom-In-Europe.htm

36 EU: European Union

37 Final Investment Decision

38 See 16th EEMO editorial and "Cost-Supply Curves of renewable electricity in Germany – First Results" M. Wiesmeth, R. Barth, A. Voß, Institute of Energy Economics and the Rational Use of Energy (IER). University of Stuttgart, IRENA-ETSAP Joint Session: REMAP 2030 17. June 2013, Paris

39 European Physical Society – Energy Group position paper July 30, 2015

In 2017, unsubsidized onshore wind LCOE varies from $25/MWh to $62/MWh without storage. When all of the storage expenses are included, LCOE amounts to around $100/MWh.

and paired with the Hornsdale wind farm developed and operated by the French company Neoen.

Cost considerations

The LCOE[40] of renewables projects is determined by wind or sun resource quality, the technical characteristics of the wind turbines or solar panels, O&M[41] costs, the economic life of the project, the cost of equipment and installation, and regulations including local public acceptance, which can cause delays.
The renewables market's spectacular growth has triggered increased competition and enabled economies of scale and supply chain optimization. These trends should continue.

However, the cost of capital today is extremely low; it will very probably grow in the future, negatively impacting on renewables costs, as they are strongly linked to capital investment (which is less so for some other electricity generation sources).

Wind

Onshore wind: Cumulative Investment amounted to $647 billion over the period 1983-2014. Total installed onshore wind capacity has increased by almost 25% per year over the last decade reaching 472 GW globally at the end of 2016[42]. The main technology improvements are larger turbines, advanced blades, advanced towers, and improved turbine reliability, which increases electricity yields from the same wind resource and reduces the land occupied. In addition to these technology drivers, improved micro-siting of turbines from better wind resource measurement and modeling will also help.

Results and outlook: As for all renewables, the global weighted average LCOE of onshore wind varies from region to region.
In 2017, unsubsidized LCOE varies from $25/MWh to $62/MWh without storage. When all of the storage expenses are included, LCOE amounts to around $100/MWh. Other external factors related to reliability or intermittency (e.g. transmission and associated back-up generation costs) lead to an empiric 30% cost increase.
Historically, the LCOE (in $/MWh) has declined by 66% from 2009-2016.[43]
These costs could fall by 26% by 2025.[44]
In 2016, the record low bid winning price was $30/MWh in Morocco.
Public opinion in certain countries (notably France), increased local opposition to onshore wind is making new projects more complex and more costly.
This is a big incentive for offshore wind.

Offshore wind

Components of offshore wind farms include turbines (including towers), foundations and grid connection to the shore. Technology improvements are similar to those for onshore wind with additional economies of scale obtained by increasing turbine size (an average 5 MW in 2016 in Europe that could more than double by 2024[45] to 12-15 MW), improving power transmission cable technologies for more distant platforms, and moving to floating sea foundations. Progress is also expected in the development and operation of offshore wind farms.
Results and outlook: Reductions in LCOE by 2025 should lower the average cost of electricity by at

40 LCOE: Levelized Cost Of Electricity
41 O&M: Operation and Maintenance
42 http://www.gwec.net/wp-content/uploads/2017/02/7_Annual-and-Global-Cumulative-Offshore-wind-capacity-in-2016.jpg
43 /www.lazard.com/media/438038/levelized-cost-of-energy-v100.pdf
44 Irena
45 http://www.telegraph.co.uk/business/2017/05/16/worlds-largest-wind-turbines-may-double-size-2024/

least 35% from around $170/MWh in 2015[46]. However, these cost decreases could be faster as some offshore wind project prices in 2017 were already as low as $50/MWh (in Germany).

Solar

Photovoltaic (PV): Significant technological progress can be reported. For example, efficiency increases: manufacturers have been able to create solar panels that are nearly 30% efficient, and in 2016 high-end commercially available cells had an efficiency between 19-21% generating 25% more electricity than average cells and reducing the area required for a given watt of power output. In France's CEA-LETI labs, efficiency of 46% was reached. However, super-high-efficiency panels are typically made of more expensive materials and are not yet cost efficient.
The cost of utility-scale solar PV could fall by more than half in the next ten years, driven by continued technological improvements, as well as supply chain and manufacturing cost decreases linked to scaling up the industry. The majority (about 70%) of cost reductions will come from lower BoS[47] costs including module lifetime increases and cost decreases. Today there is a large spread of BoS costs and convergence towards best practice is key to achieve those cost reductions.
Competition: Chinese solar panel manufacturing capacity is oversized for domestic needs, leading to massive exports[48]. Despite trade tariffs imposed by the USA government and by the EU[49], China has continued to supply cheaper and lower performance panels to many regions (21% of the USA market in 2016 and 63% of the Japanese market). This is undermining local industries and many of them have disappeared[50].
In May 2017, at the same time that he announced USA withdrawal from the Paris Agreement, President Donald Trump revealed the USA International Trade Commission's decision to investigate imports of solar panels. This could result in increased taxation and solar cost increases.
Results and outlook: From 2009 to 2016, the average utility scale PV systems LCOE decreased by 85% reaching $46-61/MWh in 2016 in the USA (without storage or additional grid costs)[51]. However, in 2016, projects were won in Chile at $29/MWh and at $24/MWh in Abu Dhabi. Electricity output costs are expected to decrease by 59% by 2025. In Germany, this cost is around $56/MWh, while in France it is around $63/MWh.

CSP (Concentrated Solar Power)

This mirrors-based technology has the advantage of being able to store electricity a few hours (8-10) but it is still in its infancy in terms of deployment, with total capacity around 5 GW at the end of 2015. The LCOE is high ($119-182/MWh[52]). There is thus still ample opportunity for cost reduction as more plants are installed, economies of scale are unlocked, and industry experience is gained.
By 2025, the LCOE of CSP technologies could decrease by around 40%[53].

Incentive systems

Even though the LCOE for renewables (mainly wind and solar) is decreasing and will continue to do so, it is still usually higher than other types of generation when their intermittent nature is taken into account.
In order to push for their deployment, nearly all countries have put subsidies in place. These cumulative public subsidies amounted globally to about $800bn[54] from 2008-2016, which is a huge figure.
These subsidies are de facto regulating the market.

In Europe the system is organized around feed-in tariffs at which Utilities are obliged to buy renewable energies even if it is more costly for them than their own electricity generation.

This extra cost is paid for by end customers through taxes in their electricity bills. As the share of renewables in the electricity mix increases (25% in Germany), so do these taxes; for example, in Germany, they amount to 50% of the total household electricity bill, while in France, where the wind and solar share of electricity generation is around 6%, they amount to slightly more than 20%. Overall, German residential prices are twice the French ones.
This feed-in tariffs system was first reformed in Germany and Spain (those countries having the highest renewables share). As a result, retail electricity prices in Germany and Spain have stabilized.
In a similar fashion to Germany, in the EU starting in 2017, feed-in

46 Without storage and not accounting for grid induced cost.
47 Balance of System Cost
48 $14 billion in solar equipment in 2016.
49 30% US Trade import tariff imposed in 2012 and 11,5% in EU
50 For example, Solar World the last German solar panel manufacturer went bust in May 2017
51 Lazard 92$/MWh with storage
52 Lazard, without storage, 237$/MWh with storage
53 Irena
54 http://www.economist.com/news/leaders/21717371-thats-no-reason-governments-stop-supporting-them-wind-and-solar-power-are-disrupting

tariffs that have little or no relation to market reality are being replaced by auctions or bidding processes open to all green energy generators competing for government funds. These reforms will probably slow down the progress of renewables, as was already observed in 2016.

The USA Congress agreed in December 2015 to extend the solar ITC[55] at its current rate of 30% through to 2019, after which it will fall progressively to 10% in 2022. In addition, the wind PTC[56] will be retroactively applied to 2015 and extended through 2016, after which it will decline each year until it expires in 2020.
These tax credits incentivize renewables by decreasing wind power and solar PV utility scale generation costs by $10-20/MWh[57].
In addition to federal tax credits, some American states have their own incentives.
However, the new USA president could well decide to roll back tax credits and other subsidies for renewable energies.

2016 position

In 2016, global new investment in renewables(excluding large hydro) fell by 23% to $241.6 billion, the lowest total since 2013, but the same period saw record installation of renewable power capacity worldwide[58]. In 2016, the installed capacity figure was equivalent to 55% of all generating capacity added globally. For the first time, more solar capacity was added (75 GW) than of any other technology. The proportion of global electricity coming from these renewable sources rose from 10.3% in 2015 to 11.3% in 2016.
There were two main reasons for the fall in investment in renewables. One was lower costs in capital expenditure per MW. The other was a marked slowdown in financing in China, Japan and some emerging markets. Overall, renewable energy investment in developing countries fell 30% to $116.6 billion, while that in developed economies dropped 14% to $125 billion.

Outlook

According to Irena[59], policies now in place will only increase the renewables share of the global energy mix to 21% by 2030 compared to 19.3% in 2015. As global energy demand continues to grow – it will be 30% higher in 2030 compared to today's level – the pace of renewables deployment is only slightly higher.[60]
Although the outlook for renewables in the power sector is highly positive, advances in transport, heating and industry are slower.
Bioenergy will have to account for half of renewable energy use in 2030 for a high enough renewables share overall. There are many hurdles to its development including today's low oil prices.
Renewables are essential to extend energy access to all. Off-grid renewable solutions offer the most cost-effective way to expand electricity access in developing countries.
Finally, significantly increasing the renewables share is key to achieving a carbon-free energy system in the next 50 years. It would also reduce the challenges of global energy security and risks to the environment and human health.

C. Storage

Wind and solar energies are intermittent by nature but electricity demand and supply has to be balanced moment by moment. Storage is thus vital to enable development of renewables.
Storage systems vary in nature and include pumped water, compressed air, magnetic flywheel, batteries and hydrogen. The first two depend on suitable natural sites (mountains, appropriate geology).
In Europe, there are adequate sites for pumped storage, which is the cheapest large storage method, and these are usually equipped. Some new projects are underway (e.g. Alpiq in Switzerland) but their competitiveness is questionable as the wholesale electricity price difference between peak hours and off hours is markedly reduced by renewables development.

The characteristics of these different forms of storage have to be analyzed regarding their usages[61]. For example:

- Transmission grid usages: notably to improve large-scale variable energy resource generation integration (e.g. utility-scale renewables), replacement of peaker plants, and frequency regulation. Storage usages and costs/benefits depend on the grid configuration, particularly the percentage of renewables in the electricity mix;
- Distribution-related storage, microgrids and island grids;
- Residential energy storage systems for behind-the-meter residential home use provide backup power, power quality improvements, and extend usefulness of self-generation (e.g. "solar plus storage");

55 ITC Investment Tax credit
56 PTC Production Tax Credit is a federal incentive that provides financial support for the development of renewable energy facilities.
57 Lazard
58 http://fs-unep-centre.org/sites/default/files/attachments/gtr_2017_-_key_findings.pdf In 2016 capacity added was138.5 GW, up from 127.5 GW in 2015
59 http://www.irena.org/DocumentDownloads/Publications/IRENA_REmap_2016_edition_summary.pdf
60 http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=290
61 https://www.lazard.com/media/438042/lazard-levelized-cost-of-storage-v20.pdf

- Electric Vehicles (EVs).

Storage is taking off in a limited number of markets, but it is still small in scale.

In 2016, approximately 0.8 GW of new non-pumped energy storage capacity became operational – mostly consisting of battery (electrochemical) storage but also some CSP[62] storage capacity – bringing the year-end total to an estimated 6.4 GW. This amount complements an estimated 150 GW of pumped storage capacity in operation worldwide.

Most of the growth took place in battery (electro-chemical) storage, with innovations driven largely by the EV industry[63], household energy storage complementing local solar photovoltaic generation and power sources for cell phones and other connected objects in the Internet of Things (IoT)[64].

The most promising technologies are:

- Lithium-ion batteries, which are relatively established and have historically been used in electronics and advanced transportation industries; they have relatively high energy density, low self-discharge, and high charging efficiency. However, they are safety issues linked to overheating;
- Zinc batteries cover a wide range of possible technology variations, including metal-air derivatives; they are non-toxic, non-combustible, and potentially low-cost due to the abundance of the primary metal; however, this technology remains unproven in widespread commercial deployment.

These battery costs have decreased by 80% from ~$1,000/kWh in 2010 to ~$227/kWh in 2016, according to McKinsey[65].
McKinsey predicts that battery pack prices will be below $190/kWh by the end of the decade but Tesla claims this has been the case since early 2016. Between 2025 and 2030, battery pack costs should fall below $100/kWh.
Unfavorable battery economics will remain a profitability barrier for EVs during the next 10 to 15 years. However, regulatory measures (linked to air pollution) and financial incentives will shorten this delay.

The storage market will grow rapidly. Between now and 2020, over 29.4 GW of new storage capacity is forecast to be deployed worldwide across all sectors at a compound annual growth rate of 60%.
Companies in the sector are well aware of this potentially huge market. This explains why, for example, Daimler is to invest $1 billion in two large battery factories and Tesla Motors is making a huge investment in the form of a massive battery factory. By doing so, the company hopes to gain economies of scale and reduce costs further.
There is no doubt that falling storage prices will pave the way to transition to cleaner energy systems.

Scarcity of critical metals

Lithium accounts for only about 5% of the materials in some batteries, and for less than 10% of their cost but it is a vital component of batteries. With demand for energy storage set to grow quickly, battery manufacturers are scrambling for supplies of lithium[66]. These tensions are reflected in surging prices.
Other rare metals[67] are critical to renewable technologies (solar PV panels and wind turbines notably).

Between 2025 and 2030, battery pack costs should fall below $100/kWh

The storage market will grow rapidly. Between now and 2020, over 29.4 GW of new storage capacity is forecast to be deployed worldwide.

62 Concentrated Solar Power
63 http://www.nature.com/nclimate/journal/v5/n4/full/nclimate2564.html
64 Internet of Things
65 http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/electrifying-insights-how-automakers-can-drive-electrified-vehicle-sales-and-profitability
66 New-York times https://www.nytimes.com/2015/11/20/opinion/the-next-resource-shortage.html?mcubz=0
67 A group of roughly 50 elements that includes indium, rare earths and gallium

They are concerns over potential shortages of these metals because the speed of renewables and storage development may soon outpace our ability to develop sustainable supplies to support them[68]. Governments and Companies must turn them into commodities, by making them cheaper, more abundant and produced with minimal environmental impact.

D. Power to gas

The power-to-gas process uses electrolysis to convert excess electricity from renewable sources into hydrogen. It can either be used immediately or turned into methane by using carbon dioxide in a subsequent step. Converting electricity to gas allows solar and wind power to be stored in the gas grid. What's more, hydrogen and methane can be used to power fuel cell vehicles or natural gas vehicles. However, this process is still too expensive as the investment costs for electrolyzers and synthesis reactors are too high in proportion to the low number of hours the plants spend in operation.

In Europe, investment in research and industrial pilots is significant, notably in Germany where DENA (the German energy agency)[69] is aiming to establish power to gas as a reliable, cost-efficient, and large-scale multipurpose option with at least 1,000 MW of electrolysis power installed in Germany by 2020.

Today there are already 14 pilot and demonstration projects in operation in Germany and more than 17 facilities are under construction. Several international projects, including Jupiter 1000[70] in France, are underway as well.[71]
On the other side of the Atlantic, where the renewables share of the electricity mix is lower than in Europe, the USA- DOE is sponsoring research and development programs on hydrogen storage so that hydrogen-fueled vehicle can meet customer performance expectations, refueling time, and overall vehicle performance targets by 2020.

E. Electric Vehicles (EVs)

Because of increasing local pollution problems and regulations prohibiting ICE[72] vehicles in certain large cities when pollution is high, consumers are excited about EVs. However, less than 5% of potential buyers ultimately purchase an EV over an ICE model.

Consumers are concerned about driving range, and complex and long battery charging. Also, the high cost of battery packs[73] means that ICE-equivalent ranges are prohibitively expensive.

Automobile manufacturers face a difficult challenge: they must strike the right balance between satisfying customers' aspirations and improving their image on environmental questions while also maintaining profitability.

Despite these obstacles, EV progression is much greater (23% in

68 https://www.economist.com/news/business/21688386-amid-surge-demand-rechargeable-batteries-companies-are-scrambling-supplies
69 https://www.dena.de/en/home/
70 http://www.jupiter1000.com/en/accueil.html
71 http://www.powertogas.info/english/introduction-to-power-to-gas/
72 ICE: Internal Combustion Engine
73 Cost of batteries is half of the total vehicle cost

Q1 2017) than the global automotive industry (around 3% per year). At the end of 2016, around 2 million EVs were on the world's roads[74], although this still represents a very low (1.4%[75]) market share.

Battery costs should be below $190/kWh by the end of the decade or even before, and between 2025 and 2030, battery pack costs should fall below $100/kWh. At that time, compact and mid-size EVs should reach true price parity (without subsidies) with ICE vehicles.

Interaction with the electricity grid

The impact on electricity grids depends very much on battery charging modes.

The main choice is between slow and cheap (at home, during the night) or quick and expensive. In the former case, and avoiding the evening electricity peak, charging happens during off-peak hours. It is cheaper and there is no significant impact on the grid.
In the latter case, especially if numerous customers charge their batteries at the same time, (lunchtime, for example), the demand peak generated can be very significant and would require substantial new investment in the distribution grid.

Innovations

Utilities are entering the EV space with innovative offers.
For example, Eneco startup Jedlix offers a smart charge application that enables charging cars with renewable energy when prices are at their lowest. Eneco shares the financial reward generated with the customer.

For company EVs, in 2017 Lampiris launched a payment solution enabling employees to bill employers directly for the charging cost when done at the employee's home.

Vehicles to grid

Given that batteries will only be used for two hours per day on average, and that the cost of slow battery charging is around €1.5/day, the question is how to use batteries during the remaining time, in order to generate an equivalent revenue so that driving becomes free.
As the share of intermittent renewable energy sources increases rapidly, it will be necessary to increase the volume of frequency regulation reserves (FRRs). EVs are among the new main sources of reserves besides controllable loads and decentralized generation units. This solution was tried at PJM[76] with 20 EVs connected and participating in frequency regulation: the remuneration was very significant, at €1,500/EV/year.[77]

The remuneration of frequency regulation services varies according to countries: in Denmark they have a price but in France there is no remuneration.[78]
EVs could also provide grid-balancing systems.
In order to optimize EV interaction with the grid system it is necessary to increase collaboration between vehicle manufacturers, grid managers, and customers. This is why the "grid motion project" was launched in May 2017, bringing together vehicle manufacturers, Utilities, service companies, and universities. It aims at evaluating possible savings achieved by real-life EV users through the implementation of smart charging and discharging strategies for EVs[79].

F. Nuclear energy

Although nuclear electricity provides carbon-free[80] schedulable electricity[81] in 31 countries around the globe, it raises questions in Western countries.

Existing reactors

- Safety and security are major concerns. In many countries they are handled by Independent Safety Authorities that oversee nuclear operations. This was not the case in Japan before the Fukushima accident but afterwards, the NRA[82] was established.
- Long lifetime and highly radioactive waste must be handled with great caution. In Europe, the best technologies for reprocessing and recycling or direct storage are used. Retrievable storage is being built (unfortunately with opposition and delays as in the case of CIGEO[83] in France) in order to store and then reprocess waste when better technology becomes available.
  Utilities have made provisions for processing spent fuel and dismantling reactors. These funds are set aside in different

74 https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017

75 La Tribune, June 9, 2017

76 PJM is a regional transmission organization that coordinates the movement of wholesale electricity in all or part of 13 USA states and the District of Columbia

77 Source: Codani, Petit & Perez (2016).

78 Source: Borne, Korte, Perez, Petit & Purkus (2017)

79 http://media.groupe-psa.com/en/gridmotion-project-reducing-electric-vehicle-usage-cost-thanks-smart-charging-process

80 For example, France (with 75% nuclear electricity) emits 64g CO_2/kWh while Germany (with 14%) emits 337g CO_2/kWh.

81 440 reactors provide 11% of worldwide electricity

82 NRA: Nuclear Regulation Authority (Japan)

83 CIGEO: Centre Industriel de stockage GEOlogique

ways: dedicated funds (Sweden), dedicated assets (France), or accounting provisions (Germany).

In 2011, under the Obama administration, the highly contested Yucca Mountain project was stopped. This left the USA government and Utilities without any designated long-term storage site for high-level radioactive waste. There are presently stored at various nuclear reactor sites around the country, which is a poor solution.

EU directives and renewables expansion have resulted in a chaotic wholesale market and the total costs of existing reactors (including lifetime extension costs and capital remuneration) are above the very low electricity market prices.

- Economic challenges:
  EU directives and renewables expansion have resulted in a chaotic wholesale market and the total costs of existing reactors (including lifetime extension costs and capital remuneration) are above the very low electricity market prices.

  In the USA, with very cheap gas prices (linked to the shale boom), some nuclear plants are no longer competitive. This is why five nuclear reactors have shut down in the past five years and other nuclear operators have announced their decision to retire their reactors from the market despite having obtained 60-year lifetime extensions.

- Political decisions:
  - In June 2017, the restart of Unit 3 of the Takahama nuclear plant brought the number of running reactors in Japan to five. Out of 54 reactors operating before the Fukushima accident, 42 are operable and potentially able to restart, and 24 of these are in the process of restart approvals.
  - On May 21, *Switzerland* voted to progressively phase out nuclear power in favor of renewable energy. The new legislation also prohibits construction of any new nuclear power plants on Swiss territory. However, it does not envisage immediate decommissioning of existing nuclear power reactors, instead allowing them to operate as long as they are deemed safe.
  - In July 2017, French Energy Transition Minister Nicolas Hulot said that *France* might close as many as 17 reactors by 2025 as it seeks to reduce the share of nuclear power in its electricity mix to 50% (compared to 73% in 2016); he also said that he would take a pragmatic approach and that he needs time to plan those closures. An important milestone will be at the end of 2018 when the French Safety Authority will give its first generic assessment on the present nuclear reactors' lifetime extensions.
    Implementing these closures while maintaining a decarbonized economy is a huge challenge, as renewable energies have not developed quickly enough to ensure security of electricity supply. This plan is very costly because investments in existing reactors are largely amortized and it would raise big social problems with significant job losses[84].
  - Despite construction of four Korean reactors in Abu Dhabi, *South Korea*'s new President, Moon Jae, decided on June 19, 2017 to neither extend the lifetime of existing reactors nor

84 The French industrial nuclear sector, which brings together 2,500 companies, employs nearly 220,000 employees (directly and indirectly)

build new ones. It is not the first time that Korea politicians take such decisions that did not apply in the past.

New plant construction

The situation in Western countries differs from Russian and Chinese ones.

- In Western countries:
  After two decades when no construction was launched, the nuclear industry (Utilities and their equipment providers) has lost its knowledge of large project construction management of new reactors. Also, because of more stringent safety regulation, particularly in view of the Fukushima accident, the third generation reactor design is more complex and thus more difficult to build.
  This explains the delays and cost overruns in the construction of those new reactors.
  In Western Europe, Olkiluoto EPR in Finland is delayed by ten years and its construction cost has tripled. It should finally be commissioned by the end of 2018. In mid-2017, Flamanville 3 in France received ASN[85] approval of its reactor vessel metallurgical characteristics, and should be commissioned by the end of 2018 after six years' delay and a cost three times the initial budget.

  In the USA, South Carolina Utilities (Santee Cooper and Scana Corporation) have decided to stop construction of the two VC Summers reactors that would have cost more than $20 billion (twice the budget) and that would not have started before 2024.

  Those huge construction delays and cost overruns have endangered the survival of some nuclear companies, such as Areva and Westinghouse.

- In Asia, the Middle East and Russia, the situation is very different:
  - At the end of March 2017 China had 36 reactors in full commercial operation and 20 nuclear reactors under construction[86]. It should complete construction of five nuclear power reactors and start construction of eight more in 2017. Planning for a further eight reactors will also be progressed in 2017.
    In China, unlike in Western countries, Western-designed reactor construction is progressing more or less on schedule.
  - Russian company Rosatom holds first place in terms of the number of simultaneously implemented nuclear reactor construction projects (eight in Russia and 34 abroad). According to Rosatom, the recent Water-Water Energetic Reactor (VVER) power plants are designed to meet all the latest international safety requirements for Generation 3 nuclear power plants.

  In March 2017, Russia announced the start of commercial operation of its first VVER-1200 reactor, Unit 1 of the Novovoronezh II nuclear power plant.

  However, because of lack of transparency, it is difficult to assess the real cost of those reactors and it is also hard to compare building costs in countries that have very different standards of living and safety.

Outlook

Worldwide, nuclear electricity is needed as a carbon-free and schedulable complement to renewables. While nuclear reactor construction is progressing in China and Russia (and in ex-Soviet influenced countries), it is encountering difficulties in Western Europe and in the USA.
The commissioning in 2018-2019 of Western-designed third generation reactors (EPR and AP1000) should restore confidence. After those milestones, economies of scale should enable cost decreases. However, Western countries should provide long-term visibility on electricity selling prices in order to enable decisions for very long-term investments to be taken (a nuclear reactor timeline spans more than 70 years). The UK Contract for Difference (CFD) implemented for carbon-free generation, should inspire other Western governments.

Digitalization

Digitalization is also a key enabler for successful energy transition and profitable Utilities.

In the past few years, advances in digital technologies have been spectacular.

The main technologies are

- Communication protocol & infrastructure (LoRa, Sigfox, WiFi, Bluetooth, radio-communication, 4G, 5G, infrared) enabling larger volumes of data transmission;
- Data collection hardware (IoT[87], sensors, smart metering, etc.);
- Additive manufacturing (e.g. 3D printing);
- Mobility hardware (tablets, smartphones) and software (mobile applications, mobility platform, geolocation);

85 ASN: French Safety Authority
86 Nuclear Energy Association
87 IoT: Internet of Things

- Analytics (big data analytics, advanced modeling, artificial intelligence, machine learning, etc.);
- Remote operations (drones, robots);
- Platforms of information and document sharing, net portal, trading platforms, SCADA (supervisory control and data acquisition);
- Virtual simulation (virtual reality, e.g. 3D glasses and helmets, augmented reality);
- Imagery (satellite pictures in real time, drone pictures);
- Automation (robots, powered exoskeleton, bots, etc.).

These advances, combined with development in sector-specific technologies and related cost decreases (see above), have incentivized Utilities to accelerate their digitalization efforts by transforming customer experience, operational processes, and, in some cases, business models.

Progress and benefits

• Customer experience:
Almost all Utilities have implemented digital channels, paperless invoices, and mobile and self-service applications[88].
In order to improve client satisfaction, they are also developing new added-value services.
For example, in 2016, EDF launched, through a dedicated subsidiary, a connected home offering called Sowee[89]. This application enables residential customers to manage their heating and cooling expenses, electricity consumption, air quality, noise level, and so on.
Offerings that combine storage and solar PV are transforming certain customers into "prosumers". In Germany, for example, residential customers account for one third of renewable energy generation[90].
In general, customer experience in the Utilities sector is still lagging behind the most advanced retailers (such as Amazon). For example, applying analytics to their customer database would enable them to improve client acquisition and retention, implement tailor-made offerings, and lower their cost to serve.
Digitalization-related cost gains are estimated at 30%.[91]

• Operational processes:
In this area, digitalization started with *grid transformation* to smarter grids, allowing an increased share of renewables in the electricity mix.
In many countries or regions, smart meter deployment is generating massive volumes of data that have to be cleansed and anonymized before made available to companies able to use them to provide new digital services. For example, in June 2017, French distribution system operators (DSOs) created a digital services agency to share distribution-related data and to provide digital services to energy transition players.
With the growth of EVs, digitalizing the charging process will be crucial in order not to create major grid disturbance
Also, growth in smart buildings will contribute to better awareness and improved energy efficiency. In Western countries, more and more customers want responsibility for their energy supply; this is made possible thanks to renewables combined with digitalization and leads to the emergence of smart homes, smart districts, and smart cities.

- Utilities around the world are leveraging digital technologies to enhance efficiency and optimize *production*. E.ON, for example, one of the world's largest owners of renewable power projects, upgraded its wind fleet with digital solutions[92]. It leveraged the Industrial Internet of Things (IIoT) and advanced analytics to increase annual energy production by 4% in the first year from the company's 283 turbines[93].
According to Capgemini research, applying digital technologies to a hypothetical 400 MW combined-cycle (gas-fired) power plant in the USA, would enable significant reductions in key cost overheads: fuel costs by 28%, maintenance by 20%, and operations by 19.5%.
- In *internal Utilities processes*, mobility, robotics and digital are leading to productivity improvements. For example, digitalizing the core process of work management enables better asset management, engineering and planning, scheduling and dispatch, as well as execution. More productivity gains will come from automation of back-office processes.
Altogether, process digitalization should enable cost savings of 20%.

88 Enerpress article
89 www.sowee.fr
90 Le Figaro, August 18, 2017
91 "Digital Utility Plant", Capgemini, 2017
92 GE Newsroom, "E.ON Achieves More Output from 469 Wind Turbines through GE's Wind PowerUp* Services", October 2014
93 "Digital Utility Plant", Capgemini, 2017

• ***Business model transformation:***
Nearly all Utilities are looking at adding new internet-based services. For that purpose, they are experimenting with new ideas through PoCs[94], innovation labs, or startup factories.
Some, such as Dutch utility Eneco, have decided to implement more radical changes. Through acquisitions, by nurturing a cluster of startups and with other initiatives, Eneco has sought to provide new services to customers as it is switching from selling a pure commodity to selling energy as a service."[95].
New services could increase Utilities revenues by 10% or more.

New players are entering the Utilities space. For example, Swisscom subsidiary Tyco is using a home-designed algorithm and artificial intelligence to collect and analyze data from tens of thousands of domestic devices. It offers solutions, based on this big data approach, to its partners (Utilities or customers) enabling them to profit from load flexibility, for example by aggregating load shedding in order to shave demand peaks and improve security of supply.

It is estimated[96] that digitalization will lead to a much-needed 20-30% overall profit boost for Utilities.

So on one hand, digital will play a major role in energy transition; on the other, energy plays a major role in ICT[97], which is becoming an increasingly important consumer of electricity. The exponential increase in the rollout of Internet of Things will also lead to rising electricity demand. Energy efficiency and energy conservation have to be embedded in these new developments, for example in the design of data centers.

How to accelerate digitalization: the main hurdles

• ***Skills and jobs:***
The Y generation is familiar with the new world and eager to find a similar digital environment at work to the one they have in their private lives. Despite this appetite, Utilities don't have enough skilled people to implement their new digital transformation. In addition, there is worldwide demand for data scientists. These skills shortages are one of the major barriers to digital implementation[98].
Utilities, as other industries, are confronted with major social change. They need to redesign their internal processes and retrain many colleagues knowing that ultimately, they will need fewer people in many areas. This is probably the main reason why large incumbent and unionized Utilities will have difficulties in changing quickly.

• ***Policies:***
Data collection and exchange is growing exponentially, triggering new regulatory frameworks (notably on data privacy). For example, the European GDPR[99] will be enforceable by May 2018. Its primary objectives are to give control back to citizens over their personal data. The GDPR places specific legal obligations on companies; for example, they are required to maintain records of personal data and processing activities and have significantly more legal liability than before, if found responsible for a breach.
Although these regulations are needed, they will add internal complexity (and cost) in Utilities management. In general, the difficulty is how to avoid excessive regulation of data, which would slow down the necessary digital transformation.

• ***Utilities regulation:***
Utilities should be enablers of transformation, particularly for vital grid digitalization, but there are no regulatory incentives to invest in these areas. In Europe, remuneration of transmission and distribution system operators (TSOs and DSOs) is built into transmission and distribution tariffs, and is solely based on physical assets investment and not on "soft" investment. For example, TSOs, which have a lot of difficulty building new connections,[100] are looking at optimizing existing transmission line operations instead of building new ones, thus removing uncertainty and the need for funding. However, the regulators don't incentivize them to do so.
Also, when they use SaaS[101], they transform CAPEX into OPEX and today's rules mean no remuneration is attached.

• ***Cybersecurity:***
In spring and summer 2017, major attacks shook some large private and governmental organizations (in May, the WannaCry ransomware attack claimed 200,000 victims in 150+ countries; in June, the Petya ransomware cyber-attack spread throughout Europe).

---

94 PoC = Proof of Concept: instead of building projects over months with scheduling, budgeting and staffing, new ideas are tested in an agile way using PoCs. If the idea seems good then a longer-term project is deployed.

95 New York Times, August 16, 2017

96 "Digital Utility Plant", Capgemini, 2017

97 ICT: Information and Communication Technologies

98 "Digital Utility Plant", Capgemini, 2017

99 GDPR: General Data Protection Regulation

100 In Europe, for regulatory and public opinion reasons, it takes around 10 years to build a new line. The duration is similar in the USA ("On average it takes 10-15 years to build a high-voltage transmission line", NC Transmission Agency, 2017)

101 SaaS: Software as a Service

Cyber defense for the state becomes a question of sovereignty; for companies, it's all about protecting their economic stake, their know-how and tools of production, and therefore their professional raison d'être.
Attacks can have multiple motivations: money (the attacker penetrates an information system and blocks its operation until payment of a ransom); disclosure or destruction of data to adversely affect one or more adversaries, or to destabilize a state or even its electoral process; and industrial espionage.
The area at risk is expected to expand with the rise of smart grids, the Internet of Things and 5G, not to mention the risks inherent in new innovation processes (open, collaborative, etc.).
Many more attacks[102] can be expected, as more than 10 countries are each training hundreds of people. This wide spread of knowledge is available to both hackers and defenders. Depending on which countries and organizations they belong to, they can be one or the other.
There is no international regulation that defines what governments can or can't do.
In some countries, such as France, some measures have already been taken, such as setting up bodies like the ANSII[103] and identifying operators of vital importance[104]. In all, a dozen sectors are concerned (including energy).

With the GDPR coming into force and mandatory implementation of the EU Directive on security of network and information systems (the NIS Directive) by Member States, the cybersecurity landscape is set to change drastically, especially in countries that do not yet have general data breach reporting obligations in place.

To ensure a high common level of network and information security in a list of sectors (including energy), the NIS Directive lays down a number of obligations for Member States in order to prevent, handle and respond to risks and incidents affecting networks and information systems.

Utilities must be able to anticipate attacks from highly malevolent sources including multiform attacks. This was the case with the electricity grid in Ukraine in 2015. It was damaged in such a way that it could no longer distribute electricity to hundreds of thousands of people. At the same time, an attack was launched on the call center, saturating it so that users could no longer report the power outage they were victims of. Neither the head of the call center nor the network manager was therefore able to link the two attacks. To deal with this kind of situation, one must be able to identify the most problematic scenarios and take preventive measures accordingly.

Outlook

• Business models

Business models and internal processes are changing profoundly: In the short term, digitalization is generating new client relationships, new operational processes, and new internet-enabled services. In the longer term, lifetime employment, still the case in many Utilities, will disappear and be replaced by more mobility in professional careers, self-employment and multi-employers.

• The digital economy

The digital economy is still at an early stage. The main issues today are to gather, regulate and share relevant and meaningful data. We are at the beginning of the digital transformation and are only now starting to process the massive amounts of data being collected, and to use tools such as artificial intelligence and machine learning. Some startups are beginning to apply these tools to visualize flows (e.g. of electricity, gas, water) on grids in order to optimize their design and operation. Others are analyzing client databases to understand churn levels.
However, using data in the cloud requires large platforms that are currently run by the big five American companies – Google, Apple, Facebook, Amazon, Microsoft (GAFAM) – and Europe is far behind. GAFAM[105] have a controlling position not only in large platform operation but also in research and development, and have gathered more skills than any other company or governmental body. This dominance is also a threat.

102 Erol Gellenbe from Imperial College (BBC June 2017)

103 ANSSI: Agence Nationale de la Sécurité des Systèmes d'Information They belong to public or private sector, operating or using facilities indispensable to the survival of the nation, the safety of the people, and the protection of its economy

104 Some of them have announced their interest in becoming players in the Utilities space but they remain cautious

105 They need a lot of space

Conclusion:

Global warming and climate change threats are triggering energy transition in many countries and regions.

Legislation that has been built progressively, taking into account not only final objectives but also responses to public opinion requests and political considerations, does not provide a coherent and stable framework.

Massive development in renewable energies, enabled by huge subsidies, has profoundly changed the energy landscape.

Other technology revolutions, such as shale oil and gas, have profoundly altered the USA energy market but have also transformed the global oil market.

In many regions, energy transition is chaotic, with energy oversupply and very low electricity and gas prices that are endangering Utilities' financial situation.

The longer-term view is more optimistic as technology improvements will render renewables competitive, providing viable large electricity storage to make them dispatchable and thus facilitating grid management.

Whatever progress is seen in these areas, renewables (wind and sun) that are dispersed forms of energy[106] will not be able to provide the whole energy supply on their own. It will be necessary to design the best low-carbon energy mix of nuclear, nega-watts (energy savings), and gas.

Another revolution is on its way, that of the digital economy. This will drastically change consumption schemes, citizen habits, and the workplace, as well as allowing significant improvements for Utilities (for example in customer experience, operations) and the creation of new revenue streams (new business models).

If our societies are able to overcome the threats related to cyber-attacks, digitalization should also benefit the energy sector and help improve the situation for Utilities.

Colette Lewiner

Senior Energy Adviser to Capgemini Chairman
September 2017

North America

Energy Transition in North America

Editorial by Perry Stoneman

Climate Change: Uncertainty looms

There is a great deal of uncertainty and contradiction on the future of climate action in North America. A significant contributor to this uncertainty in the US is the announcement by US President Donald J. Trump on June 1, 2017 to pull the US out of the Paris climate agreement as promised in the 2016 election campaign. Not only does this decision by the US have implications for North America's climate action targets, it will also likely impact climate aid programs in the developing nations, as the US reduces its commitment to help fund these programs. These impacts may be offset by the natural course of political compromise that occurs in the United States between the two dominant political parties and the Federal and State governments.

Additionally, ideological differences within the US are emerging. While the federal government has decided to exit the agreement, some states and cities are continuing and even accelerating local programs. However, without federal action and uniform policies nationwide, it will be difficult to know how much states and cities can achieve on their own.

- States, cities, businesses, philanthropies, and universities have vowed to fill the void left by the US Federal government's withdrawal from the Paris accord and voluntary targets: a 26% to 28% reduction in carbon emissions by 2025, relative to 2005 levels, and further cuts thereafter.
- Philanthropist and former New York City Mayor Michael Bloomberg has pledged to donate US $15 million to the UNFCCC, in order to help fill any funding gaps created by the Trump administration's exit from the Paris accord.
- As of September 20, 2017, 14 states, one territory and 211 cities remain committed to the Paris Agreement targets under the United States Climate Alliance (USCA). This includes the most populous state California, along with New York, Washington, Connecticut, Rhode Island, Massachusetts, Vermont, Oregon, Hawaii, Virginia, Minnesota, Delaware, Colorado, North Carolina, and the territory of Puerto Rico, which represents approximately 22% of total US emissions.
- Additionally, as of July 2017, there are nine states that represent approximately 20% of total US emissions, and have also set emission mitigation targets in place, including Maryland, Montana, Ohio, Pennsylvania, New Mexico, Iowa, Illinois and Maine.
- Even in conservative states, a major trend like lower energy intensity will continue to contribute to GHG emission reduction, driven by energy efficiency, fuel economy improvements, and structural changes in the economies.
- States, state attorney generals, cities, businesses and universities have banded together into a coalition called 'We Are Still In', spearheaded by York City mayor Michael Bloomberg, with signatories from 125 cities, nine states, 183 colleges and universities, and 902 businesses.
- In addition, as of June 2017, 274 US mayors representing 58 million Americans have signed onto a statement prepared by the Mayors National Climate Action Agenda (MNCAA) to uphold the Paris Agreement.

Another likely factor contributing to the North American uncertainty is the future of the Clean Power Plan (CPP).

If approved, the CPP would require states to develop plans to reduce CO_2 emissions from existing generating units that use fossil fuels. With the CPP currently pending judicial review, the trajectory for carbon emissions in the US remains unclear. Without the CPP program to drive the shift away from coal-fired electricity generation to alternative generation it will be difficult for the energy sector to achieve the 32% decrease in CO_2 emissions by 2030. Some potential impacts of stripped down CPP may include:

- Longer life for some marginal coal-fired generating units.
- Coal may become the leading source of electricity generation by 2019, potentially retaining that position through 2032, although that is uncertain due to state regulatory impact
- Little incentive to switch from coal to less carbon-intensive natural gas and carbon-free renewable resources, again depending on the interplay between state and federal regulation and incentives.
- Possible increase of CO_2 equivalent emissions of more than 500 million metric tons in 2030 and 1,200 million metric tons in 2050.

While the US federal withdrawal could increase the risk of destabilizing the Paris accord, it is clear the EU, Canada, Mexico and China remain committed to the agreement and objectives. In a September 16 news conference following a meeting in Montreal with 34 environment ministers and climate change ambassadors, Canada's Federal Environment and Climate Change Minister Catherine McKenna said the Paris Agreement is "irreversible and non-negotiable". While the Canadian federal government remains committed to the Paris agreement and the objectives, Canada may still have a gap to be addressed. According to a government framework document on the commercialization and application of new energy technologies and establishing norms for inter provincial energy, there is a need to find an additional 44 million tons CO_2 emission reductions for Canada to meet its 2030 target. Mexico plans to launch a national carbon price by 2018 and remains committed to an emissions reduction target of 25% by 2030. It also plans to peak its emissions by 2026, which is encouraging and should inspire others to follow a similar course. Mexico approved a landmark energy reform in 2013, transitioning from almost an entirely closed model to one of the most open in the world, resulting in growing foreign and national investment in the sector, as well as competitive prices for electricity.

China, the world's largest emitter of greenhouse gasses, recently gave the world a clear message that they will stand by the Paris Agreement and accelerated its efforts to reduce greenhouse gas emissions. . In an interview in Montreal, Mr. Xie Zhenhua, China's Special Representative on Climate Change stated that the Chinese government is shifting its growth model from one that depended on heavily polluting, carbon-intensive industry and coal-fired power to a "more sustainable economy."

China however continues to point out that it is still a developing country and emissions will continue to rise until it peaks in 2030. It remains to be seen if this clear commitment by China, as well as Canada and Mexico will incent the United States Federal Government to reconsider its current position.

With this uncertainty on North American climate change, it is difficult to decipher the net impact the US will have on CO_2 emissions and previously agreed reductions. The US political environment is dynamic and subject to change as political cycles and public opinions morph over time. We will continue to monitor important developments in this area.

Energy Transition: Monumental shift in generation, delivery and consumption of energy

Since 2007, the US has experienced a decoupling of economic growth from energy consumption, where the overall consumption has dropped by 3.6% against a GDP growth of 12%. In 2016, energy productivity advanced by 1.8%; GDP grew 1.6%; while energy consumption declined by 0.2%. Energy efficiency measures continue to account for slowing load growth. Overall, efficiencies in energy production and provisioning have allowed economic gains without a corresponding linear growth in energy production. In North American economic history, this is a relatively new development and the utility industry is still struggling to adapt to this new reality.

Within the power and utilities sector, efficiency program spending has almost tripled since 2007, from US$2.2 billion to $6.3 billion in 2015. Similar energy efficiency investments in the natural gas system also appear to be gaining prominence. Natural gas utilities invested an estimated $1.4 billion into the efficiency programs in 2015, a 350% increase over 2007 levels. Increasing efficiency of renewables driven by continued decline in cost, indicates an enhanced competitiveness with traditional sources. Alternative energy, particularly solar and wind, are achieving outstanding cost improvements.

2016 was a record year with renewable energy capacity additions of over 22GW. While clean energy capacity and renewable energy capacity additions have witnessed a steady increase, 2016 saw a 7% decline in investment from the 2015 record spend of $63.2 billion, down to $58.8 billion. This decline was likely due to the falling cost of solar and other clean energy projects and technologies.

While energy transition will continue to see its share of setbacks and failures, there are clear signs which indicate that energy transition will continue. Since 2009, the LCOE for utility scale solar has declined by a striking 85% and wind by 66% with further gains expected from industrialization, technology advancement and asset efficiency and reliability. From 2015 to 2016 the median-leveled cost of energy from utility-scale PV technologies declined by ~11% and rooftop residential PV technology declined ~26%. The median cost of generating energy from offshore wind generation has declined approximately 22%, but remains substantially more expensive than onshore wind facilities, especially in the US.

While the continued decline in the LCOE of renewable energy technologies will continue to make these projects attractive, they could still be heavily influenced by regulatory and government policies, including:

- Interplay between Federal and State Policy mentioned earlier. Federal and State policy relative to tax incentives. Renewable Portfolio Standards (RPS) across regulatory jurisdictions.

Despite the transition and investment in green and renewable energy, the US and its advanced economy might continue to rely on a highly diversified generation portfolio to meet its base load generation requirements. Investment in base load generation will likely continue into the foreseeable future.

One element to watch is the emerging energy storage market. The US is one of the most active markets with both new technologies and emerging business models. While the vast majority of energy storage is pumped hydropower storage, a majority of new projects are new lithium-ion battery technology implementation, some of which are ironically being driven by the need to shore up grid reliability in regions with significant renewable generation.

- In January 2017, Tesla Motors Inc. and Southern California Edison unveiled one of the world's largest energy storage facilities, part of a massive deployment of grid-connected batteries that regulators hail as key to helping California in reducing fossil-fuel dependence.
- The Mira Loma substation in Ontario contains nearly 400 Tesla PowerPack units on a 1.5-acre site, with a capacity of 20 MW and is designed to discharge 80 MWh of electricity in four-hour periods. The project pushes the state-mandated effort to compensate for the stumbled Aliso Canyon natural gas storage facility.
- Tesla has been building another battery farm on the Hawaiian island of Kauai, and has projects in Connecticut and North Carolina, as well. Tesla's Kapaia installation in Hawaii includes a 13 MW solar system and 52 MWh of batteries, under a 20-year contract with the Kauai Island Utility Cooperative on the island of Kauai to deliver electricity at USc13.9/kWh. The project is the largest of its kind to be placed in service by Tesla since its $2 billion acquisition of panel installer SolarCity Corp. in November 2016.
- Additionally in March 2017, responding to Southern Australia's energy concerns, pertaining to a statewide black-out, Tesla's CEO Elon Musk tweeted a pitch to solve Southern Australia's electricity woes in 100 days 'or free', with a battery-storage system. Tesla has been striking its PowerWall 2 and PowerPack 2 battery products in Australia.
- In addition, projects of similar size are being rolled out by San Diego Gas & Electric with AES Energy Storage and by Greensmith Energy Partners with AltaGas.

Infrastructure & Adequacy of Supply: Enhanced infrastructure underpins a decisive success-factor

With the growth in renewable energy, enhancing infrastructure and grid modernization will most likely be instrumental in the future of the North American electricity infrastructure and adequacy of supply. As renewable energy capacity grows, investments in transmission enhancements should be key. One such example is the $7 billion Texas investment in transmission for the Competitive Renewable Energy Zone and the MISO Multi-value Project. Without similar transmission enhancement projects, continued investment in renewable energy will possibly be limited in regions with constrained transmission capabilities. This is likely the case in some regions including the Midwest.

While we have seen growth in renewable energy projects in the past decade, there has also been a reduction in base load capacity. This has been the first time that baseload retirements outpaced base load additions with 84.2 GWs of base load retirements. Economic pressures caused by capacity oversupply is likely part of the decline. As a result many of the new combined cycle plants are being forced to cycle and reduce their run rates and revenue. Despite policies, aging coal, oil and gas steam turbine generators will continue to be replaced by newer combined-cycle and gas turbine plants. In Canada for example, coal-fired generation without carbon capture and storage technology will likely be an insignificant part of Canada's electricity mix by 2040.

Another probable key element in ensuring adequacy of supply will be the investment in grid modernization. Grid Modernization Initiative (GMI) was launched by the DOE in 2016 to help shape the future of the grid. Grid modernization is necessary to manage the ever-growing renewable energy and DERs, as well as technologies and algorithms to ensure that critical loads will be served in the event of a large-scale outage. Technologies being studied and developed include:

- Energy storage including battery technologies
- Transformer resilience and advanced components
- Transmission controls and visualization technologies
- Advanced grid modeling using analytics and machine learning to enhance and/or automate decision making
- Cybersecurity
- Smart grid R&D and Micro grid R&D

With the apparent increase in renewable and distributed energy assets, the grid is becoming dynamic and ever-changing, and perhaps more difficult to manage with traditional models and methods. One area that could have a great deal of potential is Advanced Grid Analytics (AGA). The AGA platforms utilize big data from SCADA, Advanced Metering Infrastructure (AMI), weather forecasting and IoT sensors to provide actionable information in support of daily operations and intelligent planning of future investments. AGA technologies are also needed to respond to events rapidly to harmonize distributed energy resources for voltage optimization, fault detection and restoration. These new technologies, renewed interest in traditional technologies and new renewable capacity may ensure adequacy of electric supply for North America.

Despite low gas prices the forecasted gas supply and demand continue to grow. As Marcellus and Utica shale gas production increase, they are starting to displace some Canadian imports. With supplies increasing, attractive prices are generating strong demand for gas and related projects. By 2020, power generation is expected to represent 31% of the demand with exported LNG with JNG and dry gas exports to grow to 11%. Furthermore, industrial demand is expected to grow by 2% per year through 2020.

Gas production increases in Canada, primarily Alberta and British Columbia, are looking westward to the Pacific to export LNG. Likely investments will build over 2,000 miles of gas pipeline in 2017 and beyond, however the fate of new LNG remains uncertain. Plunging prices have flung the economics of export terminals from Russia to Mozambique into question as snowballing volumes from Australia and USA's shale descend the market, resulting in a glut up until the next decade. The fate of more than two-thirds of the LNG terminals proposed to come online in Canada by the mid-2020s depends more likely on cost management towards a resilient break-even price.

There is a clear and renewed support for pipeline development and highlights a new precedent for progress – safe and responsible energy progress in the US. There is also new recognition that the US needs dependable transportation of energy from various production areas. This includes the energy-rich Bakken region, the world-class refining facilities on the Gulf Coast and Illinois, which produces fuels and other products that support the economy.

In contrast to the US, the future of pipeline development had a significant setback in early October after TransCanada Corp. killed its $15.7 billion Energy East pipeline project. This cancellation is bound to intensify the debate over the Kinder Morgan Inc.'s Trans Mountain project, which is already facing significant opposition and a challenge in the courts. With the cancellation of Energy East, Eastern Canadian refineries will not receive the planned 1.1 million barrels a day of crude oil from Western Canada.

Supply and Final Customer: Efficient provisioning of energy gaining traction

While the energy transition is frequently associated with carbon reduction, it also delivers benefits to most North American end customers by providing greater energy choices, as covered in the next section. Lower energy cost is another benefit of energy transition. In 2016, US residential consumers spent 3.9% of their total household expenses on energy, with electricity coming in at 1.4% and natural gas at 0.4%. Transportation largely made up the balance of 1.1%. In real terms the average household saw electricity prices decline by 2.2% over 2015 levels. This was the first time that this measure from the Bureau of Economic Analysts has been below 4% since first reported in 1959.

The average 2016 electrical energy price in the US was 10.28 cents per kWh; residential was 12.55 cents per kWh; commercial was 10.37 cents per kWh; and industrial was 6.75 cents per kWh. In 2016, the average retail price in the US was 7% lower than the peak price in 2008. The decline in energy spend was primarily due to the low cost of gasoline, natural gas, as well as energy efficiency programs.

The abundance and low cost of natural gas is creating incentives for utilities to invest in coal-to-gas conversion. This trend was witnessed in 2012, 2015 and in 2016, when gas-fired plants were less expensive to run compared to coal. This fuel-switching and new investments in combined cycle and gas turbine plants reflects a critical link between electricity prices and natural gas. A curtailment in fuel-switching and a modest rise in electricity prices is perhaps inevitable if natural gas prices increased due to export markets. Countering the inflationary pressure of export markets, is the technology-driven improvements in Shale Gas onshore production. The US should expect to see growth in the natural gas supply as onshore Shale Gas productivity improvements are made and in some cases, is surpassing long-standing supply sources. With this improvement in productivity and the corresponding increase in reserves, natural gas prices are expected to remain low.

Market Transitions and Innovation: The United States in the midst of an energy revolution

Digital technologies, combined with consumer and community preference are driving the North American energy system transformation. In 2016, the advanced energy market in the US grew to $199.2 billion with Building Efficiency leading with $68.8 billion, followed closely by Advance Electricity Generation at $52.2 (Advance Energy Economy or Navigant). The growth figures of the other five segments: Advance Fuel Production ($28.9 billion); Advance Transportation ($21.8 billion); Advance Electric Delivery ($19 billion), Advance Industry ($8.3 million) and Advance Fuel Delivery ($178 million)

At the heart of this market transition is Big Data and advanced analytics. Adoption began with AMI infrastructure and Smart Meter data and analytics. Now with the maturation of the IoT and the proliferation of low-cost powerful sensors, the industry can monitor and measure virtually anything including energy, buildings and energy assets. With this digitization of energy and the advancement in machine-learning and robotics, we are now seeing successful implementations of intelligent transformer monitoring and management, distribution edge power quality management, and distributed generation optimization. Big Data and machine learning can also help manage the traditional grid infrastructure and avoid service interruption risks. However, transmission congestion is becoming an issue with the increase of renewable energy and making it challenging to manage the grid. As renewal energy sources grow, so will the risk of congestion-driven outages. In the longer term, achieving grid stability will likely require big data and analytics versus human-based processes and procedures.

Another major contributor to advance the energy transition is the declining cost of hardware such as PV modules, LED lighting and battery technology as corporations build giga-factories to manufacture at scale. As the component parts become cheaper, the gamut of applications grows, thereby increasing the pressure on margin and revenue. In response, many energy suppliers are shifting their business model from a product supplier to a service-based model.

Consumers are also influencing the transition by making choices about energy efficiency, EPV, solar and energy storage technologies. Furthermore, as consumers adopt advanced energy technologies, they are also incentivized to participate in new energy market models. They are also engaging in sharing or selling energy back to the utility or to a member's only community.

Micro grids and Distributed Energy Resources are also making a comeback, likely in part from the aftermath felt by hurricanes Sandy in 2012 and now in 2017, Henry, Irma and Maria. As a result of these devastating storms, a disproportionate number of Advanced Energy Assets are making their way to these storm-ravaged communities. EPV, energy storage technologies and residential solar programs are also contributing to micro-grid and DER projects and adoption. Since 2001 PEV revenue has grown 1,000% and may surpass traditional Hybrid electric vehicle revenue in 2017

Big Data is also driving Demand Side Management (DSM) innovation. Data-driven behavioral DSM offerings that leverage a variety of technologies are rapidly becoming a cost-effective way to increase customer engagement and satisfaction. Not all drivers of the market transition are based on new or emerging technologies. Investment in digitally enhancing and retrofitting the existing energy infrastructure will continue. This is particularly needed in states with high renewable energy generation, like California.

While the digitization of energy is creating opportunity, it also increases the risk of cyber threats. There is a direct correlation between Smart Grid projects and a growing demand for cyber security.

Nearly $3 trillion has been invested globally in grid modernization since 2000 and according to IEA, another $8 trillion will be required over the next 25 years to accommodate emerging areas like distributed intelligence and data analytics.

Financials: North America utilities appear fundamentally strong

According to the Edison Electric Institute, US utilities' operating profit margin rose 3% while net profits increased by an enormous 17% in 2016, year-over-year despite flat electricity demand growth. Most utilities finished 2016 in a stronger position with improved income statement measures, especially earnings per share (EPS) which rebounded from a 2015 decline. The majority of North American utilities continued to have attractive dividend profiles including, AEP, NextEra, Consolidated Edison, Sempra, Duke and Southern Company.

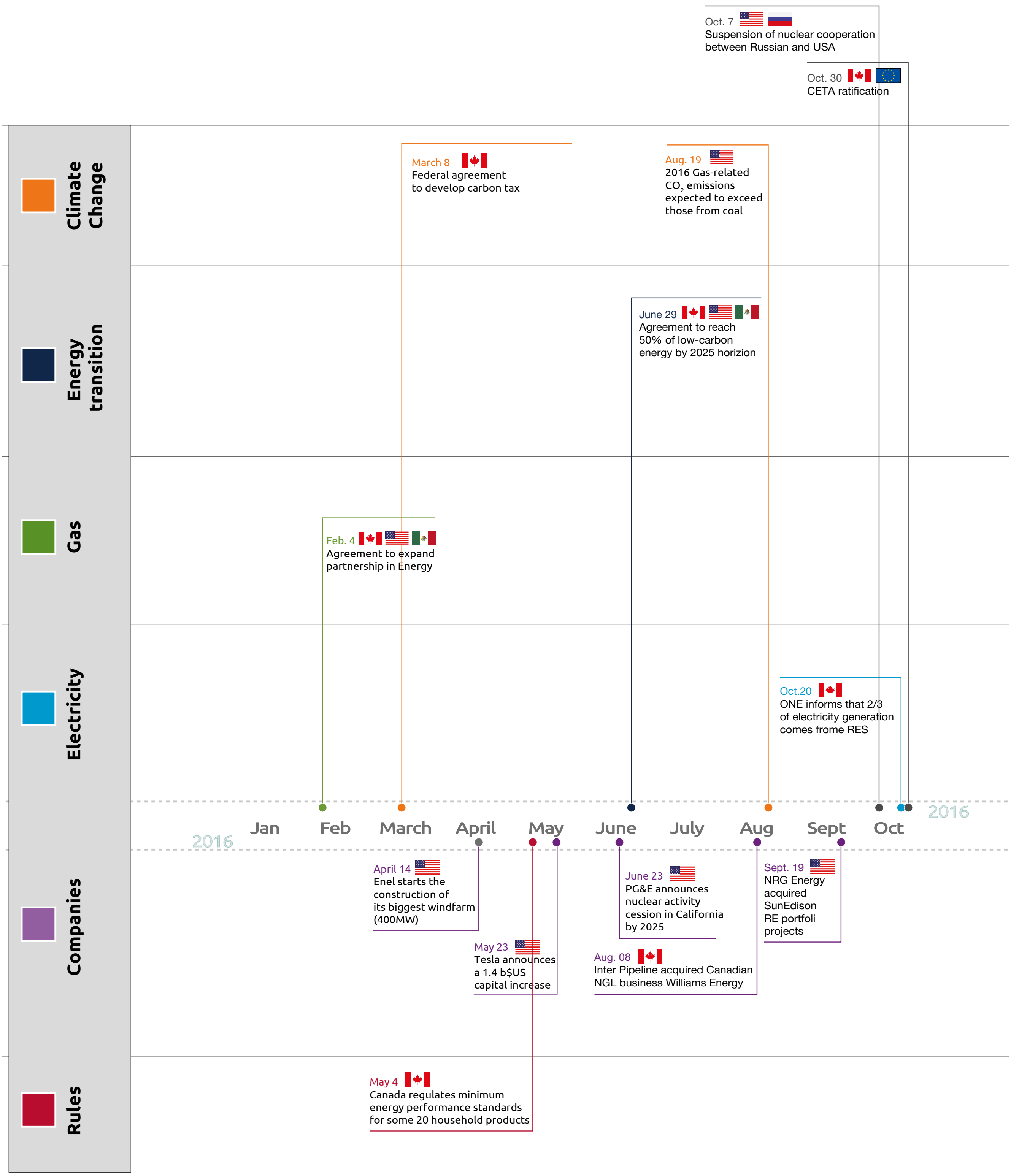
Interest rate increases could bring temporary weakness to US utility stocks; but fundamentally, these stocks look financially strong and their reasonable target dividend growth seems quite achievable in spite of concerns regarding flattish electricity demand growth.

Total shareholder return was 18%, up significantly from 2015 and outperforming the S&P 1500 broadly. US utilities, including major players like Duke Energy and Southern Company have performed fairly well over the last few months compared to broader markets. The rally has boosted utilities' valuations, and analysts now expect modest movements going forward.

Perry Stoneman

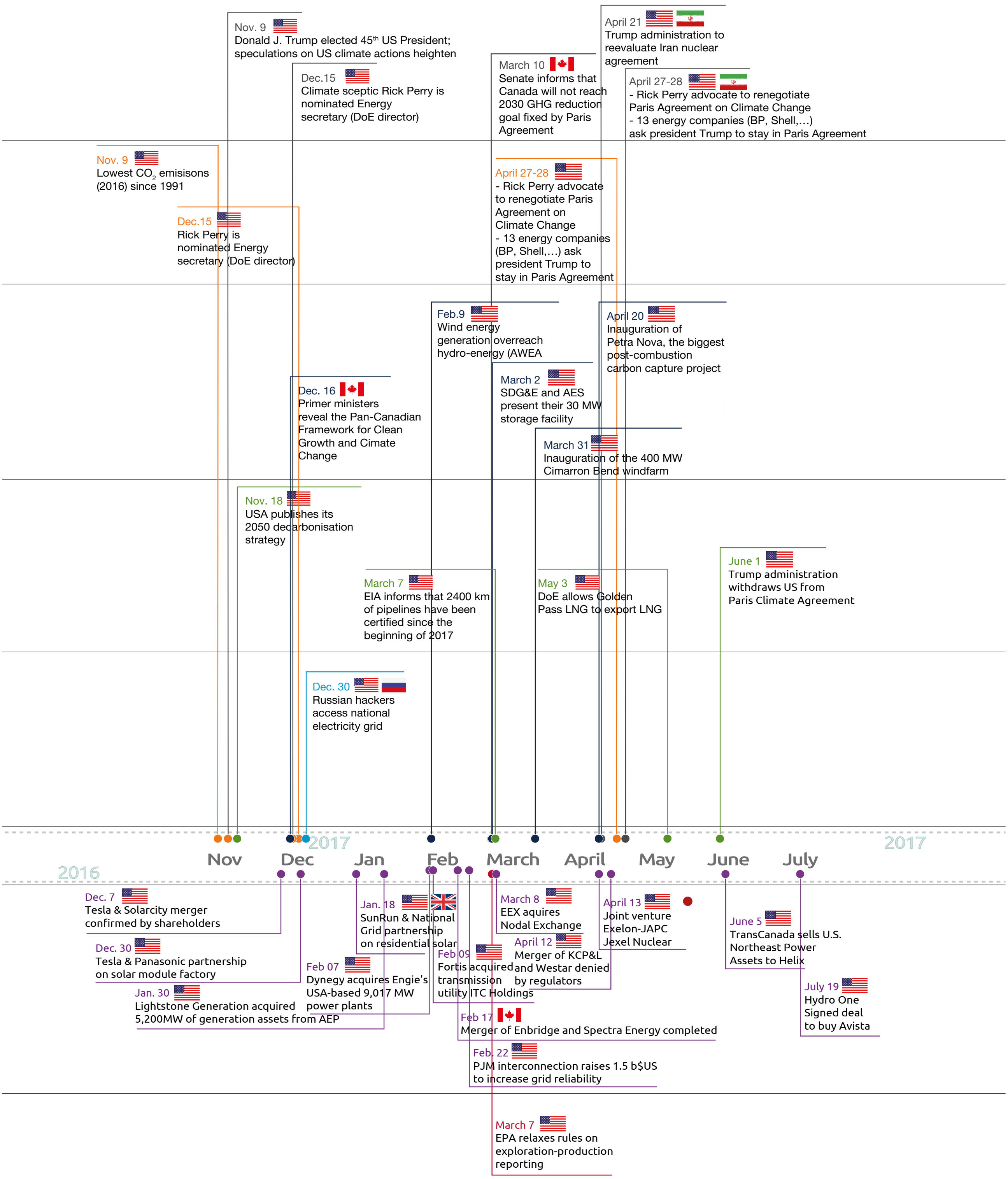
EVP, Global Head of Energy & Utilities

Major energy events (January 2016 - July 2017)[1]



Source: Various industry sources - Capgemini analysis, WEMO2017

1 Capgemini Analysis, WEMO2017


Nov. 9
Donald J. Trump elected 45th US President; speculations on US climate actions heighten
Dec.15
Climate sceptic Rick Perry is nominated Energy secretary (DoE director)
March 10
Senate informs that Canada will not reach 2030 GHG reduction goal fixed by Paris Agreement
April 21
Trump administration to reevaluate Iran nuclear agreement
April 27-28
- Rick Perry advocate to renegotiate Paris Agreement on Climate Change
- 13 energy companies (BP, Shell,…) ask president Trump to stay in Paris Agreement
Nov. 9
Lowest CO2 emisisons (2016) since 1991
Dec.15
Rick Perry is nominated Energy secretary (DoE director)
April 27-28
- Rick Perry advocate to renegotiate Paris Agreement on Climate Change
- 13 energy companies (BP, Shell,…) ask president Trump to stay in Paris Agreement
Feb.9
Wind energy generation overreach hydro-energy (AWEA
April 20
Inauguration of Petra Nova, the biggest post-combustion carbon capture project
Dec. 16
Primer ministers reveal the Pan-Canadian Framework for Clean Growth and Cimate Change
March 2
SDG&E and AES present their 30 MW storage facility
March 31
Inauguration of the 400 MW Cimarron Bend windfarm
Nov. 18
USA publishes its 2050 decarbonisation strategy
June 1
Trump administration withdraws US from Paris Climate Agreement
March 7
EIA informs that 2400 km of pipelines have been certified since the beginning of 2017
May 3
DoE allows Golden Pass LNG to export LNG
Dec. 30
Russian hackers access national electricity grid
2017
2017
Nov
Dec
Jan
Feb
March
April
May
June
July
2016
Dec. 7
Tesla & Solarcity merger confirmed by shareholders
Jan. 18
SunRun & National Grid partnership on residential solar
March 8
EEX aquires Nodal Exchange
April 13
Joint venture Exelon-JAPC Jexel Nuclear
June 5
TransCanada sells U.S. Northeast Power Assets to Helix
Dec. 30
Tesla & Panasonic partnership on solar module factory
Feb 07
Dynegy acquires Engie's USA-based 9,017 MW power plants
Feb 09
Fortis acquired transmission utility ITC Holdings
April 12
Merger of KCP&L and Westar denied by regulators
July 19
Hydro One Signed deal to buy Avista
Jan. 30
Lightstone Generation acquired 5,200MW of generation assets from AEP
Feb 17
Merger of Enbridge and Spectra Energy completed
Feb. 22
PJM interconnection raises 1.5 b$US to increase grid reliability
March 7
EPA relaxes rules on exploration-production reporting

Climate Challenges & Regulatory Policies

The North American energy landscape, over-hanging a regulatory transition, appears on track to either evade or miss climate change targets.

Trump administration continues to move to loosen environmental rules.

Despite enacting a wide swath of measures to combat climate change, Canada's contradictory priorities and subsequent policies indicate risk.

Mexico remains committed to cut emissions 25% by 2030 and plans to launch a national carbon price by 2018.

The looming uncertainty amid the ideological differences between Federal Government and States is prompting critical questions regarding the future of climate action by the US

On June 1, 2017, US President Donald J. Trump framed the decision to pull the US from the landmark Paris climate agreement as 'a reassertion of America's sovereignty'

The question now becomes what efforts, if any, the US will adopt towards tackling climate change on its own terms?

Another pertinent questions that arises, amid the current disagreement, is whether the US States and Cities will be able to meet Paris agreement goals without Trump?

What does the US withdrawal from Paris Agreement imply?

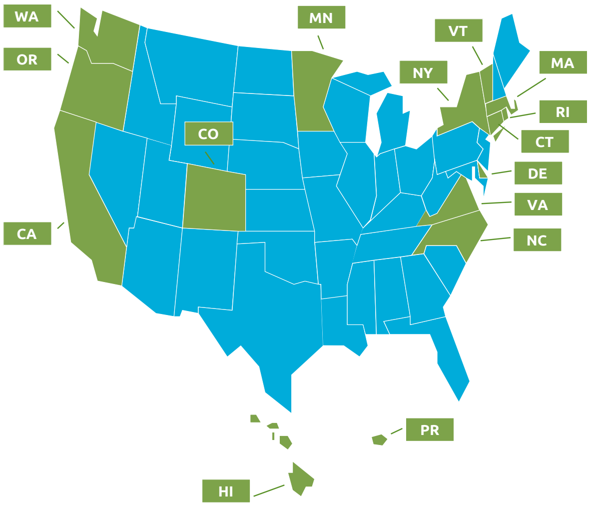
- Risks destabilizing the Paris deal, with remaining participants faced with the choice of trying to make up the shortfall in emissions cuts or following the US's lead and abandoning the agreement
- The US has been a major funder of climate aid programs, which have been vital in winning over developing nations that view

Disagreement between Federal Government and States

States in Favor of Paris Agreement	States Against Paris Agreement
Favoring social constraints on environmental actions	Favoring the legacy jobs in traditional energy amid fear of uncertainty
Apprehending lag in technological development compared to other economies	Apprehending technological issues with transition to alternative energy

Figure 1.1 : States and cities committed to meeting the Paris Agreement targets (September 2017)
States committing to Paris Agreement targets despite Federal withdrawal[2]

US Climate Alliance ~ Subnational coalition (not legally binding)
14 states, 1 territory and over 211 cities committed to the Paris Agreement targets



Members	• **14 states ~** California, Colorado, Connecticut, Delaware, Hawaii, Massachusetts, Minnesota, New York, North Carolina, Oregon, Rhode Island, Vermont, Virginia, Washington • **1 territory ~** Puerto Rico
Co-chairs	• Edmund Gerald Brown Jr. ~ 39th Governor of California, since 2011 • Andrew Mark Cuomo ~ 56th Governor of New York, since 2011 • Jay Robert Inslee ~ 23rd Governor of Washington since 2013
Established	• June 1, 2017
GDP	• Total (2016 estimate): US$7.09 trillion • Per capita (2016 estimate): US$65,783
Share of US CO2 emissions (2014)	• ~22%

- Members of the alliance, representing ~22% of total US CO_2 emissions and ~36% of US population have joined and committed to meeting their share of US target under the Paris Agreement ~ 26-28% reduction in GHG emissions below 2005 levels by 2025
- The alliance's collective GHG emissions fell by 15% between 2005 and 2015, compared to 10% for non-Alliance states
- Based on climate and clean energy policies already in place, Alliance states are projected to achieve a combined 24-29% GHG emission reduction below 2005 levels by 2025
- ~10 additional states accounting for ~20% of US CO_2 emissions have emission mitigation targets in place
- Even in states with no targets, there has been a rapid expansion of wind and solar generation driven by falling prices, as well as a shift from coal to lower-carbon natural gas generation

Source: Rhodium Group, Capgemini Analysis, WEMO2017

global warming as a crisis inflicted on them by industrialized nations

States actively moving forward with their own mitigation strategies in absence of Federal action by the US

- Nearly 40% of US CO_2 emissions are in the hands of states
- These states account for 30% of US power sector emissions, 47% of its transportation sector emissions and 38% of emissions from buildings and factories

With the fitting political will, states possess all the levers of power needed to reduce emissions enough to meet the 26-28% CO_2 reductions below 2005 levels by 2025 that the US committed to under the Paris Agreement. However, the political divide over the need to take action on climate change at the federal level is reflected in the states, with many reluctant to establish emission reduction policies.

While federal action would establish uniform policies nationwide and help combat problems such as carbon leakage, states can and will undertake significant mitigation policies on their own. States can help serve as a laboratory for mitigation policy, with many different strategies developed and tested. The best can be adopted by other states and, potentially, by a future federal administration that more highly prioritizes action on climate change.

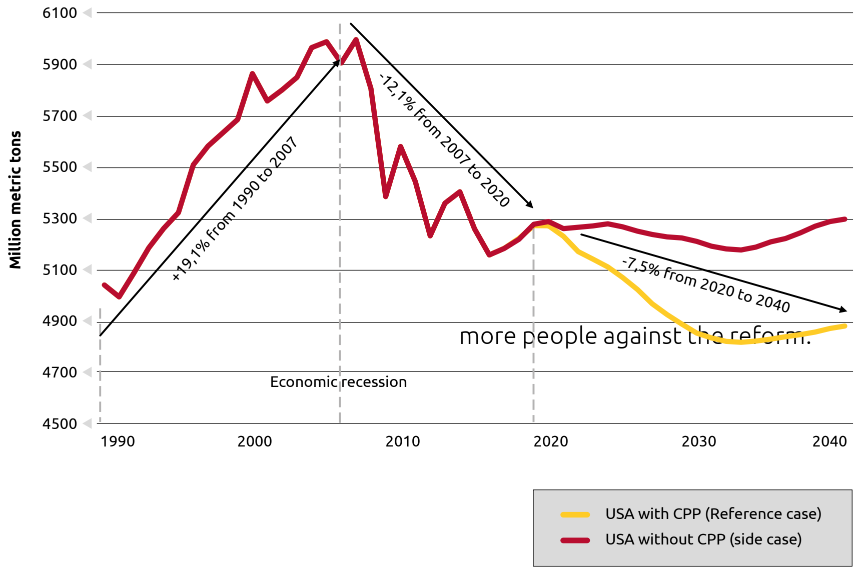
2 Rhodium Group, US Climate Alliance ~ 2017 Annual Report: Alliance States Take the Lead, Capgemini Analysis, WEMO 2017

The Curious Case of Canada and Mexico

In the wake of the 2015 Paris Agreement and the 2016 Pan-Canadian Framework on Clean Growth and Climate Change, it is imperative that major fossil fuel energy projects be reviewed by the Canadian National Energy Board (NEB) for their impact on GHG emissions. The total mitigation effort in the Pan-Canadian Framework is itself insufficient relative to Canada's INDC. Further effort is required to estimate the emissions impact of commitments in the Pan-Canadian Framework, but modeling cited in framework document itself notes that additional emission reductions of 44 MT CO_2 are required for Canada to meet its 2030 target.

Over the past three years, the United States and Mexico have deepened their cooperation on energy issues to an extent never before seen. By January of 2017, the NAFTA partners had developed complementary approaches to questions of energy markets, emissions controls, infrastructure planning and regulatory cooperation. Through bilateral meetings, and through the trilateral mechanism of the energy ministers meetings and the North American Cooperation Energy Information initiative, mutual understanding and shared interests were being discussed in ways that would have been unthinkable even five years before. Having approved a landmark energy reform in 2013, Mexico is now open and willing to cooperate with the United States in a wide variety of ways. The extraordinary successes of the past 3 and a half years have transformed Mexico's energy sector from an almost entirely closed model to one of the most open in the world. Mexico is benefiting from growing foreign and national investment in the sector as well as competitive prices for electricity. But the new energy model in Mexico continues to face serious challenges. According to public opinion polls, the reform is still deeply unpopular, and rising gasoline prices due to currency volatility and the removal of subsidies has turned more people against the reform.

Figure 1.2: Energy-related CO_2 emissions with and without the US Clean Power Plan (CPP), 1990–2040 (million metric tons)



Source: EIA, Capgemini Analysis, WEMO2017

Energy-related CO_2 emissions continue decade-long declining trend

2016 emission totaled ~5,157 MMT, 14% lower than 2005 level

Unlike the relatively flat energy-related CO_2 emissions globally in 2016, the US energy sector emissions fell by 1.7% year-on-year, after dropping by 2.7% between 2014 and 2015. The notable recent drops in emissions are consistent with a decade-long trend.

- From 2005 to 2016, energy-related CO_2 emissions fell at an average annual rate of 1.4%
- Both oil and natural gas consumption were higher in 2016 than in 2015, while coal consumption was significantly lower
- Consistent with changes in fuel consumption, energy-related CO_2 emissions in 2016 from petroleum and natural gas increased 1.1% and 0.9%, respectively, while coal-related emissions decreased 8.6%
- Significant reduction in coal use for electricity generation was offset by increased generation from natural gas and renewable sources

Of the four end-use sectors, only transportation emissions increased in 2016, while the industrial, residential, and commercial sectors have been more consistent; Power sector has shown the greatest decline in emissions

> Growth of shale gas and renewable power displaced coal

What drove the decline?

- Changes in fuel consumption in the power sector
  - Consistent with changes in fuel consumption, energy-related CO_2 emissions in 2016 from petroleum and natural gas increased 1.1% and 0.9%, respectively, while coal-related emissions decreased 8.6%
  - Significant reduction in coal use for electricity generation was offset by increased generation from natural gas and renewable sources
  - In addition to more generation from natural gas, EIA notes that renewable sources also helped to replace reduced generation from coal

- Weather related consumption decline
  - 2016 is expected to have had 10% fewer heating degree days (indicating lower heating demand) and 13% more cooling degree days (indicating more cooling demand) than normal
  - Heating degree days in 2016 were the second fewest of any year since at least 1949, consistent with relatively warmer winter months

- Energy intensity and carbon intensity continue to decline
  - The amount of energy used per unit of economic growth (energy intensity) has declined steadily for many years, while the amount of CO_2 emissions associated with energy consumption (carbon intensity) has generally declined since 2008
  - Overall, the data indicate about a 5% decline in the carbon intensity of the power sector, a rate that was also realized in 2015
  - Since 1973, no two consecutive years have seen a decline of this magnitude, and only one other year (2009) has seen a similar decline
  - These trends are projected to continue as energy efficiency, fuel economy improvements, and structural changes in the economy all lower energy intensity
  - Carbon intensity declines largely 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
  - By 2040, energy intensity and carbon intensity are expected to be 37% and 10% lower than their respective 2016 values

Proposed Changes
Elimination of or stripped down Clean Power Plan
Potential Impacts
Longer life for some marginal coal-fired generating units
Coal-to-gas switching will continue recent trend as gas production and takeaway capacity increase as a result of other policies, absent some gas price dislocation
States with higher climate-related focus (e.g., CA, the Northeast) will continue to ratchet emissions compliance, with patchwork of rules from region to region
CPP might then be narrowed to "inside the fence line" performance with greater flexibility for states
Difficult administrative process to undo rules, especially major ones
Environmental groups are expected to sue EPA, others to force regulation where there are judicial or statutory guidelines

Transportation-related emissions increased by 1.9% in 2016 and surpassed power sector emission levels, largely due to motor gasoline

Future without the Clean Power Plan (CPP)

The Clean Power Plan (CPP), which is currently stayed pending judicial review, requires states to develop plans to reduce CO_2 emissions from existing generating units that use fossil fuels

Combined with lower natural gas prices and the extension of renewable tax credits, the CPP accelerates a shift toward less carbon-intensive electricity generation

With an ongoing litigation before the D.C. Circuit and possible action from the Trump Administration, the future of CPP stands highly uncertain. While determining the fate of the CPP will end up being an immensely complex multi-year undertaking, the White House March 28, 2017 Energy Executive Order on domestic energy policy that seeks to hobble or reverse some of broad set of climate and clean energy initiatives developed by the Obama administration also includes the following actions that can be carried out quickly:

- Reversing Obama's moratorium on new coal mining leases on federal lands;
- Removing the consideration of greenhouse gases from permit reviews under the National Environmental Policy Act;
- Formally abandoning Obama's roadmap on how to achieve US emissions reductions
- Eliminating a tool for cost-benefit analysis in regulatory review called the 'Social Cost of Carbon'

The US Clean Power Plan (CPP) Rule

- The US Environmental Protection Agency (EPA) published the final version of the CPP Rule in August 2015
- The final CPP reflects substantive changes from the proposed rule, but the overall expected level of CO_2 emissions reduction is similar to the level expected under the proposed rule. To the extent that the requirements are similar, a reasonable indicator of potential changes resulting from the final CPP is provided in EIA's analysis of the proposed rule
  - In EIA's analysis, the key impact of the proposed CPP rule was a projected reduction in US coal-fired generation, by 560 billion kilowatt-hours (kWh) in 2030, to approximately 33% less than the projected 1,713 billion kWh without the CPP rule
  - Thus, under the proposed rule, the projected reduction in output from US coal-fired power plants would yield CO_2 emissions of roughly 613 million metric tons (25% below 2005 levels) in 2020 and roughly 830 million metric tons (34% below 2005 levels) in 2030
  - The Clean Power Plan leads to a decrease in coal-fired generation, reflecting both additional coal plant retirements and lower utilization rates for plants that remain in use
  - Significant changes from the proposed rule to the final rule include:

- More gradual implementation over the compliance period
- Increased emphasis on trading options, including examples of rules for rate-based and mass-based programs to speed the creation of interstate cooperative programs
- Reduced variability across states in the required CO_2 emissions reductions, with the EPA basing its emission rate standards on CO_2 averages determined at the electricity grid interconnection level rather than at the state level

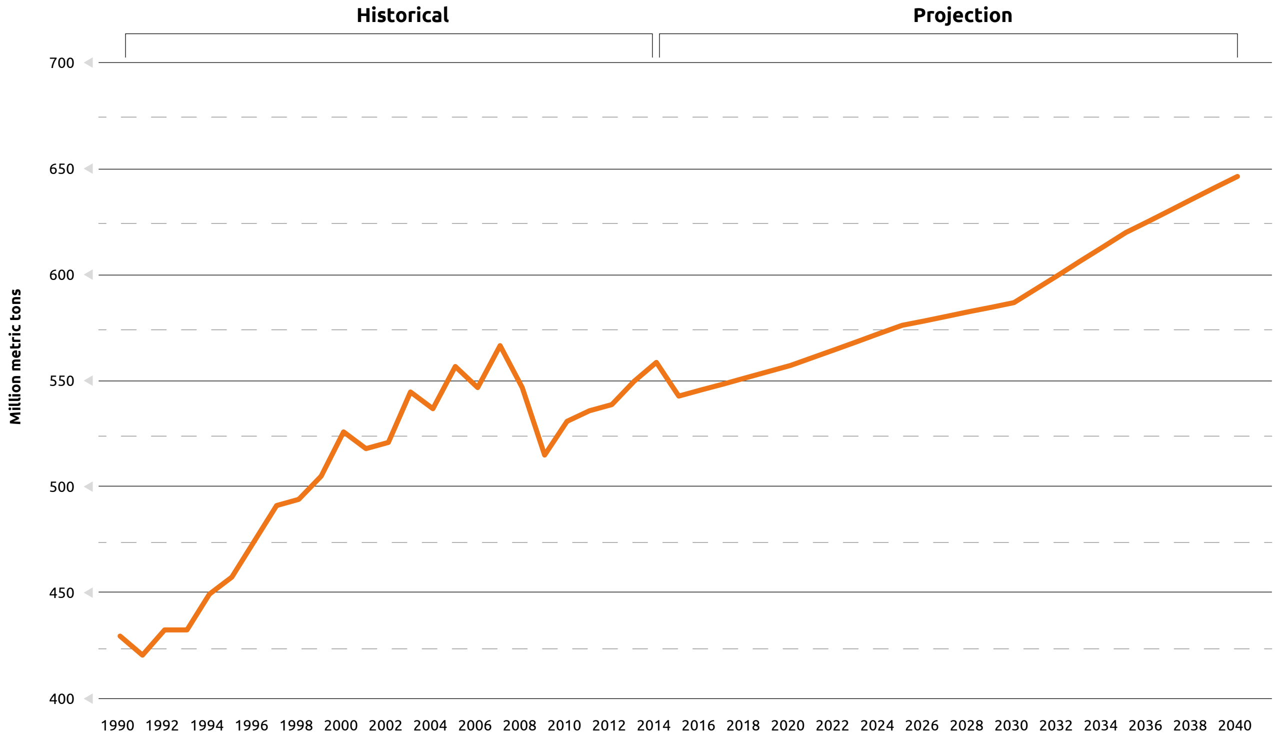
Dismantling the CPP would put the US on a higher pollution and less ambitious emissions track in the medium term

Repealing CPP could impact the nation's generation mix, economy, and public health

Dismantling the CPP would have an effect on the overall US climate strategy and will make it harder and more expensive to achieve the necessary levels of greenhouse gas emissions in the longer term. The CPP targeted a roughly 32% decrease in CO_2 emissions from the power sector by 2030, primarily from accelerating the long-term shift away from coal-fired electricity generation. In addition to having impacts on the US economy and health, removing the CPP would imply a costly delay in implementing what in the long run will be necessary reductions in our overall greenhouse gas emissions over time. In addition, the approach in the CPP was developed over many years of consultation with industry, health advocates, states, and other stakeholders. While it would impact coal, it did provide a reasonable approach to reducing the most harmful emissions and steering the economy toward a sounder energy system for the future.

Scenario where CPP in not implemented...	
According to US EIA	**According to Energy Innovation**
Coal could become the leading source of electricity generation by 2019	Increase of CO_2 equivalent emissions of more than 500 million metric tons in 2030 and 1,200 million metric tons in 2050
Coal would retain that position through 2032, when it is predicted to be surpassed by natural gas	Net cost to the US economy of nearly US$600 billion by 2050 from increased capital, fuel, and operating and maintenance expenditures, since some more efficient technologies will be unable to overcome market barriers without the CPP in place
Less incentive to switch from coal to less carbon-intensive natural gas and carbon-free renewable resources	
As a result, renewable generation would not surpass coal until 2040 in this scenario	Increase particulate pollution, causing an increase in premature deaths of 120,000 by 2050

Figure 1.3: Energy-related CO_2 emissions for Canada (million metric tons)[3]



Source: EIA, Enerdata, Capgemini Analysis, WEMO2017

Canada's Nationally Determined Contribution (NDC) currently inadequate; carbon reduction policies crucial for Canada; planning and coordination decisive to keep the impact of the wave of sub-federal policies minimally disruptive

Based on policies implemented as of 1 November 2016, Canada's GHG emissions will increase 17-23% above 1990 levels by 2020. By 2030, emissions are projected to increase by 14-29% above 1990 levels.[4]

Total mitigation effort in the Pan-Canadian Framework insufficient relative to Canada's INDC

Esoteric mechanisms deliberated to establish support or pretense lack of thorough planning/coordination and should be avoided

- The federal government and provinces have recently made headway by agreeing to national carbon emissions targets and

Contradiction at play [5]

Canada is at great risk of approving new fossil fuel infrastructure that will be contrary to the long-term objective of the Paris Agreement. This "carbon lock in" results when new production capacity ensures a certain amount of GHG emissions moving forward, making it more difficult to achieve emission-reduction targets.

The NEB continues to anticipate increased Canadian fossil fuel production and exports in its October 2016 reference forecast. The federal government appears to want to have it both ways: supporting fossil fuel production growth and climate action.

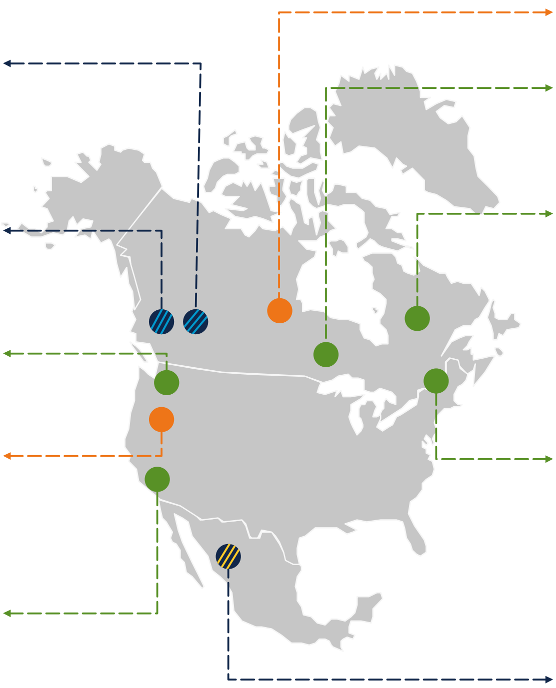
3 EIA, Enerdata, Capgemini Analysis, WEMO2017
4 http://climateactiontracker.org/countries/canada.html
5 http://behindthenumbers.ca/2017/05/24/greenhouse-gas-emissions-energy-east-pipeline/

helping advance the development critical energy infrastructure
- However, further work is required, including the commercialization and application of new energy technologies and establishing norms for inter provincial energy cooperation through a national framework
- The framework document notes that additional emission reductions of 44 Mt CO_2 are required for Canada to meet its 2030 target
- Deeper de-carbonization after 2030 will be needed for Canada to meet a 2050 target of 80-90% below 2005 levels to be consistent with the Paris Agreement objectives

New rules aim to cut methane emissions in Canada's oil, gas sector

- New rules to reduce methane emissions from Canada's energy sector will cost the industry an estimated US$3.3 billion over the next two decades, and will hit conventional oil and natural-gas producers the most dramatically
- The value of conserved gas from 2018 to 2035, as a result of the regulatory changes, could total US$1.6 billion, alongside billion saved in avoiding costs related to climate-change damage
- The draft rules for the oil and gas sector are part of Ottawa's climate-change plan that includes a goal of reducing methane emissions by 40-45% from 2012 levels by 2025

Figure 1.4: Carbon tax implementation[6]



Alberta
- **2017:** Set carbon tax of C$20/t as of January, 2017, rising to C$30/t in 2018 for transportation and heating fuel emissions
- Carbon tax includes rebate support to citizen
- Carbon currently regulated through the 2007 Specified Gas Emitters Regulation (SGER); to be phased out completely by 2018

British Columbia
- **2008:** Implemented a revenue-neutral carbon tax **2008-2012:** The tax was raised from C$10/t of CO2 to C$30/t
- Plans to increase and expand tax and use the new revenue to deliver rebate support to citizen

Washington
- **2017:** Launched ETS, in the form of a baseline-and-credit-system

Oregon
- Continues to study carbon pricing options, including a cap-and-trade program that could be linked to the California and Québec ETSs

California
- **2012-2013:** Implemented cap-and-trade system in 2012, linking with Quebec in 2013
- **2017:** Proposed plan for meeting 2030 GHG emission reduction target, including an extension of the state's ETS from 2020 to 2030
- The plan also proposes to continue the link with the Québec ETS and to link to the Ontario ETS
- Dividends key to the new proposal

Manitoba
- Continues to study carbon pricing options

Ontario
- Launched a cap-and-trade program

Québec
- **2013:** Implemented a price on carbon through a cap-and-trade system linked to California's pre-existing program, as part of the 2007 Western Climate Initiative Covers around 85% of the province's overall emissions

Regional Greenhouse Gas Initiative (RGGI)
- **2005:** First mandatory cap-and-trade program in North America, composed of Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont
- Currently being reviewed to inform design decisions for the period after 2020, considering several changes to the cap trajectory to 2030, the auction reserve price, the Cost Containment Reserve and offset
- rules Looking into setting up an Emissions Containment Reserve as a new measure to curb the supply of allowances

Mexico
- **2018:** Plans launch a national carbon price Remains committed to cut emissions by 25% by 2030

Legend:
- ETS implemented or scheduled for implementation
- ETS or carbon tax under consideration
- ETS and carbon tax implemented or scheduled
- Carbon tax implemented or scheduled, ETS under consideration

Sources: Carbon Pricing Watch 2017 – Capgemini Analysis, WEMO2017

Mixed momentum for carbon pricing across North America; US hangs back [7]

- While the US federal government is reviewing energy and climate-related policies of the previous government at a national level; at the state level, Governors of Washington, Oregon and California, together with mayors of five large cities, released a Joint Statement stating that their jurisdictions would continue to accelerate the transition to low-carbon power generation
- Canada's federalist experiment around carbon pricing has been a success: four different provinces are running four different programs, and now the federal government is ready to implement a national price in 2018
- Mexico is scheduled to launch a national carbon price in 2018

Canada and Mexico set to roll out national programs, meanwhile, the US lags[8]; California's trailblazing climate efforts, and some conservative thought leadership on dividends, is laying promising groundwork for US action

6 https://openknowledge.worldbank.org/bitstream/handle/10986/26565/9781464811296.pdf?sequence=2&isAllowed=y
7 http://www.sightline.org/2017/06/06/map-the-future-is-carbon-priced-and-the-us-is-getting-left-behind/
8 https://www.wilsoncenter.org/article/infographic-carbon-pricing-north-america

Topic Box 1: Evolution of policies and their impacts on markets

The US climate policy is undergoing a huge transformation with President Donald Trump's decision to roll back Obama Administration's environmental and energy policies on global warming, that includes emissions rules for power plants, limits on methane leaks, a ban on federal coal leasing, and use of the social cost of carbon to guide government actions.

Key features include:
Rolling back the Clean Power Plan (Obama's signature climate policy, a major EPA (Environmental Protection Agency) rule aiming to cut emissions from existing US power plants 32% below 2005 levels by 2030)
Reconsider CO_2 standards for new coal plants (Obama's EPA defined a set CO_2 standards for new plants, with CCS technology to capture carbon emissions and isolate them underground)
Reconsider regulations on methane emissions from oil and gas operations (A goal of reducing methane emissions 40% below 2012 levels by 2025)
Reconsider the 'Social Cost of Carbon' (SCC) estimate used to justify climate regulations (Central's estimation of US$36 per ton in 2015 as the SCC, justifies regulations that reduce emissions, such as the Department of Energy's efficiency standards for appliances)
Lift the moratorium on federal coal leasing (In 2016, Obama's Department of Interior put a moratorium on new federal coal leases until they could review and revamp the program)
Revoke guidance for factoring climate change into the National Environmental Policy Act (NEPA) reviews
Repeal many of Obama's other executive orders on climate, such as, the Climate Action Plan; an order urging federal agencies to reduce their CO_2 output; and an order urging federal agencies to help communities strengthen their resilience to climate impacts.[9]

Conflicts between Federal Government and the States

An alliance of conservative states has challenged both the Clean Power Plan and the Water Rule, which expanded the definition of waters protected under the Clean Water Act to smaller non-navigable waters, as the new rule would safeguard drinking water for 117 million people, but Republicans and some Democrats representing rural areas also argue that the regulations are costly, confusing and amount to a government power grab. Trump administration has said that the tax credits and other subsidies for wind and solar power "distort" the market, however, the US should "encourage all facets of the energy industry", including wind and solar power, as a means to achieve energy independence.[10]

States like California are likely to challenge the new regulation changes. California is the only state that can write its own rules, under Section 177 of the Clean Air Act. From unleaded gasoline to catalytic converters to counting CO_2 and other GHG emissions in vehicle standards, the state has played a key role. Thirteen (mostly northeastern) states along with Washington D.C. have adopted California's extra-stringent emissions standards. Nine states also follow California's mandate that calls for auto-makers to sell zero-emission vehicles. [11]

In May 2009, the Obama administration announced a settlement of sorts: the EPA would include GHGs in new standards, and the auto-industry would deliver cleaner cars. With a new government in the White House, the auto-industry seems willing to revoke the peace treaty.[12]

Revival of fossil fuels

In an executive order, Trump administration is planning to undo Obama-era climate policies, and is trying to revive fossil fuels, but is likely to struggle, since considering cost as a key point to reflect on, fossil fuels are facing an inevitable decline.

Solar energy system prices fell by 25% in 2016, and the solar adoption is growing at an annual rate of about 30%. Overall, renewable sources provided 63% of new electricity generation in 2016. Carbon pollution from coal, oil and natural gas is a key reason for growing heat in the atmosphere. Coal industry is facing another major problem that renewables are getting cheaper, and the easiest-to-reach coal has already been extracted.[13]

The Trump administration, which made dismantling the Paris agreement a central part of its campaign in 2016, does not intend to target the agreement directly, rather reduce UN funding.

The US has nearly half a trillion metric tons of coal, and had pledged US$3 billion to the Green Climate Fund (GCF), which is the main financing tool under the UN Framework Convention on Climate Change (UNFCCC), and it delivered US$1 billion under the administration of Obama. The other US$2 billion will not materialize under Trump, and the GCF will be left with a massive deficit if other countries follow suit.[14] The coal industry was interested in ensuring that the Paris deal provides a role for low-emission coal-fired power plants and financial support for carbon capture and storage technology.

Trump administration's executive order also helped revive the possible construction of the Keystone Pipeline that was rejected by the Obama administration. This would facilitate the transportation of crude oil from the Canadian oil sands to the US market. The current administration has also announced intentions to renegotiate the North American Free Trade Agreement (NAFTA) with Canada and Mexico.

Strengthening ties with Mexico for a sustainable future

For the energy business, there are two possible concerns, first being the number of projects completed or under construction to transport natural gas from the US to Mexico in order to replace Mexican crude oil with cheaper natural gas for industrial uses including electric generation. It would also allow Mexico to sell more of its valuable crude oil overseas. In addition, Mexico has begun the process of opening up its crude oil and gas exploration and production market to foreign competition. Prior to these reforms, PEMEX, Mexico's state-owned enterprise, had a monopoly on energy exploration and production.[15]

In Mexico, long-term energy and capacity Power Purchasing Agreements (PPAs) have been extended to 15 years, while all power produced by a generation unit will now be guaranteed to be commercialized. These recent changes increase the viability of renewable energy projects in Mexico by reducing the uncertainty around potential renewable energy development. With this, US renewable energy companies are leveraging the benefits of doing business in the Mexican market, and are uniquely positioned to help develop, supply, build, and finance projects in Mexico's evolving energy market.[16]

9 http://www.vox.com/energy-and-environment/2017/3/27/14922516/trump-executive-order-climate

10 http://energy.economictimes.indiatimes.com/news/power/trump-set-to-roll-back-obama-policies-on-energy-environment/55424757

11 https://www.wired.com/2017/03/want-gut-emission-rules-prepare-war-california/

12 https://www.wired.com/2017/03/want-gut-emission-rules-prepare-war-california/

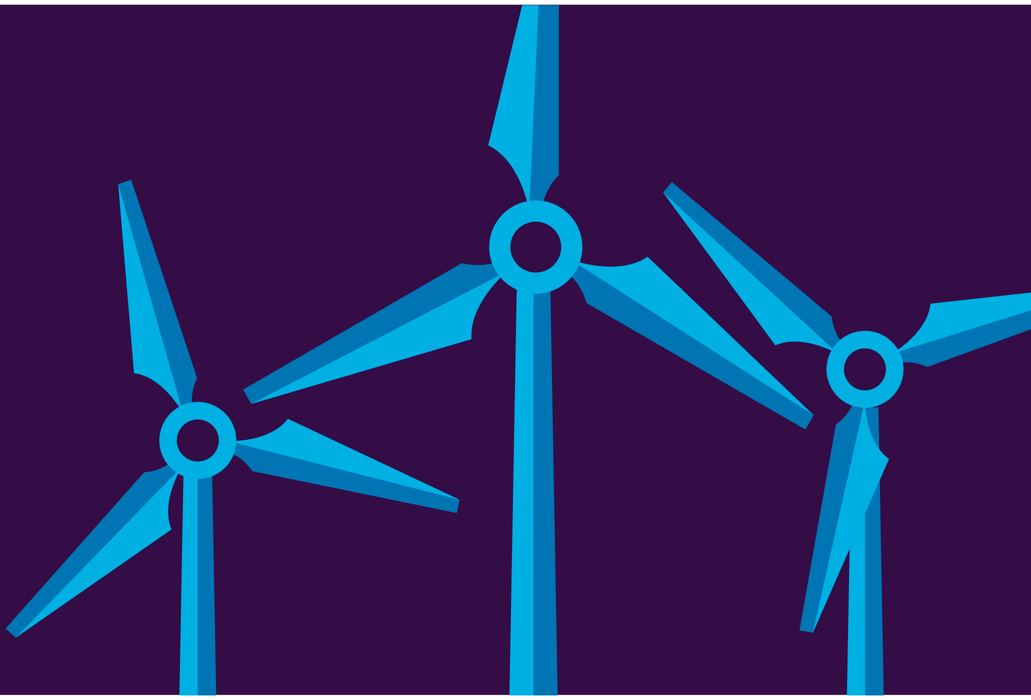
13 http://time.com/4709796/trump-epa-climate-fossil-fuels/

14 https://www.irinnews.org/analysis/2017/03/20/paris-discord-trump-unravelling-climate-change-agreement

15 https://seekingalpha.com/article/4040040-trump-administration-energy-policies-will-affect-energy-infrastructure

16 https://www.forbes.com/sites/energysource/2016/01/20/opportunities-dawning-for-u-s-renewable-energy-companies-in-mexico/#6d7c61c73ac2

Energy Transition



Mature market, attractive state-level policies and general investment climate have been attracting sizeable renewable energy investments in the US, primarily in progressive states

Monumental shift in generation, delivery and consumption of energy; energy efficiency measures appear to be making an impact

Further decoupling of economic growth from energy consumption since 2007

- **Energy productivity continues to improve, with drop in energy usage to fuel growth**
- **Trend continued in 2016: Energy productivity advanced by 1.8%; GDP grew 1.6%; while energy consumption declined by 0.2%[17]**

Meanwhile, energy has grown cleaner with accelerated renewable deployment; natural gas demand and exports have achieved new highs

Shift from alternative to sustainable energy	
What…	**How…**
• **2016: new record for annual renewable energy capacity additions** • Addition of over 22GW of renewable generating capacity	• 8.9 GW of utility-scale photovoltaic additions more than doubled 2015's record of 4.4GW • Commercial and industrial solar installs increased 34% to 1.1GW • Wind additions hit 8.5 GW (similar to 2015's level) • New hydroelectricity build totaled 379 MW, while biomass, biogas and waste-to-energy added 132 MW • 47 MW worth of stationary fuel cells were installed. • Since 1990, over 90% of cumulative generating capacity additions have been renewable energy or natural gas, and, in the past 10 years, over 54% of total additions have been dedicated to renewable energy resources

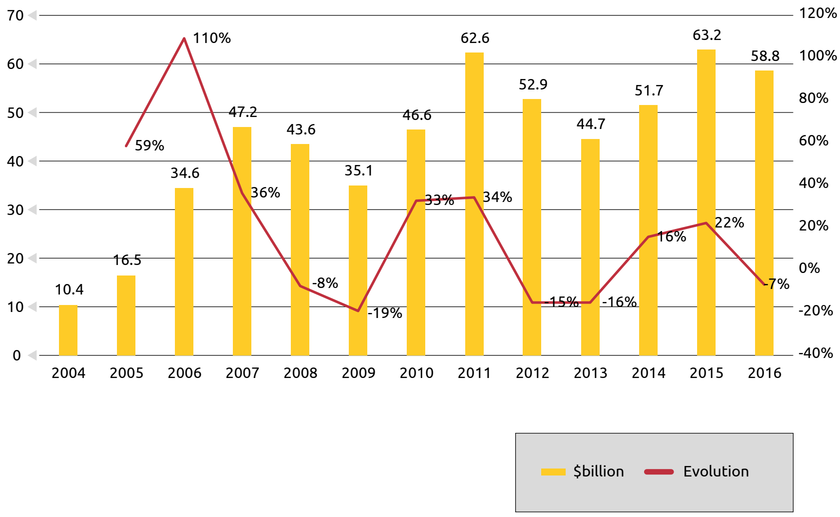
17 https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf

Concurrent with the growth in capacity additions, US Clean Energy Investment witnessed a decline in 2016, dropping to US$58.8 billion, a 7% decline from 2015's all-time record of US$63.2 billion, a surge of 46% from 2014 levels

- The decline in spending was visible particularly within the solar sector, which dropped to US$29 billion from US$35 billion in 2015 as solar costs fell
- Clean energy investment has averaged US$54.3 billion annually after 2011
- 2011's high level of investment was primarily driven by spending under the American Recovery and Reinvestment Act

The 2016 financing slump reflects a return to normalcy after the 2015 rush to finance wind and solar projects before what was then seen as the expiration of the federal tax credits, the Investment Tax Credit for solar, and the Production Tax Credit for wind, which were ultimately extended in late 2015 for five years apiece by the Congress.

Figure 2.1: US Clean Energy Investment (2012-2016)[18]



Source: BCSE - BNEF – Capgemini Analysis, WEMO2017

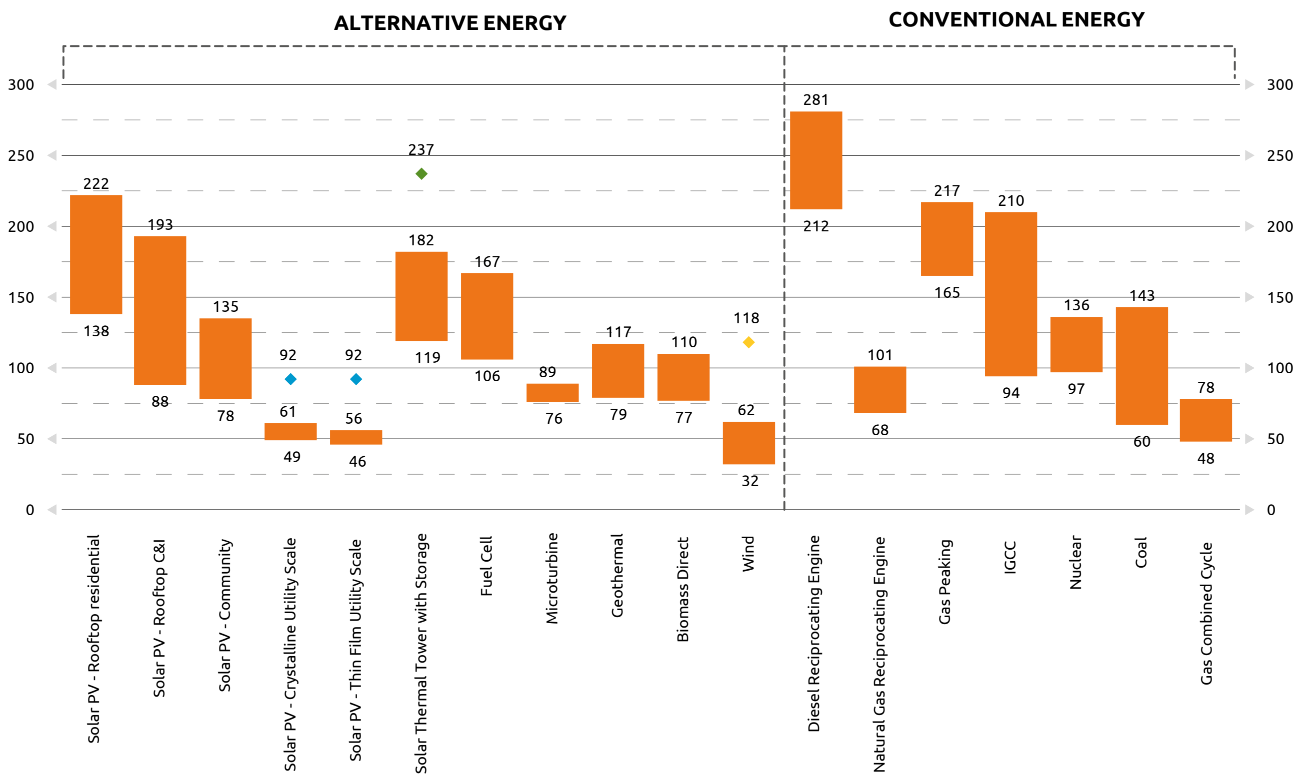
Drop in investment in zero-carbon technologies post 2015	
What...	**How...**
• Investment over the past 10 years into zero-carbon technologies has been substantial, with US$507 billion flowing into the US clean energy sector • After US$63 billion worth of investment into renewable energy and energy smart technologies in 2015, investment in 2016 fell to US$59 billion	• The decline in 2016 primarily resulted from fewer companies turning to the public markets for financing, after solar roped in a record US$8.3 billion in 2015 • The April 2016 bankruptcy of SunEdison, which raised US$2.3 billion alone in 2015, and a pause in capital raising by yieldcos appear to be drivers of the decline

18 https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf

Asset Class	2016 Investment Update
• Asset Finance • (Utility-scale projects only)	• Investment of US$31.6 billion, a small drop-off from 2015's US$32.2 billion • Investment in wind up US$0.7 billion (+5%) from 2015; solar down by US$1 billion (-6%) as costs fell • Biomass financing amounted to US$196 million, down from US$286 million in 2015 • Small hydro witnessed the first significant investment since 2011, with US$77 million • Bio-gas received US$24 million • Virtually no new financing tracked for waste-to-energy, geothermal, or carbon capture and storage
• Public Markets	• Transactions plummeted 70% year-over-year, since the solar sector barely tapped this source
• Venture Capital / Private Equity	• Investment totaled US$3.5 billion in 2016, down US$0.5 billion year-over-year

Going forward, given the uncertainty that looms the future of climate action stand by the US Federal government, the future outlook for investment also hangs in uncertainty.

Figure 2.2 : Levelized Cost of Energy (US$ / MWh)[19]



Source: Lazard - Levelized Cost of Energy Analysis 10.0

19 https://www.lazard.com/media/438038/levelized-cost-of-energy-v100.pdf

Exhilarating times for alternative energy, as already competitive costs continue to fall… with no end in sight!

Alternative energy challenging traditional sources on price: continued cost declines for alternative energy technologies indicate enhanced competitiveness with traditional sources, without subsidies

The cost of generating energy from renewable sources other than solar, such as onshore wind, geothermal, and biomass, declined only at the margins from last year, reflecting both the maturing of technology in those areas and a relatively low level of investment

Alternative energy, particularly solar and wind, achieving outstanding cost improvements

- **Solar energy:** The median levelized cost of energy from utility-scale PV technologies is down ~11% over 2015, while rooftop residential PV technology is down ~26%, although the latter is still not cost competitive without significant subsidies and other policy support[20]
- **Wind energy:** The median cost of generating energy from offshore wind generation has declined approximately 22%, but remains substantially more expensive than onshore wind facilities, especially in the US[21]

Onshore wind power is the cheapest power generation technology on an unsubsidized LCOE basis, calling for a level playing field between all power sources

Utility-scale solar is also exceedingly attractive from a purely economic point of view, however not much different in terms of cost than wind power

Costs from solar are falling faster than other energy sources

The rate of cost declines is somewhat muted in 2016, compared to the last five years

20 https://www.lazard.com/perspective/levelized-cost-of-energy-analysis-100/

21 https://www.lazard.com/perspective/levelized-cost-of-energy-analysis-100/

Historically, the sector has been evolving over the last 8 years, leading to a sharp fall in wind and solar power costs since 2009

- Decrease in LCOE since 2009 (7-year percentage decrease):
  - Wind: ~66%
  - Utility-Scale Solar: ~85%
- Technological advances have resulted in 50% more productive turbines in 2016 compared to 2009, with recent generations achieving average capacity factors over 40%, all while costs continued to fall[23]
- Wind and solar have witnessed cost declines, amid material declines in the pricing of system components, including but not limited to panels, inverters, racking, turbines, etc., and improvements in efficiency, among other factors

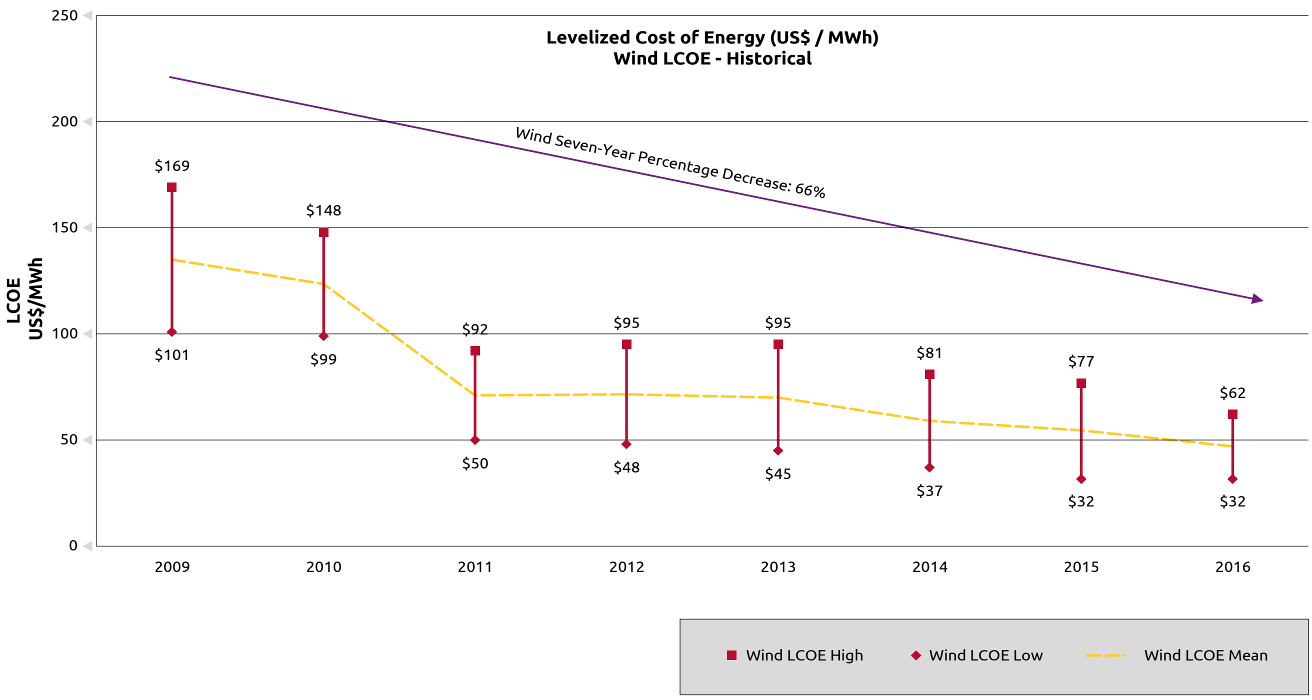
Way forward: Diversified generation fleet backed by rational and transparent policies

There is no reason to believe that these costs declines will stop, given that both wind and solar power are seeing continued technological advances and other cost-cutting measures

Despite the sustained and growing cost-competitiveness of alternative energy technologies and immense potential of storage technology, advanced economies like USA would require a diversified generation fleet to meet the baseload generation needs for the foreseeable future.

- The US remains one of the most dynamic energy storage market globally, with a variety of new

Figure 2.3 : Historical Levelized Cost of Energy – Wind/Solar PV (US$ / MWh) (1/3)[22]

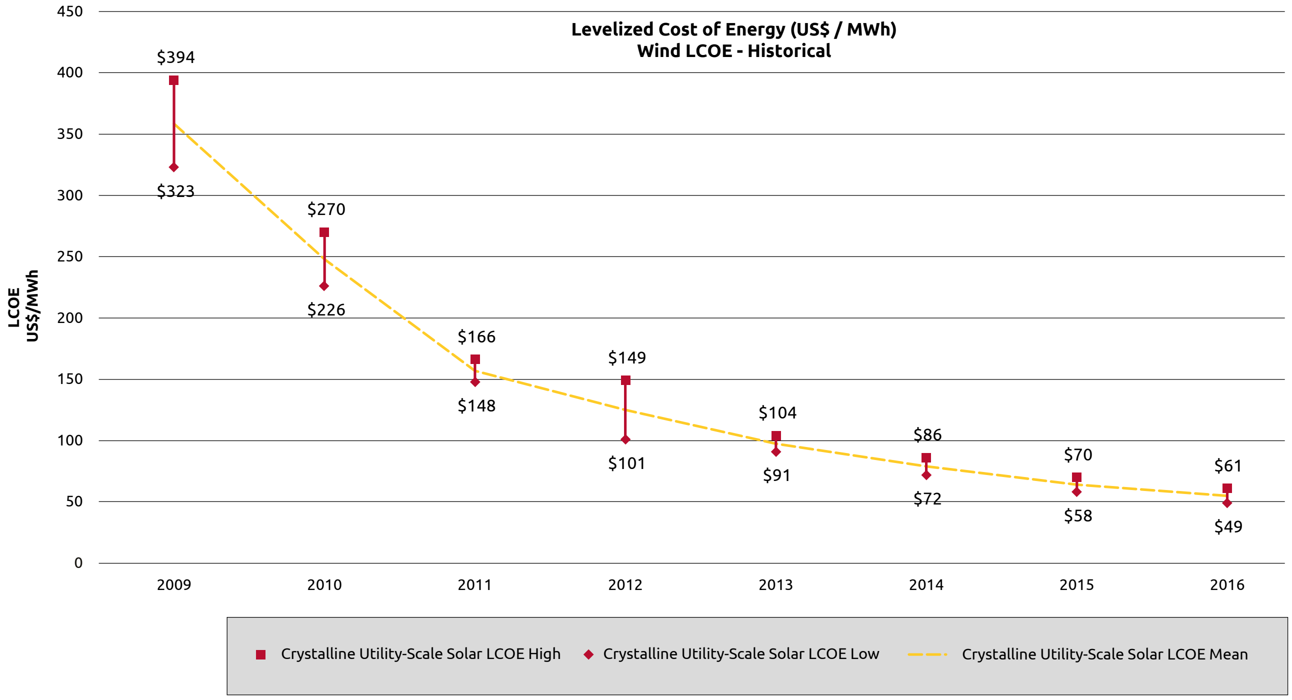


Source: Lazard - Levelized Cost of Energy Analysis 10.0

22 https://www.lazard.com/media/438038/levelized-cost-of-energy-v100.pdf

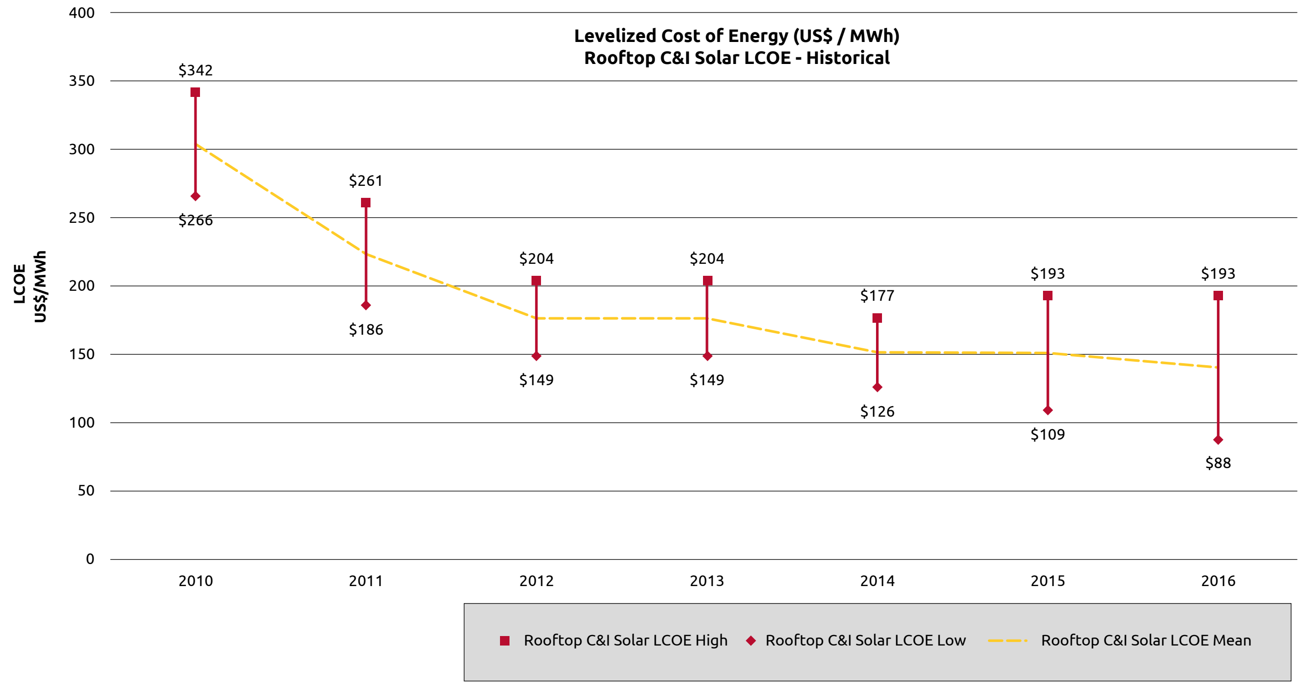
23 http://www.aweablog.org/top-11-wind-energy-trends-2016/

Figure 2.3 : Historical Levelized Cost of Energy – Wind/Solar PV (US$ / MWh) (2/3)



Source: Lazard - Levelized Cost of Energy Analysis 10.0

Figure 2.3 : Historical Levelized Cost of Energy – Wind/Solar PV (US$ / MWh) (3/3)



Source: Lazard - Levelized Cost of Energy Analysis 10.0

business and financing models being deployed across the sector
- Project activity has tended to be erratic, but new announced projects grew markedly in 2014-2016
- The 2009 American Recovery and Reinvestment Act (ARRA) funded the majority of projects commissioned between 2011 and 2014
- Pumped hydropower storage projects account for roughly 97% of installed energy storage capacity in the US
- While pumped hydro is likely to remain the bulk of energy storage capacity in the US, new capacity additions since 2011 have been dominated by other technologies, mainly lithium-ion batteries
- As of January 2017, FERC had pending licenses for nearly 2GW of new pumped storage capacity
- Batteries and flywheels, which provide electricity storage, are among the newest operating units, as almost all of these generators have been added since 2010
- Half of the 540 MW of batteries are in California, Illinois, and West Virginia
- Flywheels provide electricity storage through rotational kinetic energy, and almost all of the nation's 44 MW of utility-scale flywheels are located in New York and Pennsylvania.
- Since 2014, however, energy storage procurements in California have focused on contracting projects to supply Resource Adequacy (for system capacity) for the Californian grid, many of which will be delivered after 2019
- There has been nearly $4 billion invested by Venture Capitalist/ Private Equity in US energy storage companies since 2006, including $352 million in 2016 according to the latest available data
- Energy storage software providers and management companies also secured considerable funding over the same period, which underlined their growing importance

Regulation Evolution

Key federal policies accommodating sustainable energy hit uncertainty; state-level measures continue

The Clean Power Plan stalled; New Source Performance Standards challenged

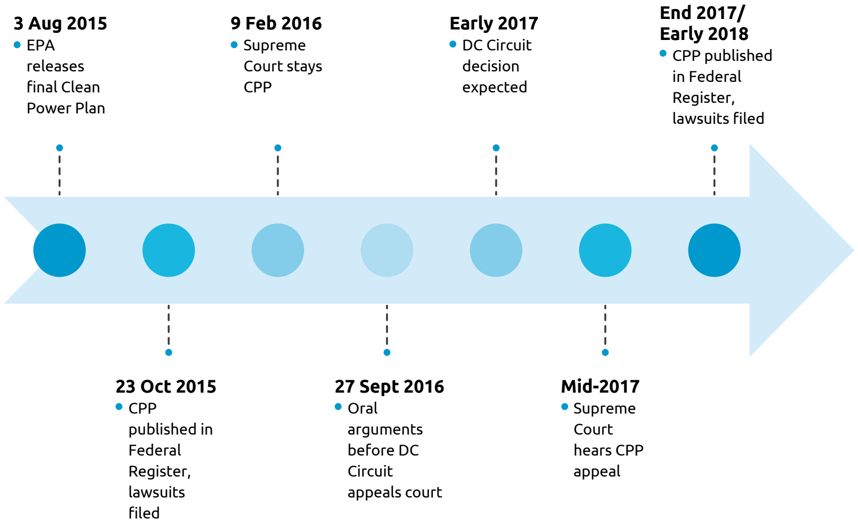
Clean Power Plan: With a stay in place, the EPA has been unable to enforce any upcoming CPP deadlines, the first of which would have required states to submit the first draft of their implementation plans in September 2016.

New Source Performance Standards: If the NSPS is overturned, it could preclude the EPA from implementing the CPP regardless of its own status (under the US Clean Air Act, the EPA must first regulate new sources of emissions before it can tackle existing sources).

Extension of Energy Tax Provisions uncertain

The tax credit extensions of late 2015 benefited the wind and solar sectors, but tax credits for other renewable energy and energy efficiency technologies were not extended at that time and ultimately expired at the end of 2016. Significant attempts were made to extend all the remaining energy efficiency and renewable energy tax provisions, but after the November 2016 election, congressional leaders shifted focus to tax reform, where these provisions may be addressed.

Figure 2.4: Evolution of Clean Power Plan (CPP)[24]



Source: Capgemini Analysis, WEMO2017

24 Capgemini Analysis, WEMO2017

Figure 2.5: State-level measures driving the sustainable energy transition[25]

Far-reaching Policy Changes at State-level in 2016

Source: Carbon Pricing Watch 2017, Capgemini Analysis, WEMO2017

- Renewable Portfolio Standards (RPS) has played a pivotal role in driving wind and solar build
- States also use Energy Efficiency Resource Standards (EERS) to encourage energy savings, and states determine net energy metering policies, which can be critical to Distributed Solar
- Moreover, Property Assessed Clean Energy (PACE) is becoming more widely available as additional states and municipalities adopt programs or enabling legislation
- PACE helps finance renewable energy and energy efficiency upgrades to buildings by allowing the owner to pay off the cost over 20 years via an addition to their property taxes

What is driving the Regulatory Paradigms?

- **Pressure on traditional unit sales-based, cost-of-service ratemaking:** Slower load and economic growth, declining cost of renewable and distributed energy resources
- **Economic efficiency:** Sending a volume-based price signal, and using it to recover largely fixed costs plus CapEx to accommodate peak usage
- **Grid modernization:** Accommodate multi-directional power flows, increased resilience and cybersecurity needs, efficiency measures, and other policy objectives, as well as resource intermittency
- **Economic incentives:** Balance efficient deployment of capital, incentives to innovate, regulatory lag, retention of service quality at reasonable cost, and rate base expansion

> The optimal solution would be a mix of complementary traditional and alternative energy resources in a diversified generation fleet

> A coordinated federal and state energy policy, grounded in cost analysis, could enable smarter energy development in USA

[25] Carbon Pricing Watch 2017 – Capgemini Analysis, WEMO2017

Topic Box 2: Is the US transitioning to a dual-path on climate action?

Falling prices for renewables and a growing sustainability movement from the bottom up have changed the stance towards energy sustainability, keeping the social constraints in mind. However, with the decision by the Trump administration to withdraw the US from the Paris Agreement on climate change and reverse many of the prior administration's climate change policies, it seems that federal action on climate change will be unlikely in the next few years.

The US system of government gives individual states broad powers to regulate CO_2 emissions within their borders, with many states actively moving forward with their own mitigation strategies in absence of federal action. However, states are divided politically, with about half committing to deep carbon reductions and about half with little or no controls on GHG emissions.

Is the US transitioning to a dual-path on climate action?

Growing US 'Climate Rebellion' against Trump administration

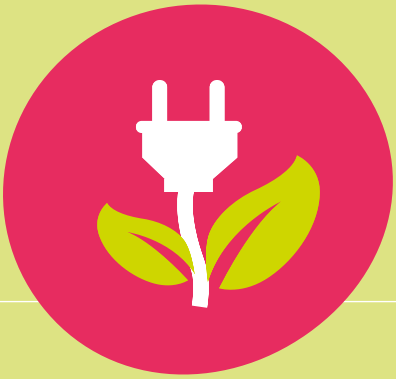
States, cities, businesses, philanthropies, and universities have vowed to fill the void left by US Federal government's withdrawal from the Paris accord and voluntary targets: a 26% to 28% reduction in carbon emissions by 2025, relative to 2005 levels, and further cuts thereafter.[26]

- Philanthropist and former New York City Mayor Michael Bloomberg has pledged to donate US$15 million to the UNFCCC, in order to help fill any funding gaps created by the Trump administration's exit from Paris accord.[27]

United States Climate Alliance

The same day as Trump administration's announcement, the states of New York, California, and Washington announced the formation of the United States Climate Alliance, a coalition aimed at upholding US commitments under the Paris Agreement.

- Jerry Brown, the governor of member state California, has positioned himself as the US's de facto climate leader, attending meetings on climate change with leading Chinese officials at a recent clean-energy conference.
- Separately, states, state attorney generals, cities, businesses, and universities have banded together into a coalition called We Are Still In. The group, spearheaded by York City mayor Michael Bloomberg, has signatories from 125 cities, nine states, 183 colleges and universities, and 902 businesses. The group says that it represents 120 million Americans and US$6.2 trillion in contributions to the US economy.
- In addition, 274 US mayors representing 58 million Americans have signed onto a statement prepared by the Mayors National Climate Action Agenda (MNCAA) network to uphold the Paris Agreement, as of the evening of June 7, 2017.
- Additionally, ten states that are not part of the United States Climate Alliance have passed laws or executive orders establishing emission targets ranging from 60% to 80% reductions in CO_2 emissions by 2050. These include Arizona, Colorado, Florida, Illinois, Maryland, Maine, Michigan, New Hampshire, New Jersey and New Mexico.
- A few additional states, including Pennsylvania, Montana, Ohio and North Carolina, are not part of the USCA and have no committed targets, but publically oppose the decision of the federal government to withdraw from the Paris Agreement.



26 http://news.nationalgeographic.com/2017/06/states-cities-usa-climate-policy-environment/
27 http://news.nationalgeographic.com/2017/06/states-cities-usa-climate-policy-environment/

Proactive initiatives

US states have also been proactive in forming agreements with other countries to collaborate around climate goals. For example, a number of states are planning on working closely with Canada to reduce emissions. A relatively straightforward way for states to control their CO_2 emissions would be to put a price on carbon, either in the form of a tax or tradable permit system. A number of states already have systems like this in place, including the Regional Greenhouse Gas Initiative (RGGI) that covers much of the northeast US and establishes a tradable permit system covering electricity generation.

Case: California

The state of California, which by itself would represent the world's 6th largest economy and 19th largest carbon emitter, recently met with both China and Germany to advance emission reductions and clean technology development

Carbon Trading

- Own cap-and-trade program covering ~85% of state emissions of CO_2 and other GHGs, linked to the cap-and-trade system in Quebec, Canada
- Proposed post-2021 revised cap-and-trade includes a carbon border adjustment that would require carbon-intensive imported products to purchase emissions permits

Zero-emission Vehicle Standard

- Ten states have adopted California's current zero-emission vehicles standard, representing around 29% of new vehicles purchased in the US
- Manufacturers of passenger vehicles have traditionally made the vast majority of their models meet California's stricter standards to avoid having to create different versions for different states
- In this case, a positive spillover is possible where stricter policies in a small number of states influence the vehicle efficiency of all states
- California can directly regulate heavy vehicle emissions, and other states can follow its lead, but here its power is a bit more limited
- About 64% of heavy vehicle emissions nationally come from long-haul trucking, the majority of which cross state borders

Distributed Energy Resource (DER)

- High DER penetration, including ~600,000 residential solar photovoltaic (PV) installations, with mandates for additional resources such as storage and fully deployed advanced metering infrastructure (AMI)
- Focusing on improved integration in support of clean energy goals amid high DER penetration level
- Step-by-step approach through a series of legislative and regulatory actions that address discrete issues presented by DERs

The divide

The political divides between states in many ways mirror those at the federal level. Thus, while many states are eager to move forward with action to tackle climate change, there are just as many reluctant to undertake any initiatives that are perceived as costly.

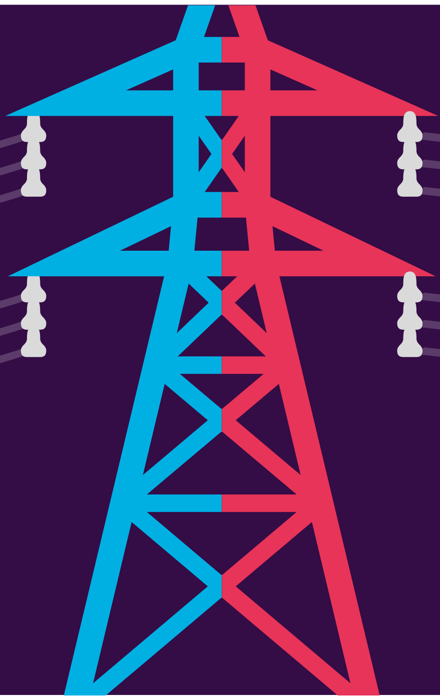
Case: Wyoming[28]

While many US states have mandates and incentives to get more of their electricity from renewable energy, Republican legislators in Wyoming are proposing to cut the state off from its most abundant and clean resource wind, and ensuring its continued dependence on coal

Electricity Production Standard

- New measure submitted to the Wyoming legislature in January 2017 would forbid utilities from providing any electricity to the state that comes from large-scale wind or solar energy projects by 2019
- An unprecedented attack on clean energy in Wyoming
- The new bill mandates utilities to use 'eligible resources' to meet 95% of the state's electricity needs in 2018 and then all of its power supply in 2019
- Sources are defined as coal, hydroelectric, natural gas, net metering sources (such as rooftop solar or backyard wind projects for homeowners and small business), nuclear and oil
- Using power from utility-scale wind, solar and other renewable projects would be outlawed under this legislation
- Another recently proposed state bill seeks to increase the state's tax on wind generation, a move that could also potentially discourage future wind projects as well

28 https://insideclimatenews.org/news/12012017/wyoming-coal-wind-energy-solar-energy-climate-change-denial



Infrastructures and Adequacy of Supply

Enhanced infrastructure underpins a decisive success-factor to sustained long-term growth for sustainable energy in the US

Transmission investment is critical to ensuring the reliable provision of electricity to consumers, relieving grid congestion, reducing curtailment and enabling diverse and distributed resources to reach demand centers

- Wind power development may have to be curtailed by as much as 15.5% in some areas without additional transmission lines and upgrades[29]
- Recent investments in large transmission networks, such as the US$7 billion Competitive Renewable Energy Zone in Texas, and the MISO Multi-value Project (by 2020), will help to connect over 30GW of clean energy, mostly wind, to the grid
- Curtailment of wind energy remains an issue in some regions, including the Midwest
- Prevailing concerns that new wind projects already under development in Texas will max out the transmission capacity built under CREZ, thereby reintroducing grid congestion and curtailment

Natural gas infrastructure remains important, along all segments of the value chain

- Production surge outstrips Appalachia's existing pipeline network; to boost pipeline capacity by 70% through 2020
- This will allow producers to export more to the South, Northeast and West and alleviate inter-regional price discrepancies caused by congestion constraints

Simultaneous rise in gas demand, much of it outside the Appalachian Basin, has given rise to a need for infrastructure build-out in other regions

- In New England, for example, coal and nuclear retirements have led to greater reliance on natural gas for power, but a lag in pipeline build has led to large, localized gas price spikes and constraints in recent winters
- Investment in new pipelines to bring gas into the region will be as important as Appalachian pipeline takeaway

Expanded service and distribution pipeline networks are connecting to more households, allowing more consumers to benefit from surging supplies

- Gas utilities now claim a record 68 million residential customers, up 13% over the past 10 years
- Annual investment in natural gas infrastructure now rivals that of electric transmission

Other investments in enabling infrastructure are helping to target demand-side efficiency and distributed energy resources: smart meter deployments breached 70 million units in 2016, up 9% from 2015

- Total smart meter penetration remains low compared to other nations, at only 44%, but a number of large utilities have plans to ramp up installations

29 http://finance-commerce.com/2017/07/infrastructure-limits-growth-in-wind-power/

The current scenario in US, over-hanging a regulatory and investment uncertainty, indicates the likelihood of a two-pronged approach:

01
Renewed interest in Traditional Energy

02
Additional capacity from Renewable Energy

Advances in Baseload Generation retirements; Underlying apprehensions about the prospect of the power generation fleet in the US heighten

- Baseload generation, much of it coal and nuclear, is exiting and is being supplanted by the entry of gas-fired and variable renewable generation

Continuing economic pressures caused by generation capacity oversupply (fueled in part by public policy), low gas prices, shifting market rules, competing regulatory priorities, and changing technology costs and preferences have brought fundamental questions to the fore about the relationship between markets and states

Average age of retired generating unit by technology type (years)[30]			
Unit	**1990**	**2000**	**2015**
Gas *Combined Cycle and Steam Turbine*	31	33	41
Coal *Steam Turbine*	46	48	55

- Aging coal, oil, and gas steam turbine generators continue to be retired while combined cycles, gas turbines, and variable renewables are taking their place
- The average size of retired plants has been increasing, with retired coal plants more than tripling since 2000, while the average size of retired gas steam turbine plants has doubled
- There are nearly 706 GWs of current operating baseload capacity, 63% of all generating capacity in the US
- A significant portion is aging and potentially at risk to retirement
- The past decade has been the first time that baseload retirements outpaced baseload additions (23 GWs of net retirements since 2010)
- There have been 84.2 GWs of baseload retirements since 2010, driven primarily by coal (61%) and gas (29%) steam turbine plants
- The 61.1 GWs of baseload additions since 2010 have been primarily combined cycles (74%) and coal steam turbines (24%)

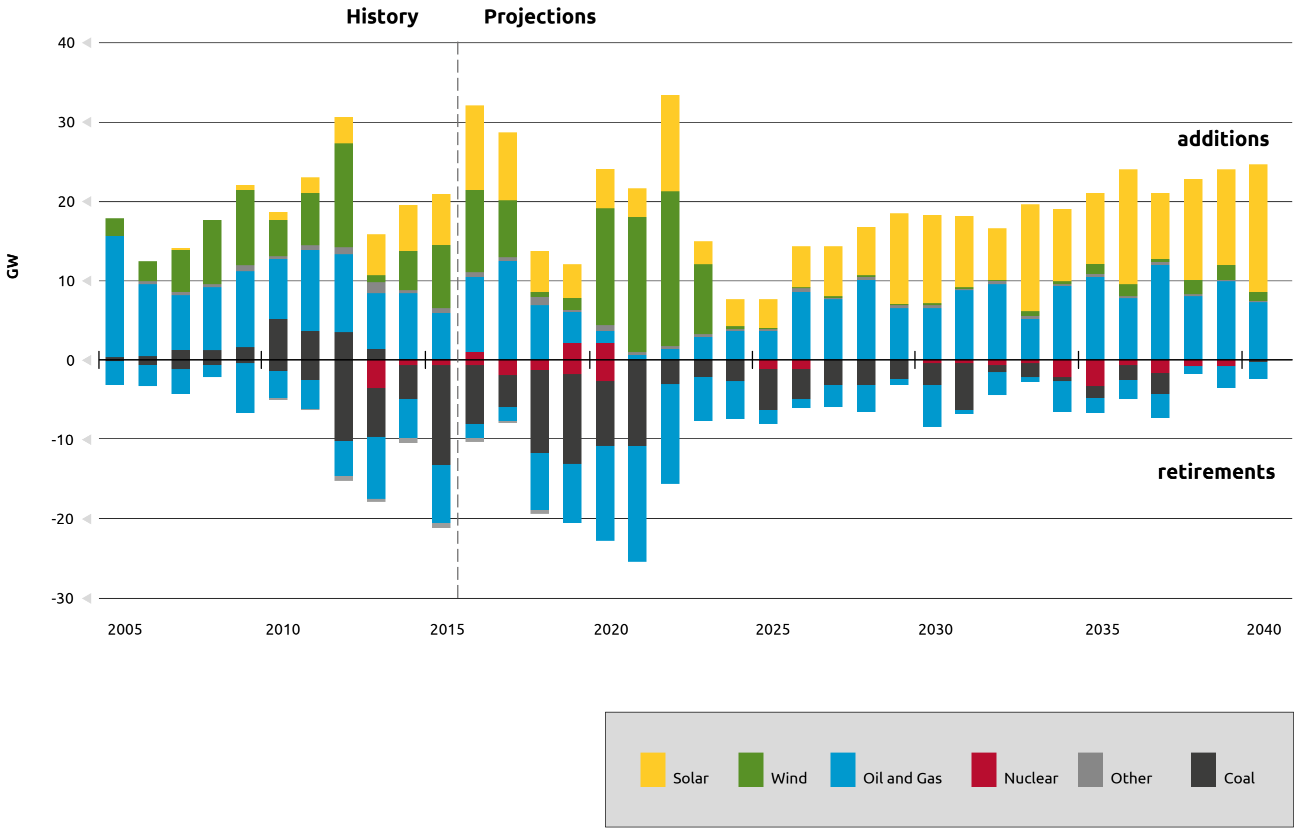
30 Scott Madden Energy Industry Update, Volume 17 – Issue 1

Newer combined cycle and gas turbine generators are more capable of cycling than their predecessors, but the oversupply generated from increasing variable renewables is depressing their run rates and revenues

- This is problematic because as oversupply increases, ramp rates will also increase
- This will require more peaking capacity
- But that peaking capacity has limited incentive to participate in the market, given the low power prices due to oversupply, primarily due to renewables, and low gas prices

The question, then, is at what penetration level would these conflicting trends collide and result in reliability issues for the grid?

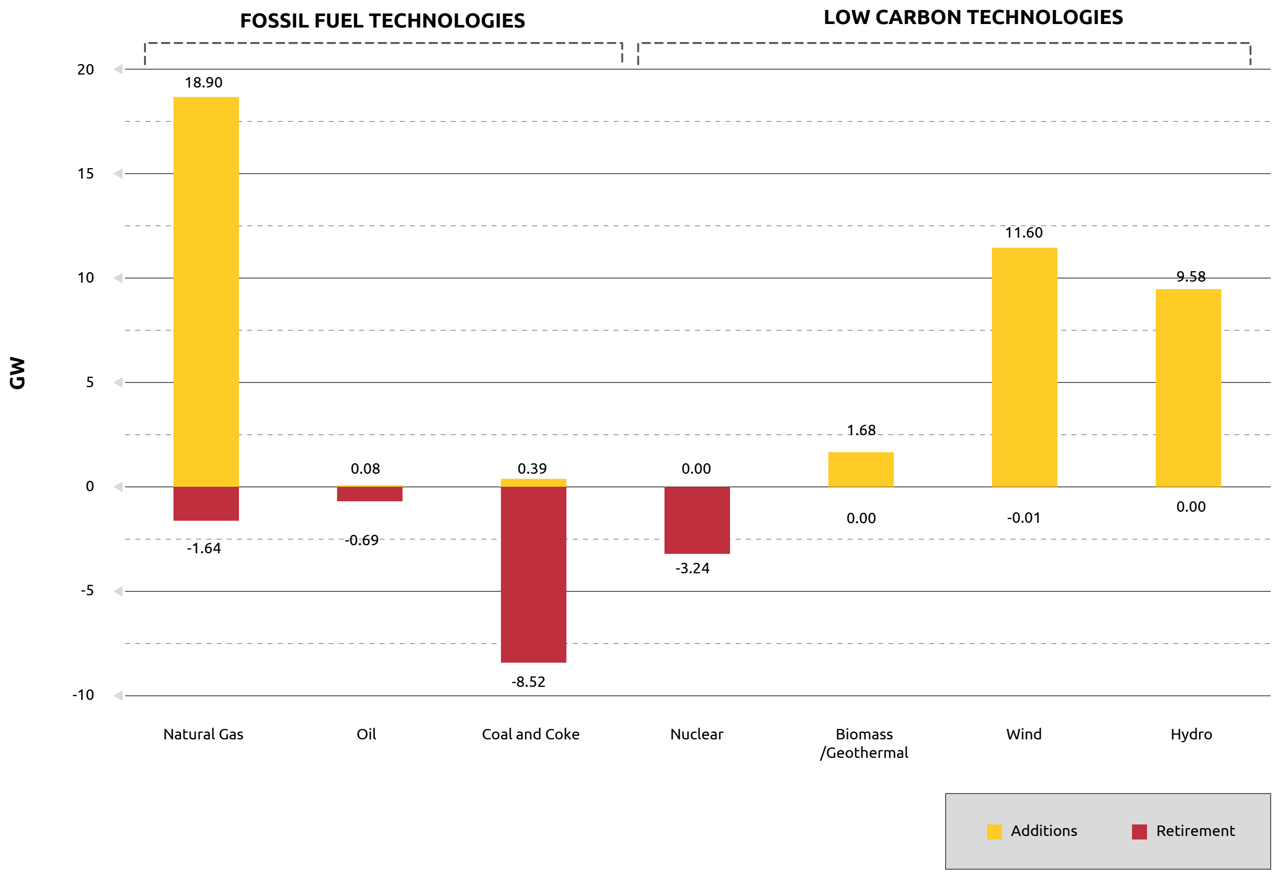
Figure 3.1 : Installed and decommissioned capacities in US[31]



Source: EIA, Annual Energy Outlook 2017

31 https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf

Figure 3.2 : Installed and decommissioned capacities in Canada by 2040[32]



Source: NEB, Capgemini Analysis, WEMO2017

Most of the wind capacity used to comply with the Clean Power Plan (CPP) is built prior to the scheduled expiration of the production tax credit for wind plants coming online by the end of 2023, although wind is still likely to be competitive without the tax credits

- Continued retirements of older, less efficient fossil fuel units under the CPP support a consistent market for new generating capacity throughout the projection period
- After 2030, new generation capacity additions are split primarily between solar and natural gas, with solar capacity representing more than 50% of new capacity additions

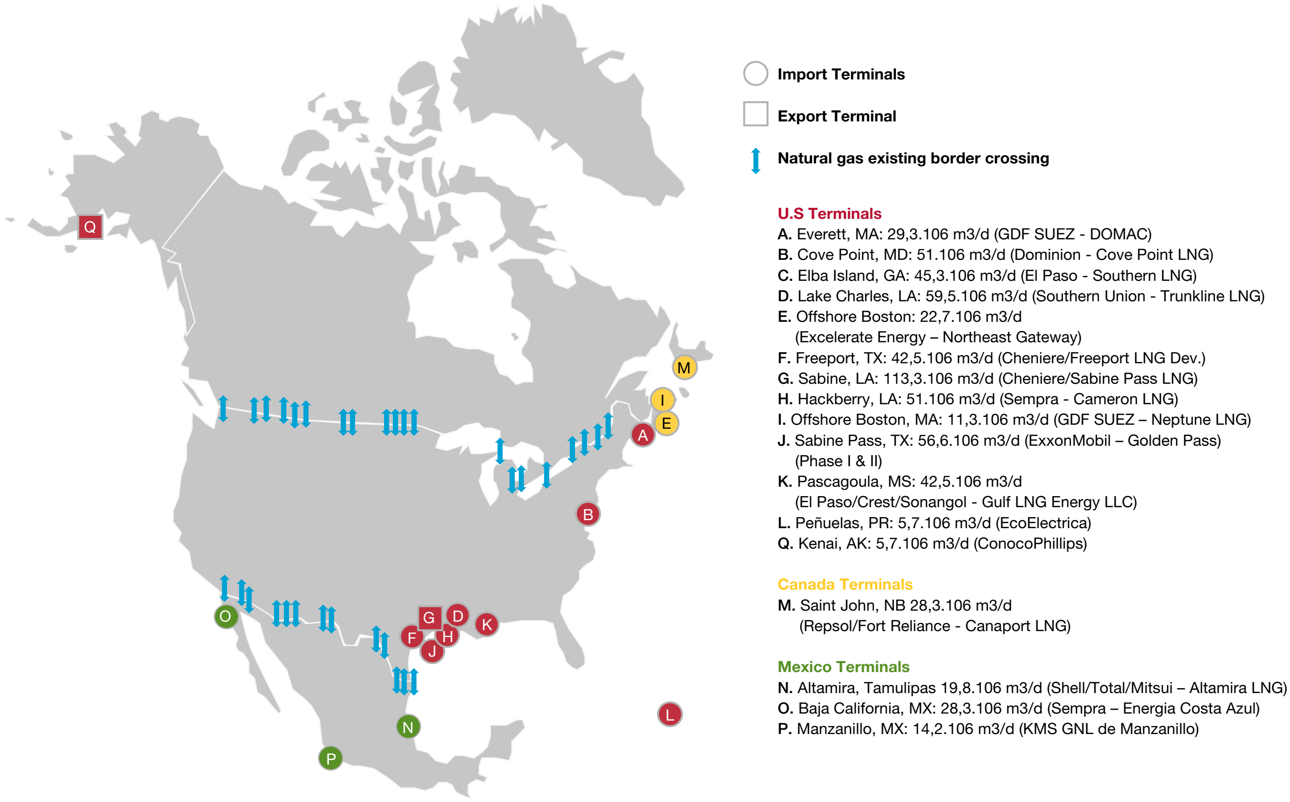
Energy use, including energy derived from fossil fuels, increases but at a slower pace

- The electricity sector is likely to add new wind, solar, hydro, and natural gas-fired generation to accommodate demand growth and replace coal-fired generation
- By 2040, coal-fired generation without carbon capture and storage technology would account for a very small part of Canada's electricity mix

32 https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2016updt/index-eng.html

Gas to play a significant role?

Figure 3.3 : Natural gas – North American cross-border pipelines and LNG terminals, with traded volumes[33]



Sources: FERC, EIA- Capgemini Analysis, WEMO2017

Forecasted gas supply and demand continue to grow

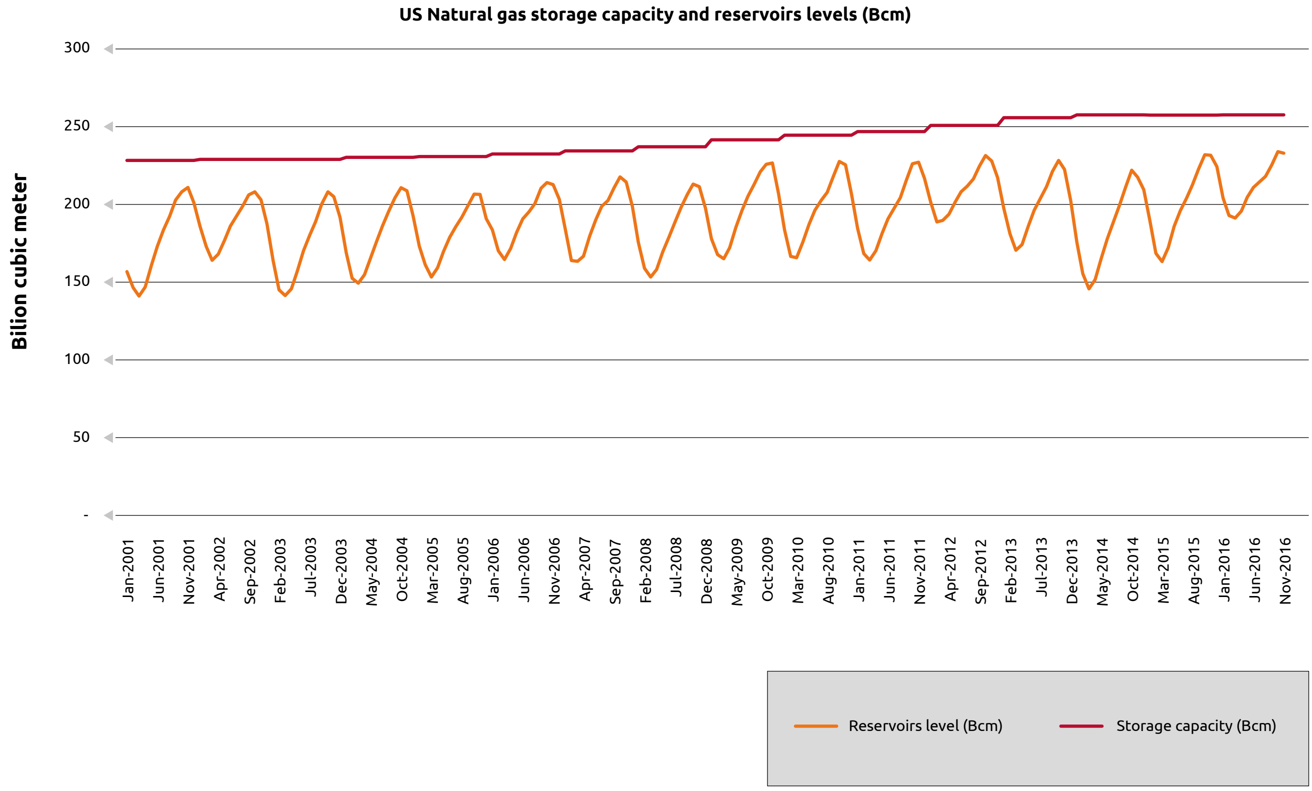
- Marcellus and Utica production continues to grow despite relatively low gas prices
- US natural gas supplies are beginning to displace some Canadian imports, which are expected to gradually decline
- In tandem with increasing supply, strong gas demand is expected
  - Latest EIA estimates have power generation comprising about 8.5 TCF of gas demand (31%) by 2020
  - Industrial gas demand is expected to grow about 2% per year through 2020
  - With the expected completion of five LNG export facilities (including the Sabine Pass terminal which began operations in 2016), approximately 2.9 TCF of demand (11%) (vs. 0.03 TCF or 0.1% in 2015) is expected to be exported as LNG and another 1.83 TCF as dry gas to Mexico, also by 2020 (compared with 1.05 TCF in 2015)
- Canada is expected to build more than 2,000 miles of gas pipelines in 2017 and beyond, with most large projects focused on shipping from shale plays in Alberta and British Columbia westward toward proposed LNG liquefaction and export facilities on the Pacific coast
- Fate of new LNG in Canada remains uncertain

The Trump administration has promoted infrastructure as a key policy priority

- Included in its focus are hydrocarbon pipelines, with the Keystone XL and Dakota Access pipelines as test cases for new, growth-oriented policy

33 FERC, EIA, Capgemini Analysis, WEMO2017

Figure 3.4 : US Natural gas storage capacity and reservoirs levels (Bcm)[34]



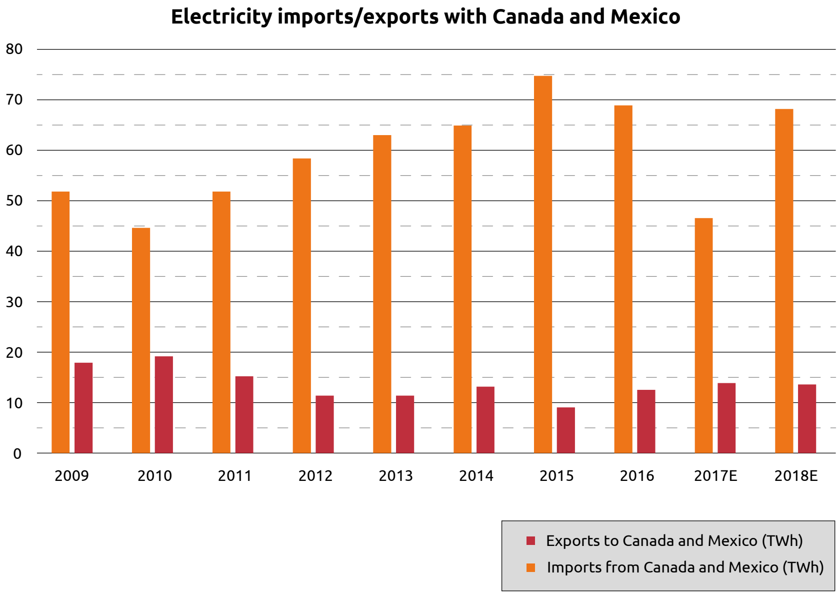
Source: EIA, Capgemini Analysis, WEMO2017

- Local opposition continues to be the most significant impediment to new pipelines, and a few pipelines are facing protest and litigation

It remains unclear whether this opposition, even in pipeline-constrained areas like New England, will stymie development

- For the past three years, underground natural gas storage capacity in the Lower 48 states has changed by relatively small increments compared to the changes in 2012 and 2013[35]
- No new storage facilities have entered service since 2013, so recent annual changes in both storage design capacities and demonstrated maximum working gas volumes reflect the aggregate effect of small changes at existing facilities

Figure 3.5 : Electricity – Major transmission interconnections in North America[36]



Source: EIA - Capgemini Analysis, WEMO2017

- US trade in electric energy with Canada and Mexico is rising, bringing economic and reliability benefits to the US and its trading partners

34 EIA, Capgemini Analysis, WEMO2017
35 https://www.eia.gov/todayinenergy/detail.php?id=30632
36 EIA, Capgemini Analysis, WEMO2017

Grid modernization, backed by Distributed Energy Resource (DER) development gaining traction in US; prominent distribution disruptions evolving

Cases: **California** and **New York** - *Common areas of focus, but different approaches*

- Both states are pressing forward with DER penetration, aimed at grid modernization
- Key factors impacting deployment include:
  - Interconnection and Hosting capacity
  - Planning with Benefit-cost analysis
  - Data sharing and Use of demonstration projects
  - Rate reform and utility incentives, with ISO interface and aggregation

Underlying Themes...
• Interconnection process improvement and hosting-capacity analysis extension
• Scrutinize impact of DERs on the distribution planning process
• Offset traditional utility capital expenditures with DER implementation

Micro Grid development dynamics and distribution disruptions at play

Theme	State of California	State of New York
DER Integration with Grid Transformation	• Strong small-scale RES penetration • > 30 operational microgrid projects • Focus on improved integration • Cost-certainty to DER providers • Facilitate locational valuation	• Urban typology and sensitivity • Multitude interlocking proceedings • Facilitate DER interconnections • Benefit-cost framework based on the Societal Cost Test
Structure of Distribution System	• 5 retailers, accounting for ~75% of sales • 3 investor-owned companies and 2 public providers	• 6 large investor-owned utilities, one large municipal utility, and several smaller utilities
Power issues	• Electricity market mainly liberalized responsible of the major outage in 2001	• Distribution systems designed as either radial or network (in concentrated metropolitan areas) systems
Smart Grid Maturity Level - Triggers and Trends	• Regulatory framework and incentive-driven programs (RE or grids) like California Solar Initiative (CSI), and Low-income Solar PV, targeted at ~50% electricity from RES by 2030 • Leads US in distributed generation with 4,975 MW installed (>630,000 solar projects) and 3.1 GW of storage facilities	• Regulatory framework and incentive-driven programs (RE or grids) like NY-Sun Incentive Program, and NY-REV 'Reforming Energy Vision', targeted at Solar PV and Wind development • Aims at accommodating more than 30,000 plug-in EV by 2018 and 1 million by 2025
Grid Modernization / Smart Grid Initiatives	• Large operational fluctuations that grid operators were not expecting until 2020 due to DES	• Current infrastructure will require US$30 billion of investment over the next 10 years
Micro Grid Penetration	• ~30 microgrid projects implemented	• ~4 operational microgrids
Outlook	• Strong innovation • Energy Storage Mandate (2016) to enhance projects • Urban structure favorable to microgrid development	• Urban structure leads the Smart Grids to be built without the DSO involvement • Socio-economic population willing to endure likely additional cost

Way forward: Industry is optimistic by renewed infrastructure focus; hurdles remain; demand-pull for natural gas continues

Supply expected to be adequate under the likelihood of the two-pronged approach to infrastructure adequacy: 1. Renewed interest in Traditional energy; 2. Additional capacity from Renewable energy

Despite the uncertainty, a smarter energy infrastructure, including modernization of the energy grid and natural gas infrastructure with supporting pipeline development highlight a new precedent for progress – safe and responsible energy progress.

There's new recognition that the US needs dependable transportation of energy from producing areas, including the energy-rich Bakken region, to world-class refining facilities on the Gulf Coast and in Illinois, which make the fuels and other products that support the economy

Energy infrastructure is a critical link in the exploration-production process, and federal policy that acknowledges the need for reasonable, timely project oversight is long overdue in Washington

Rapid growth in natural gas production has spurred historic need for increased infrastructure; connecting to key demand pull markets: US Northeast, US Southeast, US Gulf Coastoverdue in Washington

Topic Box 3: Investment in the US Transmission & Distribution infrastructure to persist

In 2016, DOE launched the Grid Modernization Initiative (GMI), an effort to help shape the future of US's grid with primary funding from DOE and the Office of Energy Efficiency and Renewable Energy. In a strategic partnership called the Grid Modernization Lab Consortium (GMLC), DOE National Laboratories are participating across GMI's technology areas, which bring together leading experts and resources to collaborate on national grid modernization goals. OE's R&D program plays a major role in the Department's Grid Modernization Initiative and significant impacts were noted.

- Cybersecurity for energy delivery systems: Exposed security vulnerabilities for critical control systems, and produced methods and technologies for ensuring the grid operates safely and reliably, from cyber-threats
- Smart grid R&D: Demonstrated technologies that allowed utilities to better view and measure conditions on the grid, communicate critical information to customers, and respond automatically to disturbances to minimize the duration and impact of outages
- Microgrid R&D: Advanced technologies and methods for isolating and reconnecting parts of the grid to ensure that critical loads will be served in the event of a large scale outage
- Energy storage: Developed and demonstrated new energy storage technologies, such as batteries and flywheels that can be used to optimize the grid and provide backup power in emergencies
- Transformer resilience and advanced components: Developed advanced components, such as superconducting wires and power electronic switches that can improve the efficiency and performance of the grid
- Transmission reliability: Developed and demonstrated new technologies to measure and visualize power flows on the grid to improve controls and minimize the risk of large scale outages
- Advanced grid modeling: Leveraged advances in mathematics and computing to improve models and data analytics for grid applications that will enhance operator decision making and minimize the cost of operating the grid.[37]

Transmission lines extension

Rise of renewable energies

- Much of the US electricity generation occurs in centralized power plants; energy is produced in large, remotely located facilities, and distributed to users in population centers via transmission lines
- Since the early 2000s, the generating capacity of renewables has been growing primarily via wind and solar installations
- In 2016, power produced from wind turbines amounted to a 40-fold increase over production in 2000
- Solar PV experienced even greater increases; 2016 generation was nearly 80 times the solar power generation in 2000
- Installed capacity of renewable distributed energy resources (DER) is expected to grow from 109.9 GW in 2015 to 335.8 GW in 2024, representing US$1.9 trillion in cumulative investment over the next 10 years
- DERs have been predicted to grow from US$69 billion in market value in 2012 to nearly US$86 billion in 2017.[38]

Grid modernization and Analytics

The future of the grid is dynamic and ever-changing with the role of telecommunication networks, the customer, and renewables is rapidly overlaying onto the electric grid.

- Together with advanced metering infrastructure, the modernized grid employs cutting-edge advances in Big Data analytics, energy storage, power generation, IoT and M2M communications, and cyber security to deliver a harmonized, distributed energy system that efficiently meets the growing requirement for clean, sustainable, and reliable energy across the service regions.[39]
- In April 2017, Seattle City Light deployed Landis+Gyr's Advanced Grid Analytics (AGA) platform to support the utility's grid modernization program
- Landis+Gyr's advanced grid analytics suite provides a big data platform with proven applications that utilize data from advanced meters, grid sensors, GIS and other sources to provide actionable information that supports daily operations and intelligent planning
- GE has updated Predix to optimize utilities, and enable smarter energy trading. A new layer in GE's Predix platform will focus on utility optimization and connecting data from the Internet of Things and operations to traders. Business Optimization' Software puts Real-Time Generating Capacity and Grid Availability Information at traders' disposal to enhance financial decision making[40]

---

37 https://energy.gov/sites/prod/files/2017/04/f34/OE%20R%26D%20Fact%20Sheet%202017.pdf
38 https://buildingenergy.cx-associates.com/renewable-energy-generation-in-the-united-states
39 http://www.grid-modernization-forum.com/2nd%20Grid%20Modernization%20Forum%202017%20-%20Brochure.pdf
40 http://www.genewsroom.com/press-releases/new-ge-predix-software-power-producers-and-utilities-breaks-down-barriers-between

- C3 has been building on big data integration and analytics engine, hosted in the cloud that can aggregate and put to use. The modules include grid-centric tasks, such as voltage optimization, asset management, fault detection and outage restoration, and integrating solar panels and batteries, to customer-centric systems like demand response, revenue protection, load forecasting and customer segmenting and targeting.

Surge in Energy Storage deployment[41]

Energy storage deployment surge 591% in the US to support renewable energy growth and stabilize the grid.

- 71 MW of energy storage were deployed in Q1 2017, growing 276% over Q1 2016
- 233.7 MWh of energy storage were deployed in Q1 2017, an increase of 944% over Q1 2016
- Front-of-the-meter deployments grew 591% from Q1 2016 in MWs, boosted by a few large projects in Arizona, California and Hawaii
- ~91% of all deployments can be attributed to front-of-meter energy storage
- Therefore, there is room to grow the behind-the-meter market
- Behind-the-meter deployments dropped 32% year-over-year in MWs, much of which can be attributed to declines in California's behind-the-meter market as players awaited the opening of the new Self-Generation Incentive Program regime
- By 2022, the US energy storage market is expected to be worth $3.2 billion, a tenfold increase from 2016 and a fivefold increase from this year
- Cumulative 2017-2022 storage market revenues will be $11 billion

Smart metering roll-out progress

Smart meter deployments, which are on the rise in states like Massachusetts and Illinois where they're being mandated, as well as with a variety of investor-owned, municipal and electric cooperative utilities that see the value in new age technology are being held to different standards than the deployments of a decade ago.

- Few states have implemented the alternative economic models of America's Power Plan, such as, Illinois imposed performance metrics on ComEd and Ameren's smart meter deployments
- However, they are not well designed to optimize utility incentive, with relatively easy tasks to complete and no opportunity for the utilities to earn more if they outperform
- The shared savings concept has been applied to a handful of specific utility projects in the United States, but not as a broad new framework to replace the rate case.[42]
- Smart meter deployments breached 70 million units in 2016, up 9% from 2015
- Total smart meter penetration remains low compared to other nations, at only 44%, but a number of large utilities have plans to ramp up installations
- For example, in New York, where smart meters have largely been ignored to date, utilities are now planning widespread installations in order to achieve the goals of the Reforming the Energy Vision process

Smart cities roll-out progress

A survey called US City Decision Maker Survey - a collaborative project by IHS Markit and the US Conference of Mayors, found that Smart city development in the United States is not limited to large cities, but many small and mid-sized US cities are implementing and planning smart city projects.

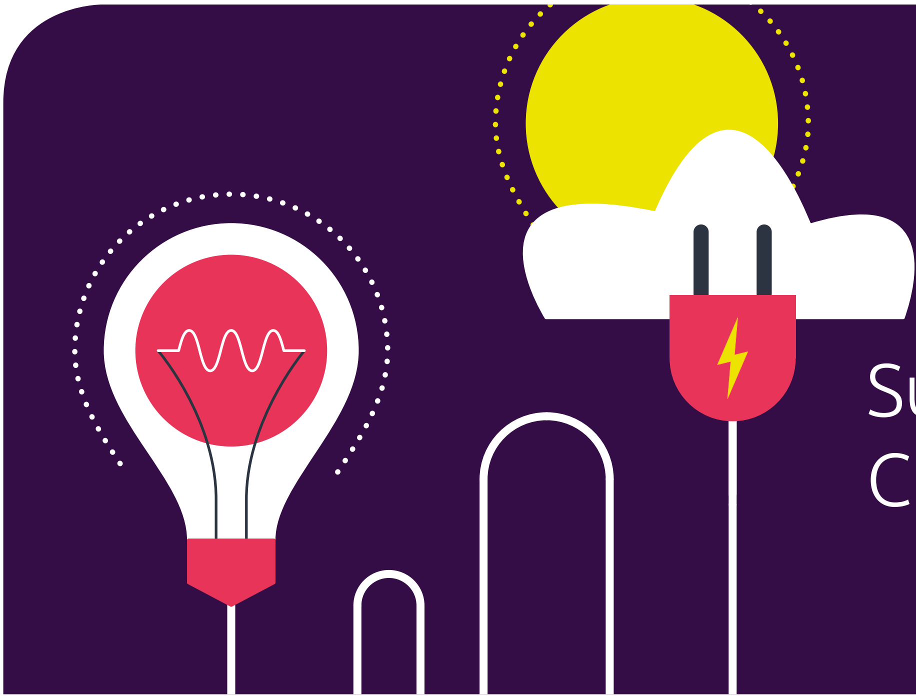
- More than US$35 million in new grants and US$10 million in proposed investments to build a research infrastructure for smart city development by the National Science Foundation and National Institute of Standards and Technology
- Almost US$70 million in new spending and more than US$45 million in proposed investments to develop new smart city solutions by the Department of Homeland Security, Department of Transportation, Department of Energy, Department of Commerce, and the Environmental Protection Agency
- Although the US smart cities market is at an early stage, it is poised to grow quickly as many cities are currently planning and implementing projects.[43]

> President Trump's executive orders clearing the way to restart the Keystone XL and Dakota Access represent great opportunity for US jobs, consumer benefits, economic growth and strengthened energy security.

> This indicates that long-needed energy infrastructure will once again be able to advance in the US, under regular-order reviews and approval processes…affirmative stance indeed!

North America

41 https://electrek.co/2017/06/06/energy-storage-deployment-surge/
42 http://breakingenergy.com/2017/02/27/a-step-by-step-plan-for-grid-modernization-in-a-distributed-energy-world/
43 https://www.usmayors.org/wp-content/uploads/2017/02/2016SmartCitiesSurvey.pdf



Supply and Final Customer

Displacement of electricity generation from more costly sources, and the ability to capture the benefits of technological change, is the motivating factor for harnessing more efficient provisioning of energy in the electric industry

- **Competition has expanded the universe of market products, technologies, fuels, and end-use energy management options**
- **Advances in a discipline that benefits the most efficient and lowest-cost alternatives while efficiently signaling the appropriate exit of less efficient, more costly generation**
- **The underlying transition is delivering benefits for consumers**

Older resources are being replaced with newer natural gas and renewable resources, and in combination with the declining price of natural gas, the costs to generate electricity and meet customer demand has fallen sharply over the last decade

- **The impact of the changing resource mix and reduced cost of fuel for electricity generation has reduced consumers' costs for electricity generation by roughly half in just ten years[44]**

However, the uncertainty that looms in terms of Federal policies puts forth questions on the sustainability of the price decline observed recently

Drop in consumers income spending on energy; smallest share ever recorded in the US[45]	
What...	**How...**
• Consumers spent less than 4% of their total annual household spending on energy in 2016 • Retail electricity prices down 2.2% in 2016 in real terms over 2015 • Retail natural gas prices continued to fall, as prices for commercial consumers sunk to their lowest levels since 1977, in real terms • Costs for wind and solar have fallen	• Falling costs for gasoline, natural gas, and electricity, along with energy efficiency • Low natural gas prices have increased the competitiveness of natural gas-fired power plants with traditional coal-fired power plants • Utility-scale photovoltaic CapEx down from US$2.65 million/MW in 2011 to ~US$1.14 million/MW in 2016

44 https://info.aee.net/hubfs/PDF/AG-Markets-Reliability-Final-June-2017.pdf?t=1498602251147

45 https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf

Energy productivity endures with lesser energy requirements; energy efficiency efforts have conferred with a further decoupled and sustainable energy economy, driven by low cost alternatives

- In 2016, energy productivity improved by 1.8%, as real GDP grew 1.6% while energy consumption decreased by 0.2%[46]
- 2016 marked further decoupling of economic growth from energy demand ~ GDP up 12% vis-à-vis overall energy consumption down 3.6%[47]
- Energy Efficiency Resource Standards (EERS)[48] and decoupling are driving utility spending on energy efficiency, which makes up the bulk of formal energy efficiency spending in the US
  - New Hampshire was the only state to introduce a new electricity EERS in 2016, followed by a natural gas EERS
  - Illinois raised the efficiency target of its largest utility, Commonwealth Edison
  - Vermont's scheme is in the implementation process
  - Ohio removed its EERS freeze, effective 2017
- Unlike in 2014 and 2015, there were no states to turn their back on EERS targets in 2016
- The uptake of EERS has slowed in the past few years, but there is currently no momentum for its reversal either
  - Utilities spent $6.3 billion on energy efficiency programs in 2015; overall spending has nearly tripled since 2007, when utilities spent $2.2 billion[49]
  - Natural gas utilities invested an estimated $1.4 billion in 2015, a 350% increase over 2007 levels[50]

In the light of recent developments, it is being observed that the US nuclear comeback is facing bottlenecks amid two reactors having been abandoned[51]

Projects once expected to showcase advanced nuclear technology are being plagued by delays and cost overruns.

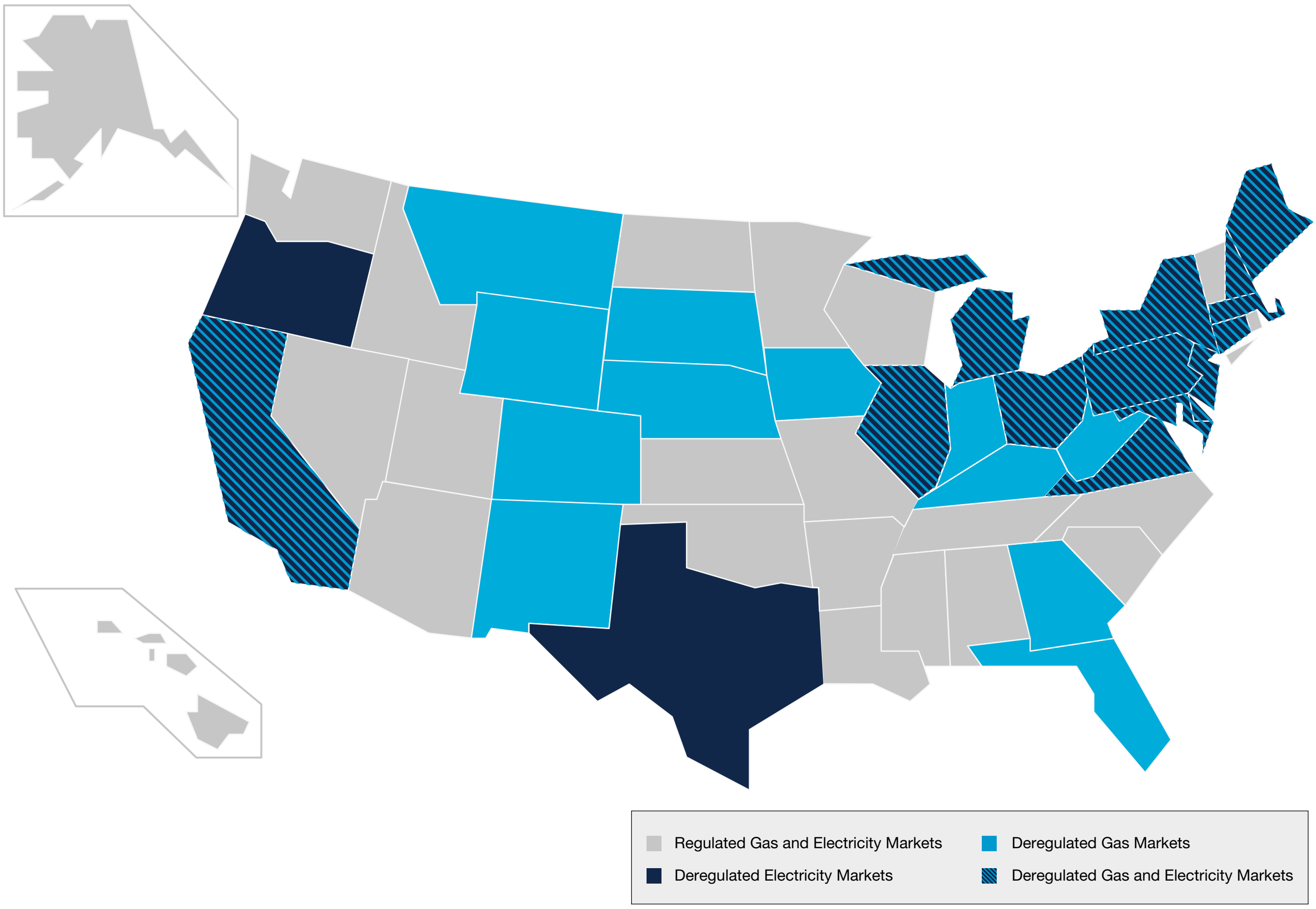
- Scheduled to come online by 2018, the cancelled V.C. Summer nuclear project in South Carolina had been plagued by disputes with regulators and numerous construction problems
- There are just two new nuclear units being built in the country, both in Georgia, while more than a dozen older nuclear plants are being retired in the face of low natural gas prices
  - The reactors will have to come online before 2021 to qualify for federal tax credits, although Congress is working on a bill to extend that deadline

Utilities have been struggling with an energy landscape that has changed dramatically since the large reactors were proposed in 2007.

- Demand for electricity has plateaued nationwide as a result of major improvements in energy efficiency, weakening the case for massive new power plants
- A glut of cheap natural gas from the hydraulic fracturing boom has given states a low-cost energy alternative
- New nuclear may still await the start-up of new units under construction as financeability remains an issue
- Limited financial support from DOE, given conflicting strategic intentions for the agency

46 https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf
47 https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf
48 An Energy Efficiency Resource Standard (EERS) is a policy requiring electricity and/or natural gas utilities to achieve specified levels of customer energy savings. Typically, EERS objectives are percentage savings of electricity or natural gas sales as compared to a business-as-usual case.
49 https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf
50 https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf
51 https://www.nytimes.com/2017/07/31/climate/nuclear-power-project-canceled-in-south-carolina.html?mcubz=0

Figure 4.1 : US Gas and Electricity Market Deregulation[52]



Source: Electric Choice

Complete deregulation absent in any of the states in the US; closest to deregulation being Texas with approximately 85% of the state having access to energy choice

Case: Texas[53]

- The Electric Reliability Council of Texas (ERCOT) coordinates the movement of electricity for 90% of the state's electric load
- The state has had retail customer choice since 2002 and a nodal market since 2010
- Prices are expected to rise moderately, but remain below 2014 levels
  - Key driver being increased demand, spurred by population shifts from the Northeast to the Sunbelt, a high household formation rate in Texas, and expanding commercial and industrial sectors
- **Power to Choose** is a program run by the Public Utility Commission of Texas, with the aim to protect residents from unfair energy costs and unregulated Retail Electric Providers (REPs), as well as develop a strong infrastructure

Other Cases[54]

- **Connecticut:**
  - In 1999, the state of **Connecticut** started deregulating public utilities, in order to stop utilities from handling the entire business process from electricity generation to delivery
  - The movement eventually opened up the market to allow different companies to supply energy to consumers

52 https://www.electricchoice.com/map-deregulated-energy-markets/
53 https://www.electricchoice.com/map-deregulated-energy-markets/
54 https://www.electricchoice.com/map-deregulated-energy-markets/

- **Energy Conscious Blueprint** is an Energize Connecticut initiative that provides financial support to help people better understand their energy options when it comes to buildings within the state
- **Delaware:**
  - Starting in 1999, Delaware Legislature passed a bill requiring the state to begin restructuring its energy services
  - Funded by the US Department of Energy, Delaware's **State Energy Program** is one of the primary sources for promoting energy efficiency, encouraging the use of renewable energy, energy security and protection to environment
- **Illinois:**
  - The Illinois Commerce Commission approved energy deregulation in 1997
  - Consumers can switch to a different energy supplier at any time, without any disruption in service
  - Approximately 75% of the state is eligible for Natural Gas Choice
  - **The Illinois Clean Jobs Coalition** is an organization that is made up of businesses concerned with the state of the environment
- **Wyoming:**
  - **Wyoming Choice Gas** program allows consumers to select or switch their supplier during a specific defined period through Source Gas Utility
- **New Hampshire:**
  - New Hampshire does not offer Natural Gas Choice to residential customers at this time
- **Nevada:**
  - Nevada is currently campaigning to adopt energy deregulation

Since 2005, US average retail prices have risen only 1.4% in real terms; Prices are down 7% from their 2008 peak

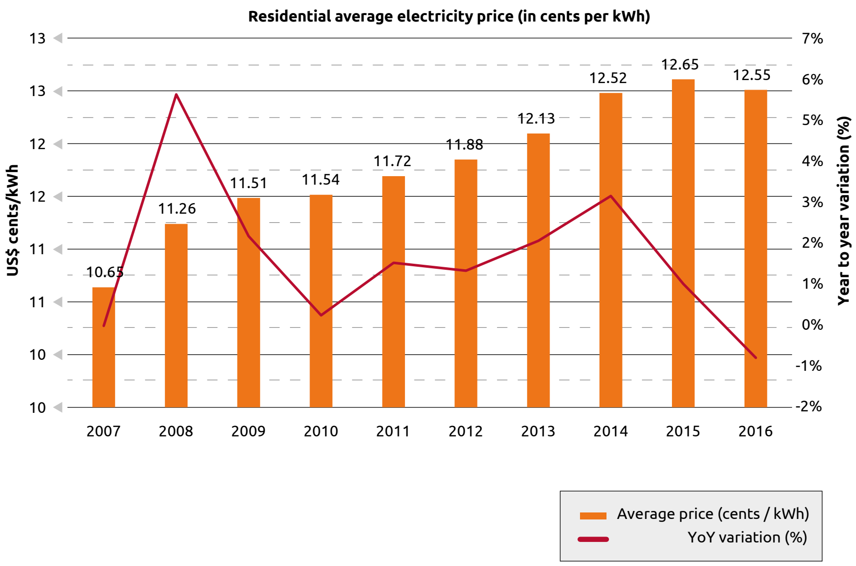
- Wholesale power prices continued their descent in 2016, as natural gas prices touched an 18-year low in March 2017 and further more zero-marginal cost renewables bid into the market
- Year-on-year, around-the-clock prices dropped by as much as 29% in New England (ISONE), 23% in New York (NYISO) and 18% in PJM in real terms
- In the Midwest (MISO), prices held relatively flat, falling 0.2% year-on-year
- The declines in 2016 followed roughly 30% slides in 2015 for most regions[55]
- Retail prices also declined, at an average clip of 2.2% across the country
- Regionally, the falloff in retail prices was most visible in New York and Texas (ERCOT), which saw decreases of 5.6% and 6.2%, respectively
- Retail prices are typically less responsive to changes in the fuel mix or in fuel prices, because wholesale power costs make up only a portion of retail bills

55 https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf

Consumers are dedicating less of their household spending to energy than at any other time on record: energy consumption as a share of total consumption expenditures averaged 3.9% in 2016, the first year in which this measure came in below 4% since the Bureau of Economic Analysis began reporting data in 1959.

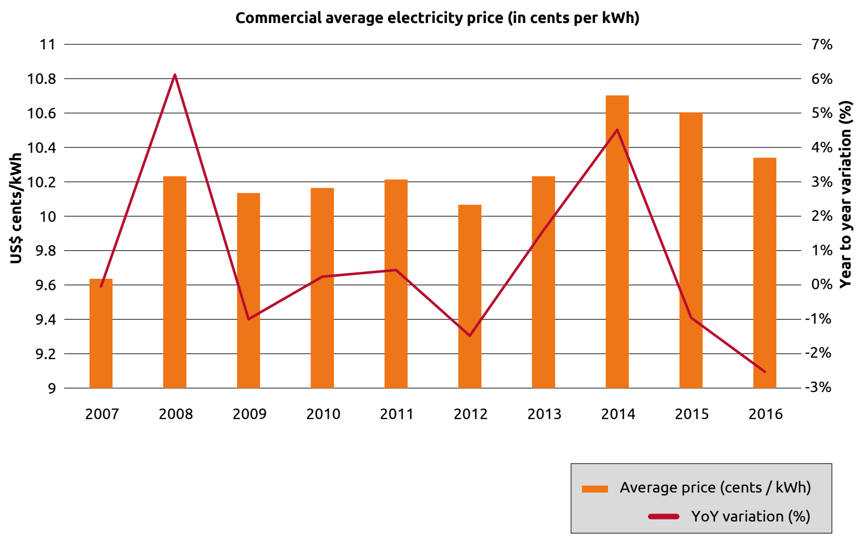
- Consumption costs for natural gas and electricity reflect a similar trend: natural gas represented under 0.4% of total spending, and electricity came in at 1.4%, both the lowest totals on record
- The falloff spending is likely a result of falling fuel costs as well as energy efficiency measures

Figure 4.2 : Residential average electricity price (in cents per kWh)[56]



Source: EIA, Capgemini Analysis, WEMO2017

Figure 4.3 : Commercial average electricity price (in cents per kWh)[57]

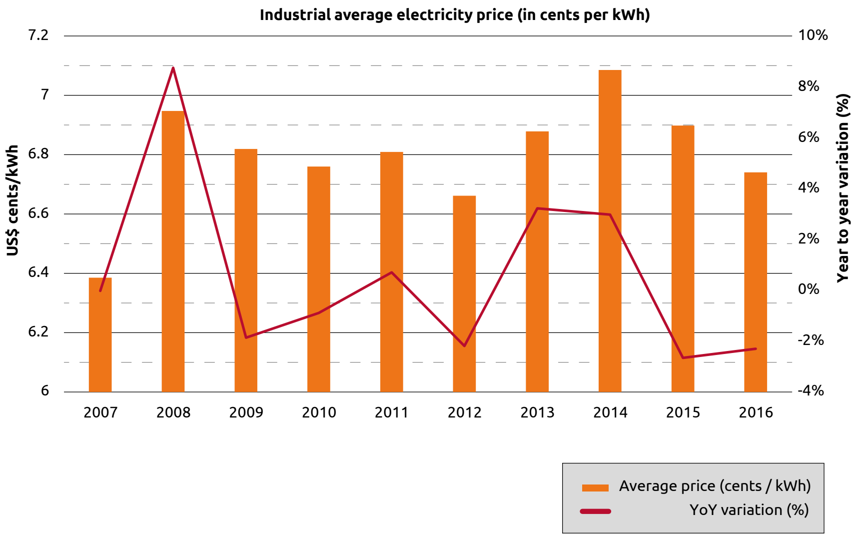


Source: EIA, Capgemini Analysis, WEMO2017

56 https://www.eia.gov/electricity/data.cfm#sales

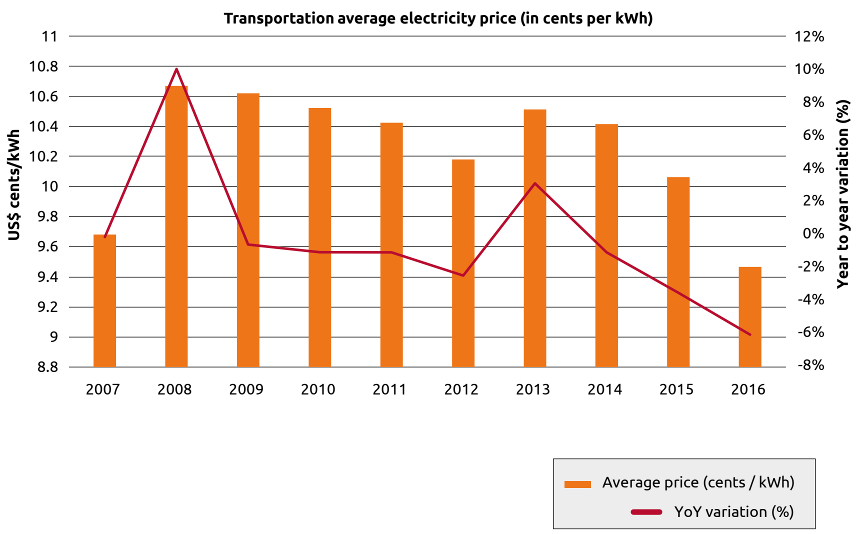
57 https://www.eia.gov/electricity/data.cfm#sales

Figure 4.4 : Industrial average electricity price (in cents per kWh)[58]



Source: EIA, Capgemini Analysis, WEMO2017

Figure 4.5 : Transportation average electricity price (in cents per kWh)[59]



Source: EIA, Capgemini Analysis, WEMO2017

Electricity prices are usually highest for residential and commercial consumers because it costs more to distribute electricity to them. Industrial consumers use more electricity and can receive it at higher voltages, so supplying electricity to these customers is more efficient and less expensive. The price of power to industrial customers is generally close to the wholesale price of electricity.

In 2016, the annual average price of electricity in the US was 10.28 cents per kWh. The annual average prices by major types of utility customers were:

- Residential: 12.55 cents per kWh
- Commercial: 10.37 cents per kWh
- Industrial: 6.75 cents per kWh
- Transportation: 9.48 cents per kWh

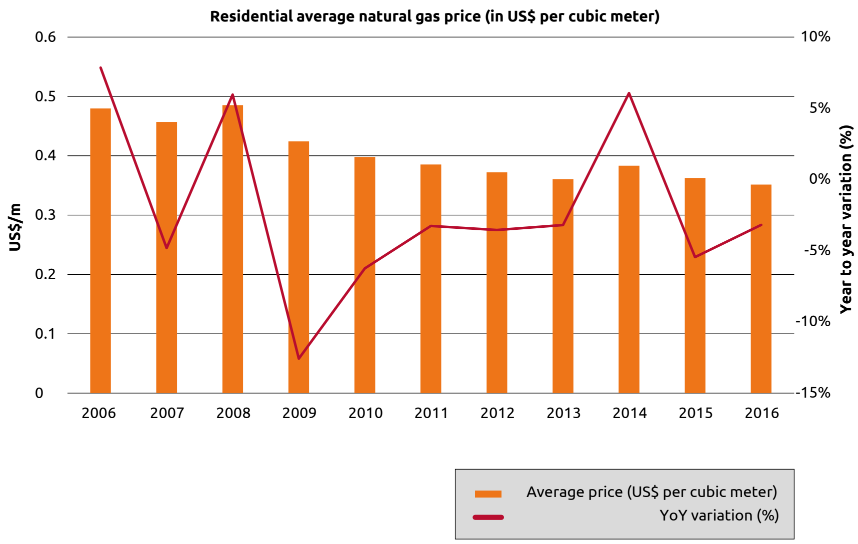
Prices vary by locality because of the availability of power plants and fuels, local fuel costs, and pricing regulations. In 2016, annual average electricity prices ranged from approximately 23.87 cents per kWh in Hawaii to about 7.41 cents per kWh in Louisiana[60]

58 https://www.eia.gov/electricity/data.cfm#sales
59 https://www.eia.gov/electricity/data.cfm#sales
60 https://www.eia.gov/energyexplained/index.cfm?page=electricity_factors_affecting_prices

Power has served as the swing demand source for Natural Gas: when the price of gas falls below that of coal, gas burn rises until the differential (in US$/MWh) between the two fuels closes

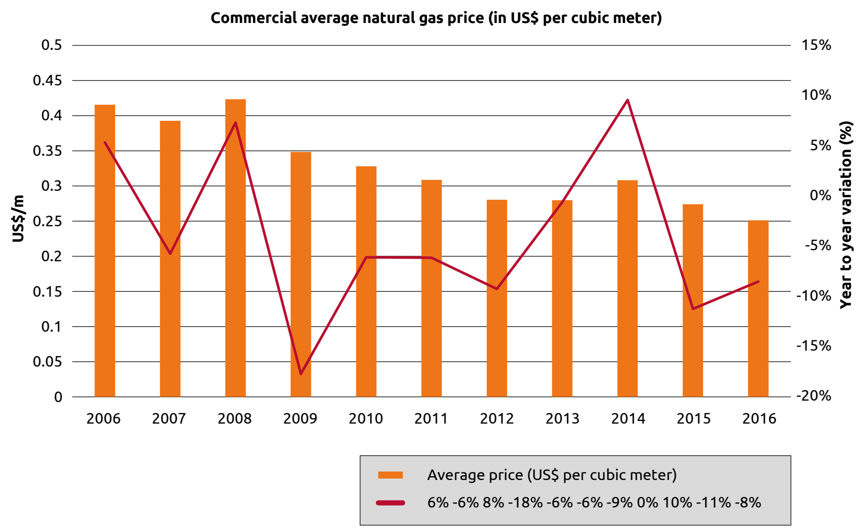
- As gas becomes consistently cheaper than coal, it creates a strong impetus for coal-to-gas switching
- The US observed this switching in 2012 and again throughout 2015 and 2016, when gas-fired power plants, on average, were cheaper to run than coal-fired units
- At the end of 2016, a rally in gas prices due to higher demand made coal-fired power plants once again competitive
- Power burn in PJM has the greatest sensitivity to gas prices and also faces lower gas prices than Henry Hub (which is shown above)
- The coal-to-gas switch potential is, therefore, the strongest in this region

Figure 4.6 : Residential average natural gas price (in US$ per cubic meter)[61]



Source: EIA, Capgemini Analysis, WEMO2017

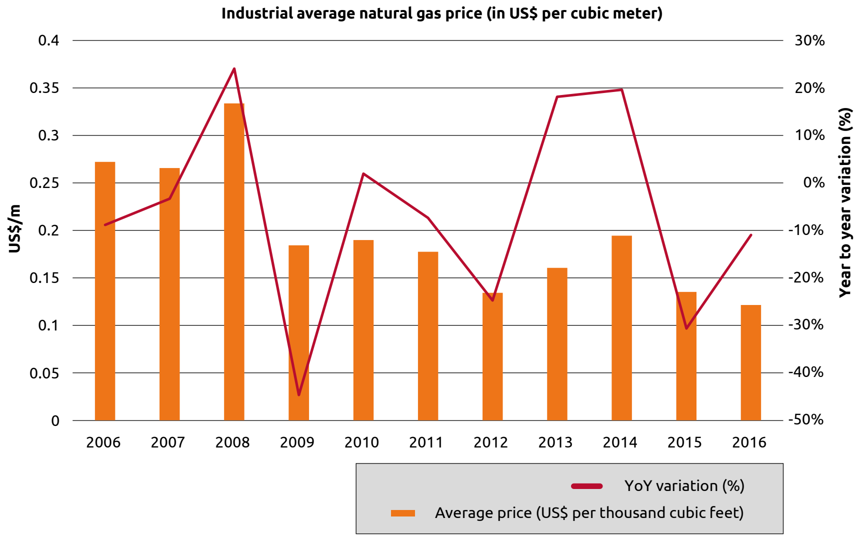
Figure 4.7 : Commercial average natural gas price (in US$ per cubic meter)[62]



Source: EIA, Capgemini Analysis, WEMO2017

61 http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm
62 http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm

Figure 4.8 : Industrial average natural gas price (in US$ per cubic meter)[63]



Source: EIA, Capgemini Analysis, WEMO2017

US LNG from Sabine Pass is currently competitive when compared to destination market prices. The short-run landed price of US LNG includes purchases of gas and shipping costs. The fixed liquefaction fee of US$2.25/MMBtu is considered a sunk cost and therefore irrelevant to marginal cost decisions.

Increasing reserves, higher well productivity indicates growing gas supplies in North America; Onshore Gas Rig Productivity in Shale Plays is improving remarkably; Shale Gas is outstripping some long-standing supply sources, pushing natural gas on its continued low-price trajectory

- Companies, regulators, and customers are torn between price stability and lowest possible prices
- The volatility and variability in regional natural gas prices leads to customized approaches to risk management

Selected regulatory activity regarding Hedging Programs with differing outcomes

State	Policy/Plan
Alberta	Government Ceiling Rate: Regulated electricity rates have experienced volatility – the Alberta government is taking steps to prevent high price spikes
Florida	Florida PSC Staff believes that continuing fuel price hedging activities in an economically efficient manner is in the consumers' best interest
Louisiana	Five-Year Price Stability
Washington	"Risk-Based" Hedging

63 http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm

Topic Box 4: Key challenges facing electricity market

At the midpoint of 2017, a number of critical developments affecting the energy sector have made headlines, most recently President Trump's announcement to withdraw US from the Paris Agreement. While President Trump has repeatedly indicated that he plans to lend his support to the fossil fuels sector, interest remains high in the US and elsewhere in renewable resources and pursuing cleaner energy. What this suggests is that, regardless of the potential political developments in the near term, the power industry will likely continue to transition to alternative energy sources and away from coal.

The maintenance of power system reliability is a fundamental necessity for the protection of public safety, health and welfare, as well as to support the nation's economy.

It is not surprising that as the power industry changes due to economic and/or regulatory factors, many in the industry almost reflexively turn their attention to reliability.

- The Federal Power Act (FPA) sets the legal framework for establishing and maintaining power system reliability
- Specifically, the FPA defines reliability and the associated obligations and responsibilities of all power system users and operators, and gives the Federal Energy Regulatory Commission (FERC) the statutory authority to require, oversee and enforce power system reliability
- The focus of FERC, NERC, and system operators or Regional Reliability Organizations (RRO) is on the reliability of the Bulk Power System (BPS), i.e., the interconnected electric transmission network, including all transmission lines, power plants, and control systems connected above the voltage of local distribution systems

While important to electricity users, local distribution system outages are not the main concern of regional entities or the focus of FERC's authority and the obligations of BPS operators, because outages due to BPS failures differ from local outages in fundamental ways: in how they can arise; in the geographic scope of power interruptions (e.g., spanning states as opposed to neighborhoods); in their ability to affect multiple utility systems rather than just one; in the process and timing of power restoration; in the magnitude of adverse consequences; and in terms of the parties responsible to fix the problems.

Key Challenges:[65]

1. Crucial link between power prices and natural gas

- As the US continues to move from coal to natural gas and renewable energy resources for power generation, wholesale electricity prices is likely to be affected
- Parts of the country are beginning to produce more renewable energy, such as with wind plants in the Midwest and solar generation in the West
- However, natural gas is rapidly becoming the primary driver in the market, serving as the single leading generation input
- Both commercial and residential end users have enjoyed lower electricity prices recently
- However, both power and natural gas prices may increase this year and next, influenced by exports of natural gas and higher domestic consumption

2. Transmission congestion issues

- The increase in the overall power production from renewable energy mixing with traditional resources may pose a challenge as grid operators continue striving to avoid congestion
- The US power grid is designed for generally predictable amounts of energy, and it has become accustomed to the relative stability that coal, natural gas, and nuclear power tend to provide
- However, even as natural gas production is expected to grow over the next several years and increase generation overall, renewable energies, such as wind

65 http://foresternetwork.com/distributed-energy-magazine/guest-commentary-distributed-energy-magazine/three-key-challenges-for-todays-electricity-market/

and solar, are also playing larger roles in the power market

- When transmission lines with a regular stream of energy from gas and coal meet with an influx from wind and solar, they run the risk of becoming overwhelmed
- To avoid this scenario, operators must work even smarter than they already do to match supply and demand and avoid congestion-driven outages

3. Managing supply and grid stability

- Achieving grid stability in the future is likely to require a transition from human-based data management to advanced information technology systems, i.e., a Smart Grid that can cope more readily with the variability of wind and solar

Flat demand for electricity, low natural gas prices and the addition of highly efficient new gas-fired resources are primarily responsible for altering the profitability of many older, merchant generating assets in the parts of the country with wholesale competitive markets administered by RTOs, resulting in retirements. Rapid growth in advanced energy technologies and state policies supporting such technologies -- also contribute to reducing the profitability of less economic assets. The retirement of aging resources is a natural element of efficient and competitive market forces, and where markets are performing well; these retirements mainly represent the efficient exit of uncompetitive assets, and will lead to lower electricity prices for consumers over time.

Regulatory Paradigms

- **Alternative ratemaking approaches:** Encourage consideration of third-party options, reduce frequency of rate cases, and decouple cost considerations from load changes

Evolution of Performance-Based Ratemaking (PBR)
• Gained prevalence in the 1990s as the electric industry was restructuring • Although not uniformly adopted, it provided incentives to improve cost and reliability improvements • Gained criticism on the following grounds: – Irrelevant performance reward – Review process transparency – Threshold effects, i.e., more investment early in the three-to five-year review cycle and slowing costs right before price cap reviews
Mechanisms like decoupling, trackers, and adjustment clauses are being adopted in different jurisdictions, along with testing new PBR frameworks
• Revised metrics include reliability, efficiency, participation/engagement, innovation, and environmental performance • States with strong policy goals for efficiency, renewable, and distributed energy, e.g., CA, MA, and NY, are looking at incentives • For example, New York's proposed Earnings Adjustment Mechanisms encompass four categories: – System efficiency (achieving peak reduction and load factor improvement targets) – Energy efficiency – Customer engagement and information access (availability of tools and opt-in rates and their use) – Interconnection (ease with which third parties can connect to the grid)

Status of selected jurisdictions looking at or employing PBR

State	Status
Missouri	Investigating PBR[64]
Oklahoma	Gas PBR in place
Texas	Not needed at the moment
Massachusetts	Programmatic focus possibly expanding
Hawaii	PBR Legislation proposed
Illinois	Formula Ratemaking

64 Other states investigating PBR include PA, MD, MN, IL, MI, and NH

Market Transitions and Innovation

United States in the midst of an energy revolution…here's how

Transformation of the US energy system and the growing contributions of sustainable energy technologies over the past five years continue to unfold; new technologies reshaping the industry

- Advanced energy represents an opportunity for US to export while also serving the domestic market
- US Advanced energy market grew to US$199.2 billion in 2016, up 1% year-on-year
- At US$68.8 billion, Building Efficiency is the largest advanced energy segment in the US

Prominent innovation in business models amid an evolving consumer and utility/ service provider dynamics indicates an accelerating shift towards Energy Cloud[66]

- Integration of emerging technologies: DER, Building Energy Management Systems, and Virtual Power Plants
- Liberalization of markets with regulation adapting to a shifting electricity generation mix
- Multiple inputs and users, supporting two-way energy flows
- Digitalization of the electric-mechanical infrastructure

2016 marked notable achievements and transitions:

- Additional decoupling of economic growth from energy consumption and productivity improvement
- Renewable deployment accelerated, with record natural gas demand and exports
- Ramped-up investment by utilities to ensure reliability; pledges to de-carbonize and reduce consumption
- Lower energy bills and unprecedented drop in consumer income spending on energy
- 'Lighting-as-a-Service' business model triggered growth opportunity
- Cybersecurity gained significance with advances in digitization of grid
- Energy storage rendered sustenance to virtual power plant growth
- New mobility system growth with Car sharing, Electrification, and Automation convergence
- Electric vehicles gained prominence
- IoT investment focus driving traction to Smart Homes
- Energy efficiency efforts conferred with a further decoupled and sustainable energy economy

66 The emerging energy cloud landscape, a concept that borrows from cloud computing, represents a range of technical, commercial, environmental, and regulatory changes that challenge the traditional hub-and-spoke grid architecture. Fueling this shift are the steady increase in distributed energy resources (DER) capacity and the continuous expansion of smart grid infrastructure. Both trends point to a future grid that will be far more dynamic, responsive, and democratized than current infrastructures allow.

The role of Digitalization underpins a critical success factor in the transition to energy efficiency; technology vendors to the smart grid and smart utility space are seeing market traction for smaller, more concise analytics platforms

However, a looming uncertainty amid the regulatory transition in the US could detriment the potential that the as-is transition holds

Renewable energy would face headwinds and have to rely on imminent cost-competitiveness and state action in the absence of attractive and reliable nation-wide policies in the US

Sustained energy efficiency efforts coupled with lower cost driving energy economy	
What...	**How...**
• Energy productivity improved by 1.8%, as real GDP grew 1.6% while energy consumption decreased by 0.2%	• Energy efficiency measures impacting drop in load growth

Recent gains in fuel economy at risk of being erased, despite low-prices oil	
What...	**How...**
• 2016 electric vehicle sales up 38% • Infrastructure ramp-up to accelerate the roll-out of electric vehicles • However, hybrid electric vehicle (HEV) sales plunge 10%, amid continued pressure from low oil prices • Battery electric vehicles, including the Tesla Models S and X, reported additional 18% in units sold	• Surge in electric vehicle sale driven by plug-in hybrid vehicles, such as the upgraded Chevy Volt and BMW X5 xDrive, with 70% more buyers • Number of public EV charging outlets soared 29% in 2016 to 40,075 • California piloting a new model targeting the main market for consumer EV charging: at home • PG&E to install 7,500 chargers in Northern California alone

2016 has been a monumental year in the energy sector, as the US sustained market transformation in terms of production, delivery and consumption, and grew more energy efficient than ever

Trends driving future transition of Advanced Energy

Big Data adoption

Amid the digitalization of energy, which has offered up the Internet of Things (IoT), connected devices, smart grid, and even autonomous vehicles to consumers, new challenges have arisen, including cybersecurity. Data analytics continues to mature in North America.

- Successful implementations are occurring in intelligent transformer monitoring and management (GridCo), distribution edge power quality management (DVI), and distributed generation optimization (AutoGrid)[67]

Declining hardware cost

Advanced energy technology deployment continues to exhibit dramatic growth rates, enabled in large part by cost declines in hardware such as solar PV modules, LED lighting, and increasingly battery technology – with giga-factories

67 http://www.altenergymag.com/article/2017/02/analytics-and-it-technology-continue-evolution-in-utility-market-highlights-from-distributech-2017/25599

being built around the globe to produce these items at scale.

- The extreme pace of these cost and commensurate price declines has restrained market revenue growth
- In response to increasing market maturity and tight margins, advanced energy companies in many sectors are undergoing a shift to services

Business model innovation

Evolving energy consumer demands and the increasing ability of customers to exercise choice in a variety of ways are also accelerating a shift towards Energy Cloud.

- Customers are increasingly focused on engaging in the generation, purchase, and sale of energy
- If appropriately incentivized, they also can provide other services such as balancing, voltage support, and voluntary load management, address broad industry goals of greater efficiency and resilience
- Growth in "as a service" models touching many aspects of industry, including lighting, analytics, technology applications and storage.

Industries bidding bigger

A number of industries have reached tipping points or otherwise hit major milestones in 2016.

- First offshore wind project in the US reached completion off the East Coast (Rhode Island Lays Foundation for US Offshore Wind)
- With a 1,000% increase in revenue since 2011, the PEV market is now eating into the traditional hybrid electric vehicle market in the US and could surpass it in terms of revenue in 2017
- From the existing need, to the organizational pressures, to the smart city movement, technology continues to converge into a working, practical narrative for water utilities in North America[68]

Future infrastructure: Replacing, Retrofitting, and Digitalization

- The supply and pricing of incumbent fuels and technologies will continue to impact advanced energy market growth in the future.
- Low oil prices affect natural gas vehicle (NGV) sales and infrastructure
- On the other hand, Smart Transmission, Distribution Automation Systems, and Advanced Metering Infrastructure (AMI) Systems are now mainstream, as the digitalization of the electric-mechanical infrastructure moves forward

Big Data drives demand side management innovation

- Behind the data-driven Behavioral demand-side management (DSM) offerings are a variety of technical, policy, and economic factors, including:
- Higher energy savings targets: Utility and state-managed DSM programs in the US have grown rapidly, from US$1.1 billion in spending in 2000 to US$7.7 billion in 2015.
- Cost-effectiveness: As utilities try to get more savings out of their DSM budgets, behavioral and analytical platforms can be a cost-effective addition to traditional programs.
- Customer engagement and satisfaction: Customer surveys have shown that behavioral and analytical DSM services can improve customer satisfaction and engagement.
- Grid modernization: Modernizing the grid needs to involve a holistic structure for smart grid planning, reliability, and payment.

68 http://www.altenergymag.com/article/2017/02/analytics-and-it-technology-continue-evolution-in-utility-market-highlights-from-distributech-2017/25599

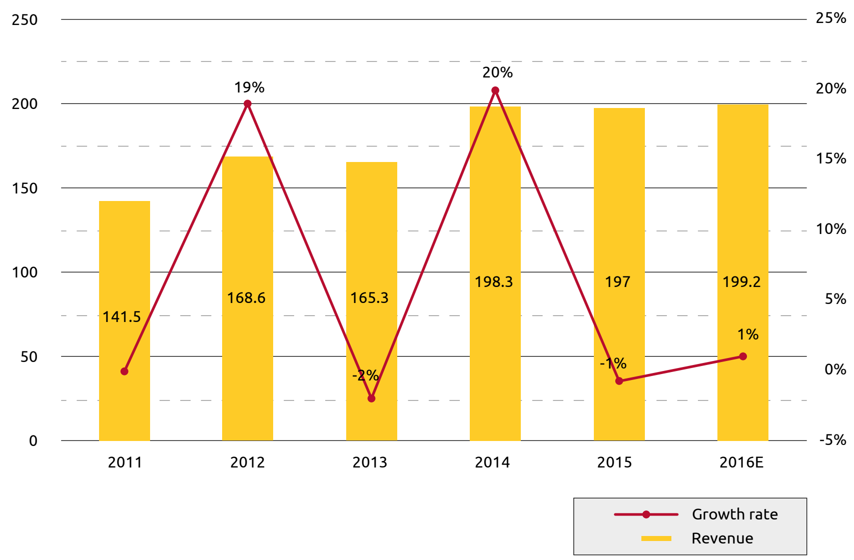
Advances in Baseload Generation retirements; Underlying apprehensions about the prospect of the power generation fleet in the US heighten

- Baseload generation, much of it coal and nuclear, is exiting and is being supplanted by the entry of gas-fired and variable renewable generation

Evolution of Advanced Energy market in US

In 2016, advanced energy represented a global market of US$1.4 trillion with a global growth of 7% from 2015 to 2016 and a US market of US$200 billion.

Figure 5.1: US Advanced Energy Revenue, 2011-2016 (US$ billion)[69]



https://cdn2.hubspot.net/hubfs/211732/PDF/AEN-2017-Market-Report-old.pdf

Continuing economic pressures caused by generation capacity oversupply (fueled in part by public policy), low gas prices, shifting market rules, competing regulatory priorities, and changing technology costs and preferences have brought fundamental questions to the fore about the relationship between markets and states

- In the US, advanced energy witnessed strong growth in power generation and building efficiency technologies, but a big decline in revenue from ethanol, for the second year in a row, resulting in overall growth of 1%
- US Advanced Electricity Generation was up 8% in revenue, or US$3.9 billion
  - Solar PV which capped off five years of growth with a 30% surge, to US$24.9 billion in 2016
  - US Wind revenue held relatively steady at US$14.1 billion, a welcome change from the boom-and-bust pattern from earlier in the decade
- Overall US Building Efficiency products and services grew 8%, or US$5 billion
  - Energy efficient lighting and commercial building retrofits, both up 7% reaching US$26.4 billion and US$8.4 billion, respectively
- In US Transportation, Plug-in Electric Vehicle (PEV) revenue has grown tenfold over five years, from US$700 million in 2011 to US$7.8 billion in 2016, and 48% over 2015, as all-electric alternatives to gasoline-powered

69 https://cdn2.hubspot.net/hubfs/211732/PDF/AEN-2017-Market-Report-old.pdf

vehicles caught on in the marketplace

- Under pressure from low gasoline prices, however, hybrid electric vehicles saw revenue fall for the third straight year, dropping 11% to US$8.9 billion
- If this trend continues, revenue from PEVs may surge past hybrid vehicles in 2017
- Energy storage also had another big year, with revenue jumping 54% to US$427 million in the US[70]

US Advanced Energy market growth fluctuation

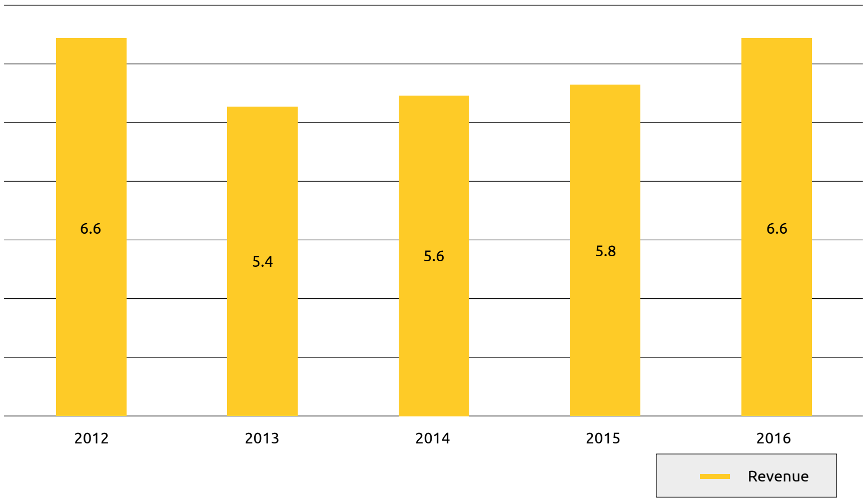
Growth in the US was dampened by a sharp drop in Ethanol revenue driven by low oil, gasoline, and corn feedstock prices. At US$20.5 billion, Ethanol revenue represents 10% of the US advanced energy total, so the drop creates a noticeable impact on the overall market. Without ethanol, US advanced energy grew 5% in 2016.

Smart Grid: Growing demand for cyber security

Nearly US$3 trillion has been invested globally in grid modernization since 2000.

- According to IEA, another US$8 trillion will be required over the next 25 years to accommodate emerging areas like distributed intelligence and data analytics
- These investments will help boost reliability and resilience while reducing operating costs
- Amid the digitalization of energy, offering up the IoT, connected devices, smart grid, and even autonomous vehicles to consumers, new challenges, such as cybersecurity, arise

Figure 5.2: US Smart Grid Revenue, 2012-2016 (US$ billion)[71]



https://cdn2.hubspot.net/hubfs/211732/PDF/AEN-2017-Market-Report-old.pdf

Distributed Energy Resources and Micro Grid march forward

At the 2017 Distributech conference in Southern California, the topics tilted towards managing distributed energy resources.

- This comes into focus in a city like San Diego, where electric vehicle charging and rooftop solar are widely prevalent
- Microgrids continue their march back into the limelight of the greater smart grid movement in North America
- Around for years, but dormant and now resurrected partially from events like Hurricane Sandy, microgrids are again in focus
- This is mainly due to the concepts of distributed energy systems alongside the evolution in energy storage technology

Distributed energy management, utility-scale renewable integration, and microgrids are combining to give new momentum to the smart grid market in North America.[72]

According to SolarVision Consulting, the US market for microgrids will grow from a near zero installation level in 2012 to 50 GW by 2025 and a value of $500 billion by 2030. The growth is attributed to high demand in the rural electrification sector, in the telecoms sector and in public safety, among other sectors

70 https://cdn2.hubspot.net/hubfs/211732/PDF/AEN-2017-Market-Report-old.pdf

71 https://cdn2.hubspot.net/hubfs/211732/PDF/AEN-2017-Market-Report-old.pdf

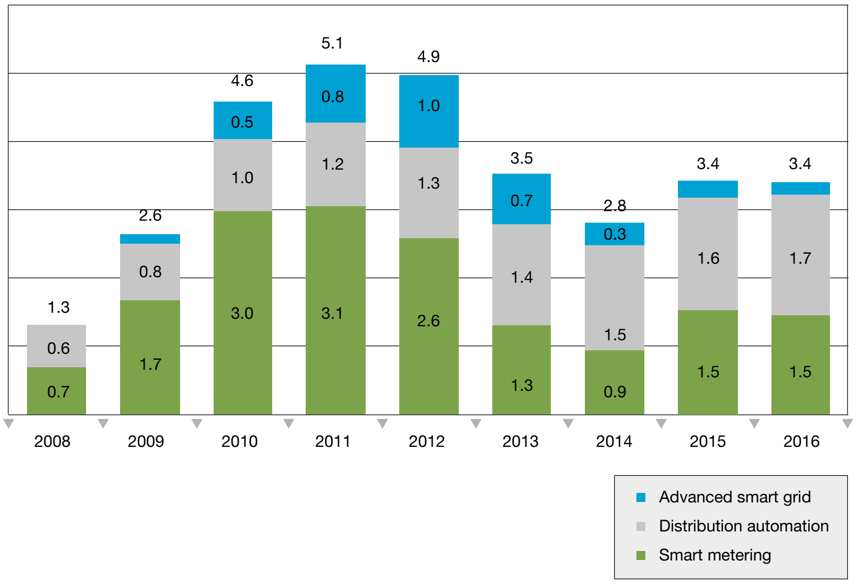
72 http://www.altenergymag.com/article/2017/02/analytics-and-it-technology-continue-evolution-in-utility-market-highlights-from-distributech-2017/25599

requiring high availability.[73]

- Microgrids have a ready economic case built, thanks to the high instance of grid support services that can be provided to local utilities and capital cost avoidance
- As the cost of batteries continues to decline, more previously uneconomic microgrid projects will become financially feasible
- Retrofitting non-renewable energy backup systems, like diesel, will also be a driver for microgrids
- Limits to growth include the perceived one-off design nature of microgrids, along with relatively high capital costs per MW of capacity installed

Streamlined legislation and permitting standards on a state level will be a major boost to microgrids, as it has been to community solar in general. Continued experience in the market with value stacking for microgrids will help accelerate the adoption rate.

Figure 5.3: US Smart Grid Spending by Segment (US$ billion)[74]



https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf

US smart grid investment

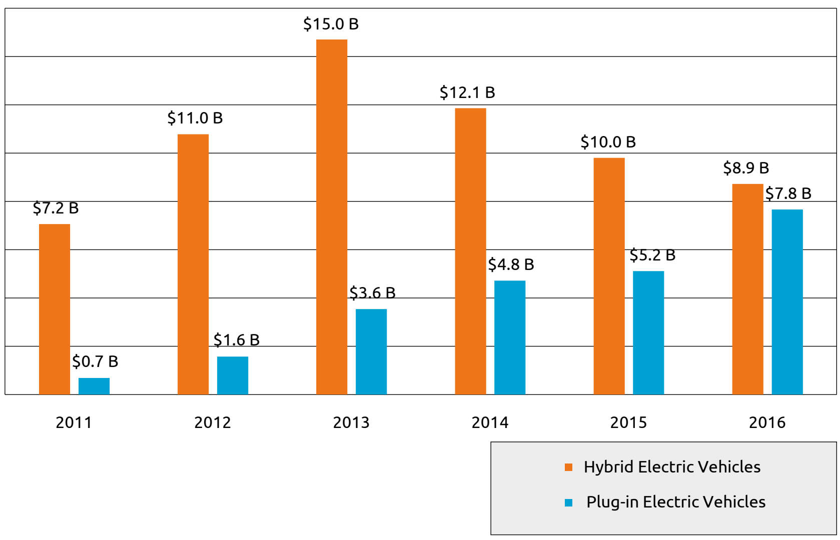
Installation of smart meters accounted for over half of US smart grid investment until 2013, when it dropped off significantly.

Expenditure on smart meters has rebounded from its low in 2014, but remains less than half its 2011 peak.

- Investments represent utility projects within the distribution system to reduce outage frequency and durations and to more efficiently manage electricity flow within the grid
- As the penetration of distributed energy resources increases, some utilities are ramping up investment in automation to manage the growing complexity of the distribution grid[75]

US Hybrid and Plug-in Electric Vehicle Revenue

Figure 5.4: US Hybrid and Plug-in Electric Vehicle Revenue, 2011-2016 (US$ billion)[76]



https://cdn2.hubspot.net/hubfs/211732/PDF/AEN-2017-Market-Report-old.pdf

73 https://pv-magazine-usa.com/2017/02/02/u-s-microgrid-market-headed-to-50-gw-in-2025/
74 https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf
75 https://data.bloomberglp.com/bnef/sites/14/2017/02/BCSE-BNEF-2017-Sustainable-Energy-in-America-Factbook.pdf
76 https://cdn2.hubspot.net/hubfs/211732/PDF/AEN-2017-Market-Report-old.pdf

If revenue from PEV sales continues to grow at the same rate, it will eclipse Hybrids by the end of 2017

- Globally, the most notable shift taking place in Advanced Transportation segment is the rapid growth of PEVs, which reached US$30.8 billion in 2016
- The shift toward PEVs in the US is even more notable than in the global market
- The Hybrid and PEV product categories account for more than three-quarters of the Advanced Transportation segment total

Key federal and state-level policies yielding support to the new energy model (National Energy Modeling System); endorsements to battery EVs sales accelerating

Trends driving EV market sentiment and growth

National Energy Modeling System (NEMS)

- National and state level policies
- Declining Battery costs
- Reduction in incremental electric vehicle costs
- Consumer sentiment regarding range anxiety, recharging availability/time, and Model availability
- Competition from improving incumbent technologies and other alternative propulsion technology

Endorsements to battery EVs

- **Corporate Average Fuel Economy (CAFE)** standard with multipliers for EVs
- **California Zero-Emission Vehicle (ZEV)** Mandate (Governor's 2016 ZEV Action Plan)[77]
  - By 2020, California's ZEV infrastructure will be able to support up to 1 million vehicles
  - Raising consumer awareness and education about ZEVs
  - Ensuring ZEVs are accessible to a broad range of Californians
  - Making ZEV technologies commercially viable in targeted applications the medium-duty, heavy-duty, and freight sectors
  - Aiding ZEV market growth beyond California
  - As on May 2017[78],
    • Nearly 300,000 ZEVs and PHEVs have been sold in California, which contributes toward the more than 600,000 ZEVs and PHEVs in the US
    • Improved Battery technology and costs leading to more than 70 models to be released over the next five model years
    • More than 10,000 Level 2[79] and 1,500 direct current fast charger (DCFC) connectors have been deployed across California
  - Adopted by nine other states

- **California Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP)[80]**
  - Cumulative program allocations for ZEVs as of June 2017[81] include US$80.1 million for EV charging infrastructure
  - To date, ARFVTP funds have provided 38.8% of statewide total public charging sites and 37.9% of charging outlets

- **California AB-32 for GHG Reduction**
  - Further increases electric vehicle share

- **Tax credits**
  - US$2,500 to US$7,500
  - To be phased out post 200,000 vehicles per manufacturer sold
  - Purchase rebates and registration tax exemptions

- **EPA/NHTSA GHG/CAFE** standards allowing CO_2 credits

77 https://www.gov.ca.gov/docs/2016_ZEV_Action_Plan.pdf
78 http://www.energy.ca.gov/renewables/tracking_progress/documents/electric_vehicle.pdf
79 Level 2 chargers use 208/240 volts, up to 19.2 kW (80 amps), whereas Level 1 chargers use 110/120 volts, 1.4 to 1.9 kW (12 to 16 amps)
80 http://www.energy.ca.gov/renewables/tracking_progress/documents/electric_vehicle.pdf
81 http://docketpublic.energy.ca.gov/PublicDocuments/16-ALT- 02/TN216732_20170328T111545_20172018_Investment_Plan_Update_for_the_Alternative_and_Renewab.pdf

State policies promoting battery EV sales[82]

EV Purchase Incentives	EV Use and Ownership Incentives	Waivers on Access Restrictions
• California • Colorado • Connecticut • Delaware • Washington DC • Louisiana • Maryland • Massachusetts • Missouri • New Jersey • Oregon • Pennsylvania • Rhode Island • Texas • Utah	• Connecticut • Hawaii • Massachusetts • Missouri • Nevada • New York • Rhode Island	• California • Colorado • Georgia • Hawaii • Maryland • New York • Utah

At the City-level, policy actions are tailored to unique local conditions[83]

City	EV Use and Adoption	Financial Incentive	Charging Infrastructure
New York, New York	Plug-in sales reached 19,274 by October 2016	• Drive Clean Rebate of ~US$2,000 with federal tax credit	Installation of two public charging stations per 5 boroughs in the city
Denver, Colorado	~ 8,000 cars sold in the state so far ~75% of charging events in Denver occur at home	• State tax credit (HB 1332) of up to US$6,000	Teaming up with Utah and Nevada to develop charging corridor covering 2,000 miles of road
San Diego, California	From 2011 to 2016, California residents purchased 244,963 EVs	• Rebates ranging from US$1,500 to US$5,000 • Average savings for San Diego is US$3,257, with the Nissan and Tesla as the leading cost effective brands	~584 level 2 charging stations, and ~28 level 3 (super charge) stations located within 10 miles of the city
Washington, DC	Among the top 5 cities since electric vehicles hit the market	• Federal tax credit for up to US$7,500 • No additional rebates at the time of purchase	DC-Baltimore area has > 700 charging stations
Seattle, Washington	Plans to enable and support the adoption of 15,000 electric vehicles by the year 2025	• Federal tax credit of US$7,500 • Average savings of US$3,592 • Sales tax exemption on all EV vehicles • City tax rate of 9.5% adds to an extra savings of ~US$6,500 depending on the vehicle model	Currently lacks the EV infrastructure to promote much growth

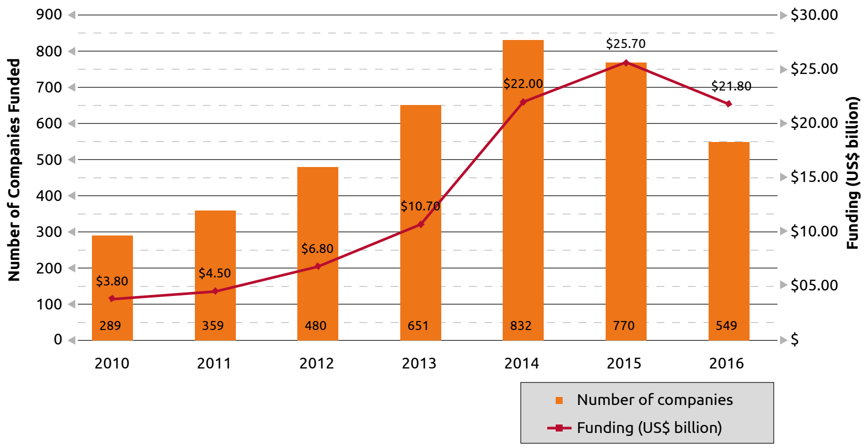
82 https://www.eia.gov/conference/2017/pdf/presentations/melisssa_lynes.pdf
83 http://www.fleetcarma.com/10-best-us-cities-electric-vehicle-2017/

As regional electric grids continue to decarbonize, emission reductions are likely to advance. Electric vehicles offer 30-90% in reduction compared to conventional vehicles, and thus are being tied into local policies, economics, and environmental concerns.

IoT revolution in North America is driving systems, applications, and devices, leading to home automation advances

~2,888 companies (2,748 companies in the US, and 140 companies in Canada) augmenting North America's IoT landscape, have raised US$125 billion in funding, have created US$613 billion in value

Figure 5.5: Number of IoT Companies Funded and Total Funding (2010-2016)[84]



https://www.forbes.com/sites/johnkoetsier/2017/07/10/iot-in-the-usa-3000-companies-125b-in-funding-613b-in-valuation-342000-employees/#58ad1aba3ef5

Figure 5.6: New IoT Entrants (Since 2010)[85]

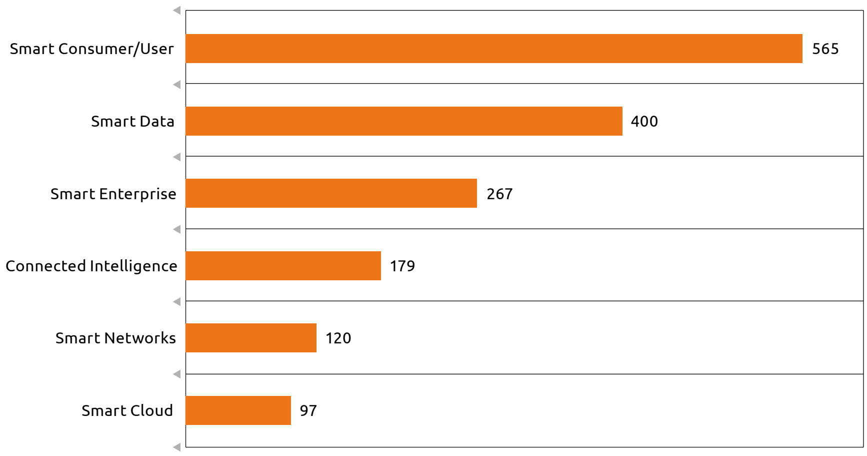
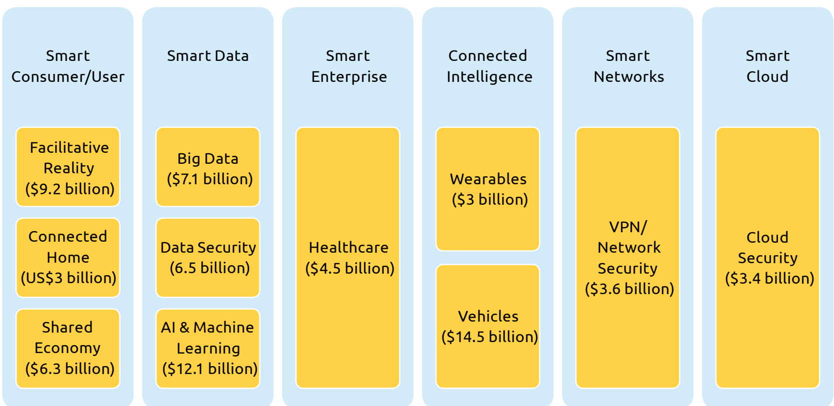


Figure 5.7: IoT Investment Focus[86]



https://www.forbes.com/sites/johnkoetsier/2017/07/10/iot-in-the-usa-3000-companies-125b-in-funding-613b-in-valuation-342000-employees/#58ad1aba3ef5

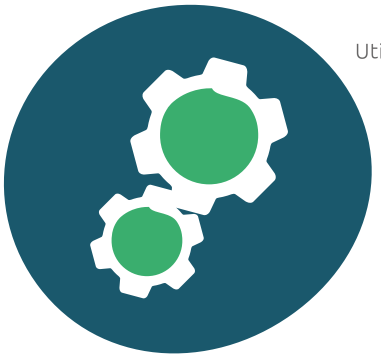
- Almost half of the companies are in California; with no less than 1,345 companies operating
- Key categories:
  1. AI and Machine Learning (401 companies)
  2. **Connected Home (282 companies)**
  3. Healthcare - Enterprise (240 companies)
  4. Facilitative Reality (216 companies)
  5. Data Security (208 companies)
- AI and Machine Learning critical to process and accelerate decision-making on the information created by IoT appliances and sensors
- The Connected Home is the low-hanging fruit of IoT, Consumer IoT, that enables people to monitor and control their home and media

With further IoT integration, Smart Home startups are creating a range of consumer-facing products and services that replace or augment existing home products such as appliances, with the requirement that they be connected to a smart phone or the

84 https://www.forbes.com/sites/johnkoetsier/2017/07/10/iot-in-the-usa-3000-companies-125b-in-funding-613b-in-valuation-342000-employees/#58ad1aba3ef5

85 https://www.forbes.com/sites/johnkoetsier/2017/07/10/iot-in-the-usa-3000-companies-125b-in-funding-613b-in-valuation-342000-employees/#58ad1aba3ef5

86 https://www.forbes.com/sites/johnkoetsier/2017/07/10/iot-in-the-usa-3000-companies-125b-in-funding-613b-in-valuation-342000-employees/#58ad1aba3ef5



internet, or integrate sensors and digital interfaces

The US smart home market still lags expectations; issues that plague the space include,

- Persistently high prices
- Technological fragmentation
- Consumers' lack of a perceived benefit from devices

However, the newfound popularity of Smart Home Voice Control has revolutionized Smart Home ecosystems[87]

- Voice Control gaining importance as a key remote interface within the home
- Introduced by Amazon Echo in 2014, Google, Samsung, and Apple have all integrated voice control into their smart home ecosystems since then
- Prices are still high amid demand slump for smart home devices
- The US Smart Home market is only now entering the mass market phase of consumer adoption

Companies targeting the Energy and Utilities space, like Tado, Rachio, Flo Technologies, Sense Labs, Radiator Labs, Cielowigle, Ecobee, ecoVent Systems, and Heatworks Technologies utilize sensors, monitoring tech, and data to conserve water and energy.[88]

Topic Box 5: Analytics and IT Technology persist as a success factor in the US energy market

Technology vendors to the smart grid and smart utility space are seeing market traction for smaller, more concise analytics platforms

Vendors to the smart utility space are increasing pressure and marketing to their clients for SaaS and managed services

Microgrids continue their comeback in North America

Data analytics continues to mature in North America

- The initial surge of Big Data has subsided as technology vendors more and more understand the sales of actual products need to have an exact and precise business case to meet
- Specialists in very narrow applications (like customer water leak detection for smart water utilities) are seeing slow, steady market growth
- While successful, narrower analytics platforms are seeing market traction, it is still unclear who wins the day for controlling the overarching system and operation platforms for utilities
- While in the water technology space, it appears traditional AMI vendors (Sensus) are winning the battle, vendors are offering mature versions of their meter data management (MDM) solutions more as a platform, while also offering modular analytics solutions for applications like operational leak detection
- The role of data scientists is growing in importance across utilities and the vendors who serve them

Managed Services and SaaS continue to evolve despite impediments

- The vendor pitch is maturing for smart utility technology in North America, however, many barriers remain
- From changing communications technologies to security to lagging industry regulation, technology vendors will have to continue to scratch and claw their way within the utility vertical to get the results they wish for
- The smart utility industry is entering a phase of budding, healthy and pragmatic growth[89]

Digital technology has increasingly been making its way into the power generation, transmission, and distribution sectors, and 2017 could be a year in which its adoption accelerates

These trends should be seen in the context of the ongoing energy transition to a less carbon-intensive global economy

A key uncertainty for the international community is what will happen now regarding the Paris Agreement on climate change

87 http://www.businessinsider.com/the-us-smart-home-market-report-systems-apps-and-devices-leading-to-home-automation-2017-4?IR=T

88 https://www.cbinsights.com/blog/smart-home-market-map-company-list/

89 http://www.altenergymag.com/article/2017/02/analytics-and-it-technology-continue-evolution-in-utility-market-highlights-from-distributech-2017/25599

Financials

Utilities seek to invest capital effectively with a focus on improving earnings, albeit in a challenging environment

- While 2015's financial performance challenges carried over to H1 2016, utilities finished 2016 largely in a stronger position
- Although growing revenue remains a challenge for the utilities sector, income statement measures improved, especially earnings per share (EPS), which had declined in 2015
- Returns improved marginally
- Cash-flow growth was a weak spot for the year, although 2016 performance did exceed expectations
- Cash flow performance is expected to decrease for 2017, which means cost control will continue to be important for utilities
- Total shareholder return was 18%, up significantly from 2015 and outperforming the S&P 1500 broadly

External political and economic conditions are likely to add uncertainty in the utility industry in 2017

- Regulatory costs may decrease as the Trump administration is expected to ditch the Clean Power Plan in support of the coal industry, and the Environmental Protection Agency is expected to reduce the number of environmental regulations
- On the other hand, with record highs in the Dow and expected interest rate hikes this year, investors may choose to move to higher-yield investments, thus reducing demand for utility stocks

Potential Federal Tax Policy reforms could adversely affect the investor-owned regulated utilities sector. The ultimate credit impact of these reforms, however, would depend on state regulatory commissions due to their input into how taxes affect utility rates and customer bills.

Tax Reform - Change Deductions; Expensing Rules; Lower Rates	
Proposals	**Potential Impacts**
• Reduction in corporate tax rate • Expensing of CAPEX • Elimination of interest deduction • Border adjustment for certain goods	• Degradation of rate base • Refunding of portion of accumulated deferred taxes • Adverse cash flow impacts for utilities with high levels of debt (reduction of tax shield) • With lower tax flow-through, potential increased rate headroom for CAPEX • With reduction in tax rates, tax equity investors, key for renewables projects, may demand increased rate of return

Evolving M&A strategies for Utilities as a means to capture efficiencies and increase earnings; Utilities seeking to expand face regulatory complexity while planning and executing deals effectively.

- In April 2017, Texas regulators rejected a bid by Florida utility giant NextEra Energy to acquire Dallas-based Oncor Electric, whose parent company was in bankruptcy. The regulators expressed concern that Oncor's new board would be controlled by an out-of-state entity, which would impair local decision making.[90]
- In May, Kansas regulators turned down the proposed sale of electric utility Westar Energy to Missouri-based electric utility Great Plains Energy, saying they were concerned about the financial leverage of the combined entity and its potential disadvantages for customers.[91]
- In July, Hydro One Ltd. signed a friendly deal to acquire US energy company Avista Corp. for $6.7 billion in an all-cash deal that would create one of the largest regulated utilities in North America. This merger agreement allows for more robust expansion into new lines of business and into new jurisdictions, including the Pacific Northwest, which is experiencing customer growth.[92]
- In August 2017, Sempra Energy said it will buy Oncor for $9.45 billion in cash after Energy Future Holdings Corp, which indirectly owns Oncor, abandoned a deal to sell the power transmission company to Warren Buffett's Berkshire Hathaway Inc.[93]

Recent events indicate that mergers and acquisitions, which have been common in the utilities industry, could face heavier scrutiny going forward. This implies that utilities seeking to gain a competitive edge through M&A will have to convince regulators that the transactions will produce meaningful efficiencies and synergies. Additional pre-requisites now include showcasing how the plans will translate into explicit benefits for ratepayers and improvements to transmission and distribution networks.

Evolution of industry consolidation

During the past two decades, the utilities sector has consolidated broadly. Since 1996, the number of US investor-owned electric and gas utilities has decreased by around 60%, and the median market capitalization in the industry has risen to US$7 billion from $1 billion.[94]

What has been driving this...?

- Utilities seeking to diversify regulatory risk by having operations in multiple states
- Expansion into complementary assets, such as gas pipelines, or new service functions, such as gas distribution or electric generation
- Revenue gains from traditional areas such as power generation and distribution have stalled for most utilities
- As services have accounted for a greater share of economic activity, demand for electricity in the economy has flattened
- Traditional electricity providers are particularly interested in natural gas utilities, driven by the fracking revolution

Evolving strategies as utilities-sector M&A cannot be approached as a one-size-fits-all effort

- Utilities are approaching a deal with sufficient up-front knowledge about what regulators are seeking
- Utilities are increasingly focused on making promises in areas such as maintaining current employment levels (or sometimes even increasing them), protecting local management, providing rate benefits to customers, and making ongoing investments in infrastructure

Returns of global clean energy indices relative to benchmarks

- Global stock markets generally rallied through 2016, following a bearish H2 2015
- While clean energy indices (NEX, S&P Global Clean Energy, and Ardour Global Alternative Energy Index) followed the broader market upward for most of 2016 (S&P 500, Dow Jones and MSCI World & Emerging), recovery was much more gradual
- The bankruptcy of US solar company SunEdison in April 2016 contributed to this slow recovery
- In Q4 2016, clean energy indices plummeted in the wake of the US election results, further widening the gap between the relative performance of these indices against the broader market indices

90 https://www.strategy-business.com/article/A-New-MA-Strategy-for-Utilities?gko=06f28
91 https://www.strategy-business.com/article/A-New-MA-Strategy-for-Utilities?gko=06f28
92 http://business.financialpost.com/commodities/energy/newsalerthydro-one-signs-blockbuster-deal-to-buy-avista-for-c6-7b-in-cash-2
93 https://www.reuters.com/article/us-oncor-m-a-sempra-ener/sempra-energy-to-buy-oncor-for-9-45-billion-in-blow-for-berkshire-idUSKCN1B10J2
94 https://www.strategy-business.com/article/A-New-MA-Strategy-for-Utilities?gko=06f28

Despite the Trump administration's withdrawal from Paris Agreement, US renewable energy capacity is expected to increase substantially during the next eight years, amid state renewable portfolio standards (RPS), and other local policies, which remain the industry's primary growth driver

- Some states continue to strengthen renewable energy standards
- Corporate renewable energy purchases likely to grow
- Low natural gas prices and turbine efficiency improvements forcing coal plant shutdowns and reduced run times for competing coal generators
- Utilities operating in states with constructive regulation and environmental policy support could realize 7%-9% annual earnings and dividend growth the next three to five years
- Utilities like Dominion Energy, Duke Energy, American Electric Power, and CMS Energy that are investing in new infrastructure likely in strong position
- NextEra Energy and Xcel Energy to widen lead as the top US renewable energy companies
- PG&E GHG-free portfolio stood at ~70% in 2016; the company delivered an average of 32.8% of its electricity in 2016 from renewable resources, more than a three-percent increase in just one year[95]

Business model innovation transformations reflect an accelerated transition towards a cleaner, more distributed and intelligent energy system

- Significant changes in the energy landscape likely to continue to transform the utility business model
- Shift from the largely one-way power system relying principally on large centralized generation plants and conventional transmission and distribution (T&D) infrastructure toward a highly networked ecosystem of two-way power flows and digitally enabled intelligent grid architecture

Impact of the shift towards a clean, decentralized and intelligent electricity grid:

Customers	• Utilities continue to focus towards end-use customers and strengthening relationships with transmission system operators, and new third party service providers
Regulation and Policy	• Energy future calls for a strong regulatory and policy framework supporting renewables, emission reduction, distributed energy resources (DERs) and grid digitalization
Technology	• Development of two-way communications, data analytics, demand-side management, DERs, and aggregation
Operations	• Asset management and system optimization being integrated amid IT and operational convergence • Utilities to expand technical and commercial capabilities
Business Models	• Utilities to evolve towards a distributed system platform business model • Enable decentralized energy system • Expansion of "as a service" offerings

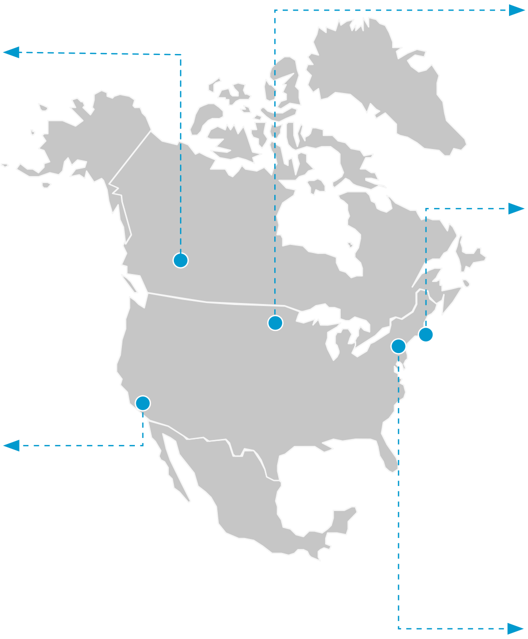
As the transformation progresses, new revenue streams are likely to be created through investments in new infrastructure, products, and services across the value chain. Furthermore, significant revenue growth is projected downstream towards the retail or behind-the-meter side, as the market evolves towards the distributed, two-way power flow scenario.

95 https://www.pge.com/en/about/newsroom/newsdetails/index.page?title=20170316_pge_renewable_energy_deliveries_grow_ghg-free_portfolio_is_nearly_70_percent

Figure 6.1: State-level initiatives conducive to Utilities[96]

Alberta
- Smart Grid Inquiry
  - To inform policy development supporting smart grid technology to achieve Alberta's provincial energy strategy goals linked to clean energy production, wise energy use and sustained economic prosperity
  - Implemented control and monitoring system applications

California
- Integrated Distribution Energy Resources Proceedings
  - Focused on establishing goals and mandates and less on the business model and regulatory framework
    DRP proceeding required utilities to file resource plans that will identify optimal locations for DER deployment
- SmartMeter ~ PG&E
  - Advanced distribution system analytics platform to do planning, forecasting, and cost calculations for high DER penetrations
- Interconnection Map ~ Southern California Edison
  - DRPs require California's three IOUs (PG&E, SCE and SDG&E)to connect developers with the system data needed to enable strategic DER citing
- Boreggo Springs Microgrid ~ SDGE
  - Borrego Springs Microgrid –San Diego Gas & Electric's (SDG&E) microgrid uses solar, energy storage, and automated switching



Minnesota
- e21 Initiative
  - Recommendations on incentive-based ratemaking, customer option and rate design reforms, planning reforms, regulatory process, and distribution grid planning
  - Optional multi-year, incentive-based framework

Minnesota
- e21 Initiative

Massachusetts
- Grid Modernization Working Group ~ nationalgrid
  - Emphasis on energy efficiency, renewable energy and DER development
- Smart Grid Investments ~ EVERSOURCE
  - To undertake an energy storage project in New Bedford for voltage smoothing to accommodate high solar PV penetration

New York
- Distributed System Platform Engagement Tool ~ nationalgrid
  - Buffalo Niagara Medical Campus Distributed System Platform Engagement Tool -National Grid aims to use the campus as a test-bed for platform functionalities, coordinating and optimizing DER throughout the campus
- NY Reforming the Energy Vision (REV)
  - Utilities to expand as Distributed System Platform providers, functioning as integrated system planners, grid operators, and market operators
  - The new framework builds from the traditional cost-of-service approach and adds a combination of market-based platform earnings and performance-based earning opportunities
- Community Energy Coordination ~ IBERDROLA
  - To aggregate local demand for clean energy technologies
- Building Efficiency Marketplace ~ conEdison
  - Platform for small commercial customers to enable clean energy project origination, bidding, and to facilitate technical support and financial options

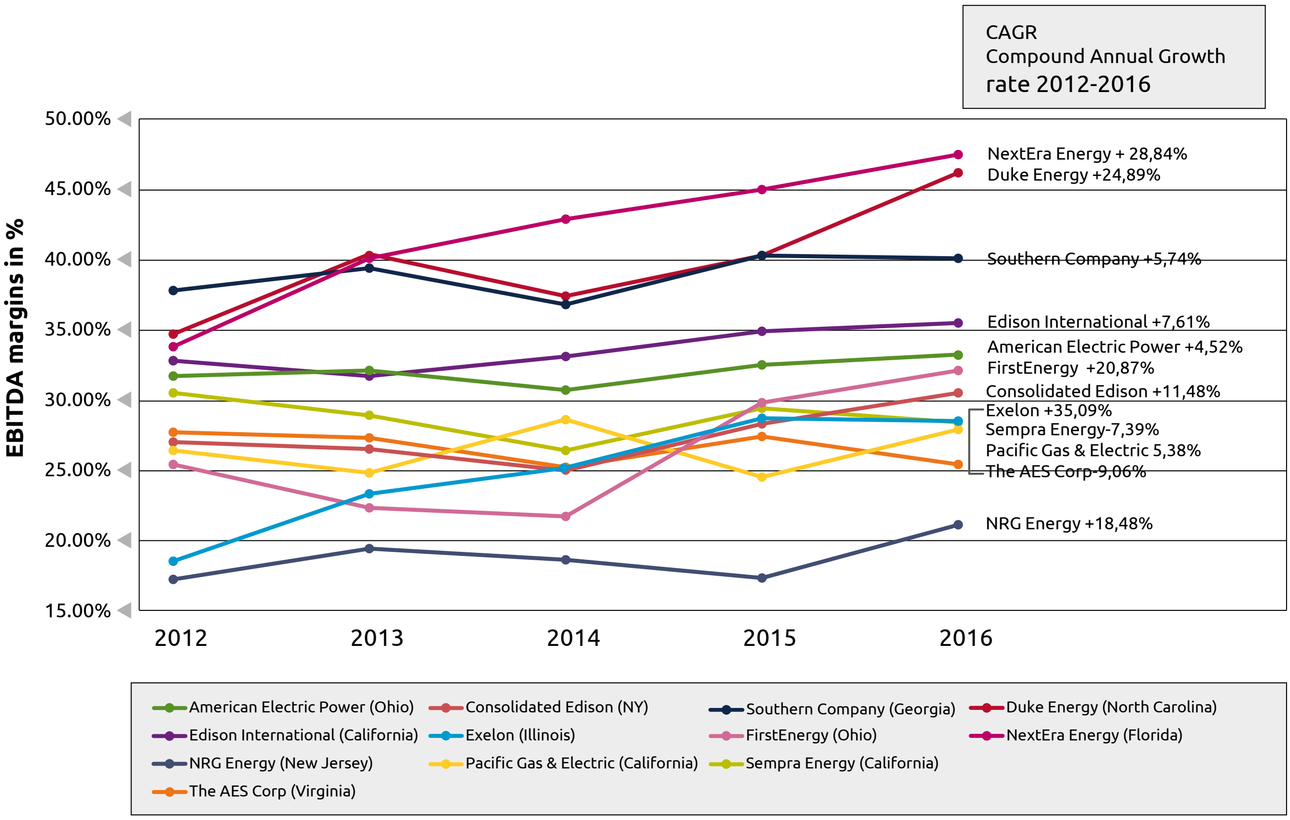
Source: Capgemini Analysis, WEMO2017

The initiatives indicate changes that can be expected in the short term, as well as different approaches in undertaking future challenges for utilities.

96 https://secure2.eda-on.ca/iMIS15/EDA/EDA_Priorities/EDA_Policy_Papers/PowerToConnect_Feb2017.aspx

Despite the flat electricity demand growth over the past ~eight years, US utilities' earnings have grown steadily. Furthermore, their earnings capabilities seem to have improved as their operations extended beyond traditional electric segments.

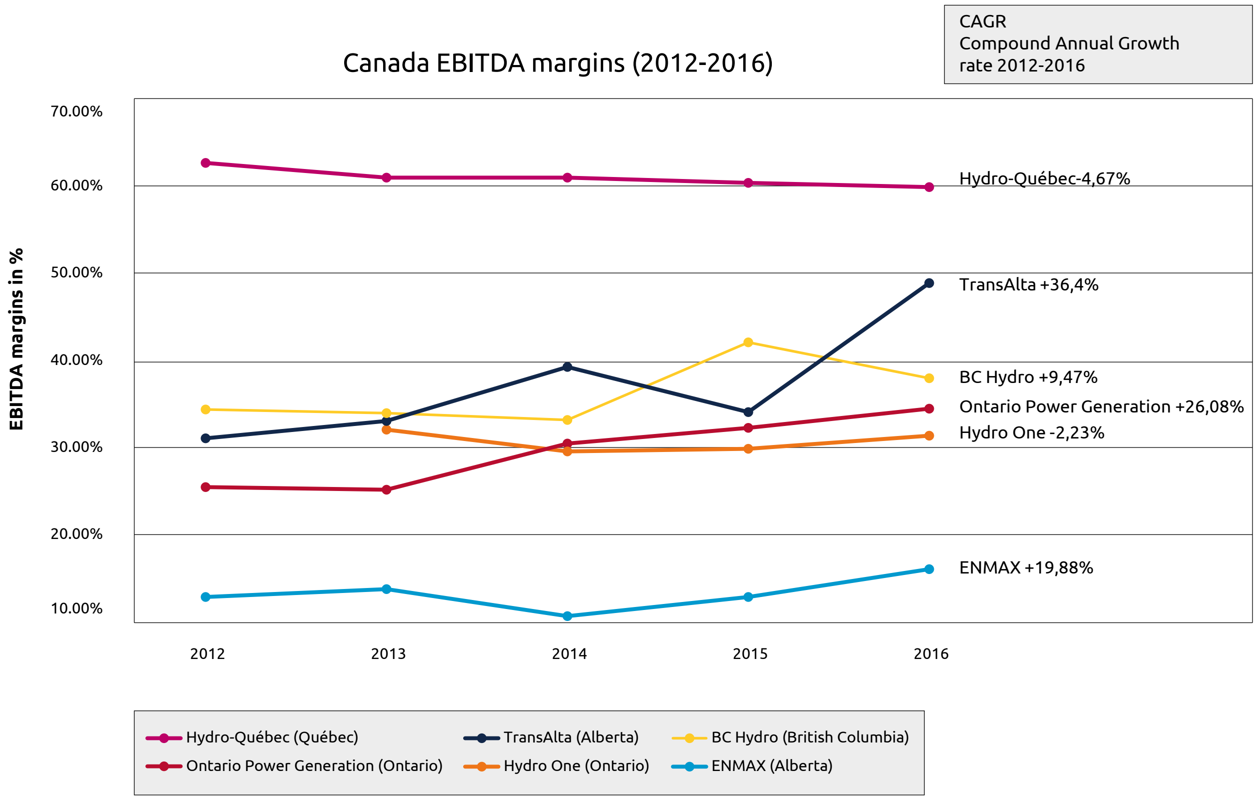
Figure 6.2 : USA - EBITDA margins (2012-2016)[97]



Sources: Company Annual Reports, Reuters, Capgemini Analysis

97 Company Annual Reports, Reuters, Capgemini Analysis

Figure 6.3 : Canada- EBITDA margins (2012-2016)[98]



Source: Company Annual Reports, Reuters, Capgemini Analysis

NextEra Energy growing fastest among peers

- In terms of earnings growth, NextEra Energy is one of the fastest-growing utility in the sector
- The company aims to grow its earnings per share (EPS) by 8%-10% over the next few years, while the industry average is around 4%-6%
- Likely to continue focus on renewable energy and hints at inorganic growth

Southern Company and Duke Energy have significantly increased their gas distribution operations after acquiring AGL Resources and Piedmont Natural Gas, respectively, in 2016

- Southern Company and Duke Energy also aim for industry-average earnings growth in the next few years

Utilities' revenue growth heavily depends on expanding the customer base

- NextEra Energy, Southern Company and Duke Energy have been expanding their customer bases by around 1% annually
- Southern Company and Duke Energy witnessed noteworthy additions of customers after completing their acquisitions last year

Sluggish revenue growth amid slower power demand among US utilities

- With a US$34 billion market capitalization, Exelon is the largest competitive utility, by revenue
- Over the last five years, Exelon's revenue growth rate averaged around 12%
- The double-digit revenue growth is noteworthy compared to FirstEnergy's and Public Service Enterprise's -3% during the same period

Utilities are expanding in gas, midstream, and renewables operations. It can be inferred that a declining dependence on traditional, slow-growing electric operations bodes well for utilities' long-term earnings growth.

98 Company Annual Reports, Reuters, Capgemini Analysis

Profit Margin

Hybrid utilities derive a relatively high portion of their earnings from competitive operations. Hybrid utilities usually generate nearly 35% to 50% of their earnings from competitive operations. These competitive operations are susceptible to wholesale power prices, which ultimately makes them very volatile.

Lower power prices continue to hamper hybrid utilities

- Competitive utilities witnessed squeezed margins in the last few years due to falling wholesale power prices
- For earnings stability, these utilities have been trying to increase their regulated operations
- FirstEnergy is looking to become a pure-play regulated utility; the transition might take a couple of years
- In 2016, Exelon generated nearly half of its earnings from competitive operations
- With Pepco Holdings, Exelon's portion of regulated operations rose 14%, which might accelerate Exelon's long-term earnings growth
- TransAlta's earnings are highly leveraged to Alberta power prices, which are volatile due to the small size of the market and supply/demand fundamentals that can change rapidly

Due to heavy infrastructure requirements, utilities generally carry large amounts of debt on their books. Thus, when interest rates increase, companies' debt servicing costs also go up. Ultimately, it hampers utilities' profitability.

Due to heavy infrastructure requirements, utilities generally carry large amounts of debt on their books. Thus, when interest rates increase, companies' debt servicing costs also go up. Ultimately, it hampers utilities' profitability.

Higher interest rates could dampen utilities' profitability

- In the last decade or so, due to the near-zero interest rates, there were more debt issuances than equity issuances by utility companies
- But now, as the interest rates are gradually getting to normal, this scenario could slowly change as the servicing cost of debt could rise significantly

Is Leverage a concern for Competitive Utilities?

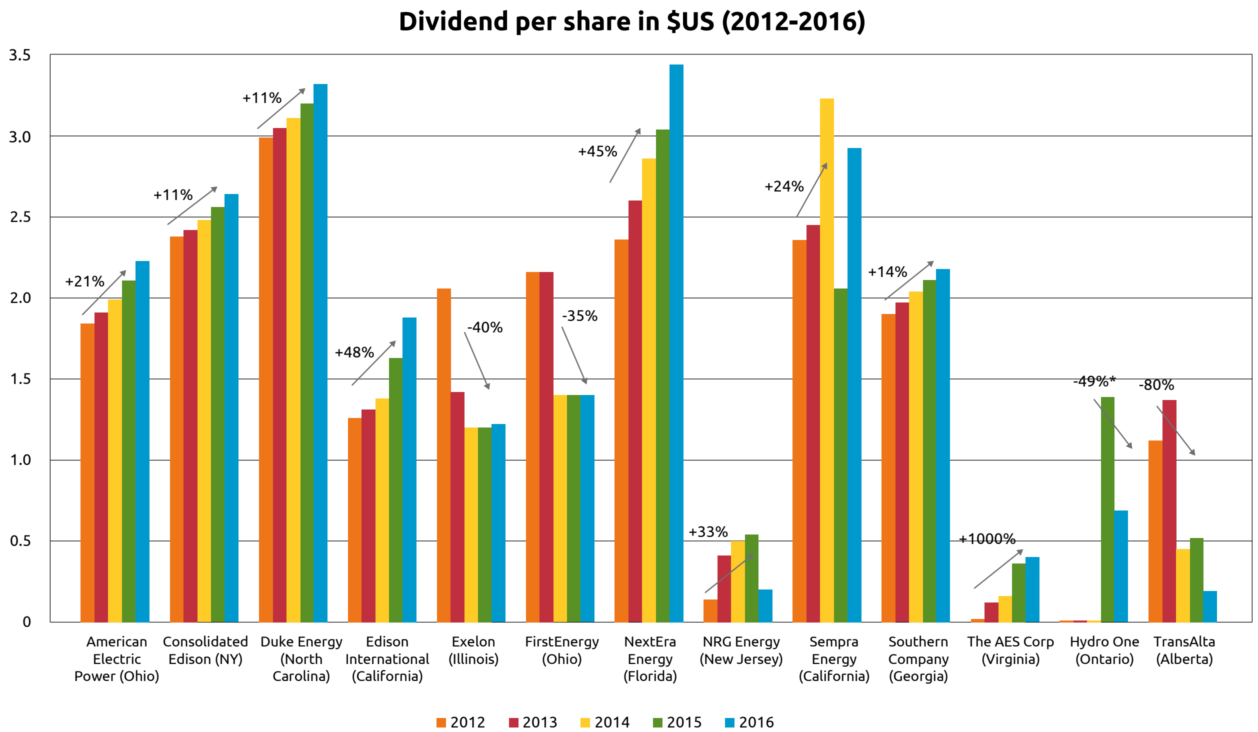
- FirstEnergy seems to have a relatively concerning leverage compared to other hybrid utility peers
  - Its net-debt-to-EBITDA ratio at the end of Q1 2017 stood at 4.8x; net debt after Q1 2017 was US$22.5 billion
  - A disproportionate increase in FirstEnergy's debt relative to its earnings might be the main reason behind the relatively higher leverage ratio

US utilities appear fundamentally strong

Compared to broader utilities, the hybrid counterparts have shown lower earnings growth. According to Edison Electric Institute US Utilities' operating profit margin rose 3% while net profits increased by an enormous 17% in 2016 year-over-year despite flattish electricity demand growth.

- Exelon's leverage ratio is about 3.8x
  - The industry average stands around 3.5x-4.0x
  - Exelon's leverage appears fair compared to the industry average, even after its Pepco Holdings acquisition last year
  - At the end of 1Q17, Exelon's net debt was around US$35.5 billion
- Public Service Enterprise Group (PEG) has a net-debt-to-EBITDA ratio of 3.7x
  - Its leverage is below industry average levels, which indicates financial soundness
  - Its net debt after 1Q17 was US$12 billion

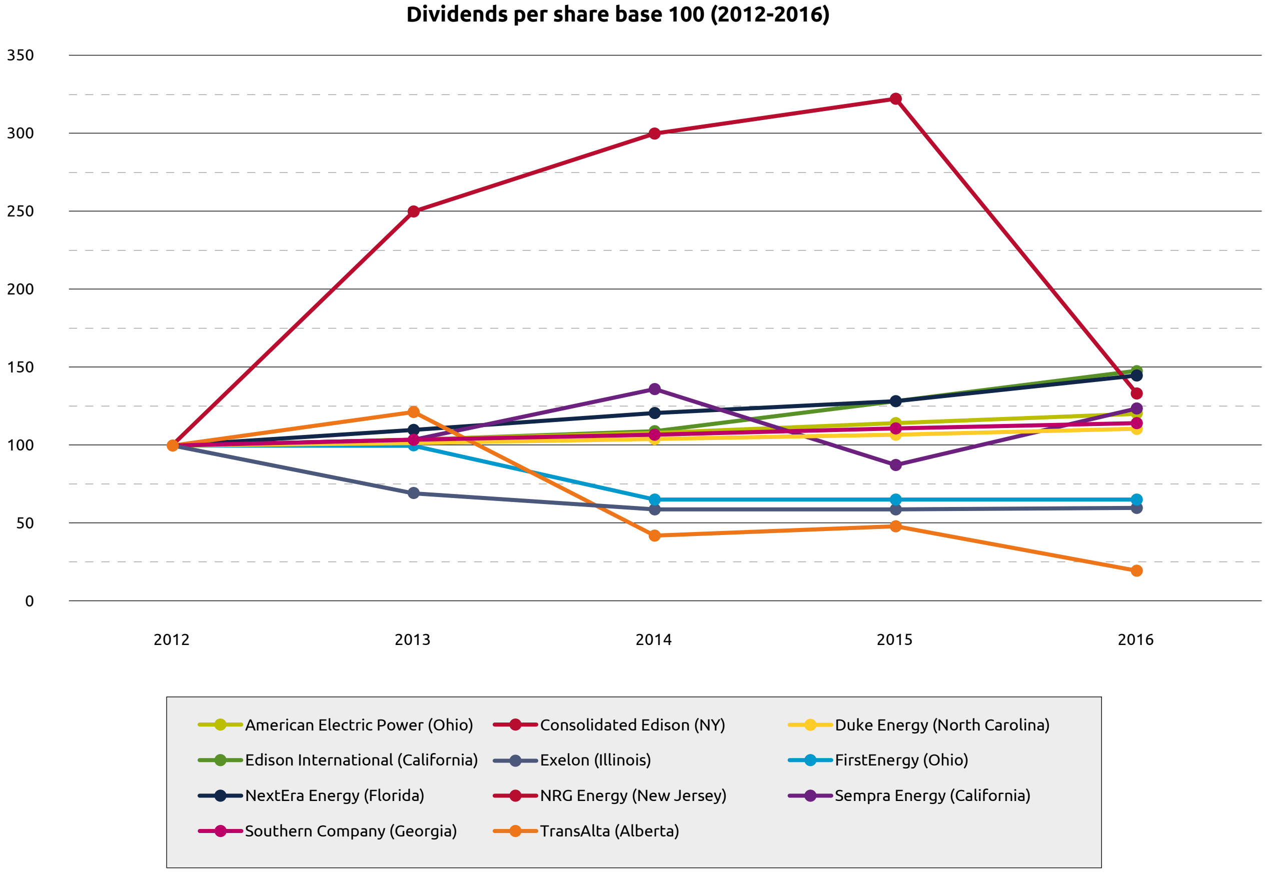
Figure 6.4 : Dividend per Share (2012-2016)[99]



Sources: Company Annual Reports, Reuters, Capgemini Analysis

99 Company Annual Reports, Reuters, Capgemini Analysis

Figure 6.5 : Dividend per Share Base 100 (2012-2016)[100]



Sources: Company Annual Reports, Reuters, Capgemini Analysis

Among the top US utility stocks, NextEra Energy seems to have the most attractive dividend profile, as compared to Duke Energy and Southern Company

- NextEra Energy's dividend profile is attractive due to its higher dividend growth; managed to grow its dividends by ~10%, compounded annually, over the past five years
- A red flag in NextEra Energy's dividend profile is its relatively lower payout ratio
- Heavy capital spending could be one of the main reasons behind its lower payout, which has contributed to a lower yield
- The company's management plans to increase its payout ratio to 65% in the future

In 2016, TransAlta cut its annual dividend 78% to C$0.16 per share

- The Dividend seems secure at the current level due to the November 2016 Off-Coal Agreement that provides annual cash payments to TransAlta to compensate for the closing of three coal-fired power plants in Alberta
- Management is promoting a strategy of developing new wind projects in Canada, while retiring two coal units at Sundance in 2018, well ahead of Alberta's environmental policy to shut coal plants by 2030
- Creating TransAlta Renewables as a yield play provides the company with an efficient way to raise equity capital

100 Company Annual Reports, Reuters, Capgemini Analysis

Figure 6.6 : Stock Performances[101]

Stock performances			
	Company	**Share price year-to-year ratio (2016/2015)**	**Share price ratio (2016/2012)**
USA	FirstEnergy (Ohio)	-11%	-30%
	Exelon (Illinois)	-2%	-11%
	Southern Company (Georgia)	-2%	9%
	The AES Corp (Virginia)	0%	-10%
	Duke Energy (North Carolina)	4%	22%
	Consolidated Edison (NY)	5%	26%
	American Electric Power (Ohio)	5%	66%
	Sempra Energy (California)	7%	61%
	Pacific Gas & Electric (California)	7%	5%
	Edison International (California)	11%	61%
	NRG Energy (New Jersey)	12%	-12%
	NextEra Energy (Florida)	13%	85%
CANADA	Hydro One (Ontario)	-8%	N/A
	TransAlta (Alberta)	-2%	-70%

Increased interest rates could bring temporary weakness to US utility stocks. But fundamentally, these stocks look financially fairly strong

- Their reasonable target dividend growth seems quite achievable in spite of concerns regarding flattish electricity demand growth over the past few years
- Given the overvaluation of utility stocks, interim weakness might, in fact, be a good opportunity for investors
- Stocks under consideration in this series have strong dividend profiles, however, NextEra Energy appears to have an edge with its higher dividend growth rate
- Duke Energy is also a relatively safe and stable utility and may continue to offer alluring investment proposition in the future
- Southern Company's delays and cost overrun issues at its power plants could continue to dent its overall performance in the near future
- FirstEnergy's total returns severely lagged behind peers due to the solid plunge in its stock

US utilities including majors like Duke Energy and Southern Company have performed fairly well over the last few months compared to broader markets. The rally has boosted utilities' valuations, and analysts now expect sluggish movements going forward.

A part of the S&P 500 Utilities Index that now looks attractive and has seen a relatively weak performance is Hybrid Utilities. Leading Hybrids like Exelon and FirstEnergy are presently trading at attractive valuations, and their price targets offer handsome upside potential as well. Lower natural gas prices marred wholesale power prices over the last few years, which ultimately dented Hybrid Utilities' performance.

101 Company Annual Reports, Reuters

While wholesale power prices show less possibility of revival in the near future, Exelon and Public Service Enterprise Group are planning to shut their nuclear power plants due to their high operating expenses. FirstEnergy plans to become a pure-play regulated utility in the next few years.

Topic Box 6: GOP-proposed US tax policy reform likely to have potential negative earnings impacts, especially for regulated utilities

Likelihood...

Tax reform is second in line on the 2017 legislative agenda

- Expected key elements include, reduction in corporate income tax rates, the elimination of corporate interest deduction, and/or expensing of CAPEX
- Amid the high leverage, unavoidable capital-intensive nature of utilities, along with unique regulatory accounting, some utilities hope for a carve-out, which may be difficult to achieve
- With lower income tax rates and reduced accumulated deferred income tax (ADIT) balances available to fund rate base, utilities may look to increasing amounts of equity and debt as sources of permanent financing
- ADIT, the difference between book and tax-basis balance sheet treatment, would have to be partially refunded to customers since expected future tax liabilities would be reduced

Likely proposals and potential implications...

Themes	Likely Proposals	Implications
Reduced corporate tax rate	• Competing proposals to reduce rates from current 35% to 15%, 20%, or 25%	• Lower tax burden, passed through in lower rates and refund of ADIT balances • Tax credits, net operating losses (NOLs) may have less value with lower rates • Some potential opportunity to maintain customer bill levels with incremental capex
100% expensing of CAPEX in first year	• Changes current 50% bonus depreciation	• Bonus depreciation • Accelerated ADIT reduces rate base (and hence earnings) in near term
Non-deductibility of interest	• Trade-off for full expensing of CAPEX • Under one plan, can choose interest or CAPEX deduction approach	• Renders firms neutral to debt vs. equity financing
Net operating loss (NOL) treatment	• Elimination of NOL carry-back in exchange for lower rates	• NOLs can carry forward into future years only, no carry-back
Border adjustment	• Foreign profits not subject to domestic taxation • VAT-like structure with no tax deduction for purchases of imports and no tax on export revenues	• NOLs can carry forward into future years only, no carry-back

Companies	Likely Implications
Companies like CenterPoint Energy, Inc. and OGE Energy Corp., with a large percentage of deferred tax liabilities to capitalization	• Likely be more exposed to changes in tax rate
Holding companies like FirstEnergy Corporation and NextEra Energy, Inc., with a significant amount of debt at the holding company and unregulated subsidiary level	• Likely to be most vulnerable to the loss of interest deductibility

Utilities set rates and accumulate customer revenue based on the statutory corporate tax rate of 35% despite utility holding companies paying a cash tax rate of only 3% on average. The discrepancy generates a significant amount of deferred taxes that contribute to roughly 13% of the sector's funds from operation (FFO) and support capitalization.[102]

- Lower corporate tax rate implies a reduction in the utility's deferred taxes, and subsequently, funds from operation
- Loss of interest deductibility would be an additional credit negative for utilities due to the increase in taxable income and tax expense
- While utilities would likely recover this added cost by passing it through to customers, doing so would permanently increase the utility cost structure and hike customer bills

The exact details of any corporate tax reforms are yet to be proposed. Credit implications of policy proposals will be decided by state regulatory commissions since these entities determine how taxes will affect utility rates and customer bills.

102 https://www.moodys.com/research/Moodys-Potential-US-tax-policy-reform-could-be-credit-negative--PR_363590

Europe

Energy Transition in Europe

Editorial by Colette Lewiner

Energy Transition in Europe

The first directive liberalizing the European electricity markets celebrated its 20th anniversary at the end of 2016. It aimed at creating a single European energy market to produce benefits for end-users, lower prices, and achieve a more competitive environment.[1] These reforms are not yet completely implemented in some Member States.[2]

In 2008, similar directives were promulgated for gas markets. Many analyses[3] exist on the benefits and failures of those market liberalizations.

These first directives were followed, in 2010, by the Climate-Energy package that de facto re-regulated these markets by giving priority in wholesale markets to renewable energy sources generation.

The Climate-Energy package objectives for 2020[4], known as 3x20, aim to reduce greenhouse gas (GHG)[5] emissions but also to improve energy efficiency and increase the share of renewables in energy consumption. No priority was allocated among these objectives but the key one should have been reduction of GHG emissions. This priority was finally recognized when the 2030 objectives were established[6].

While the three objectives all contribute to reducing GHG emissions, they were established separately without economic coherence.

Renewables development is the most expensive way to reduce GHG emissions, while energy efficiency is the cheapest.

- However, because of the very granular nature of *energy efficiency* measures, and despite financial incentives at the national or regional levels, the 2020 objective could be difficult to reach. The timescale for achieving these measures was too short, especially for renewable energies that were not yet mature technologies. Also, energy sobriety is related to

1 http://ec.europa.eu/competition/sectors/energy/overview_en.html

2 In some countries, there are still tariffs for residential customers.

3 The European electricity market liberalization, R Serena, 2014 arno.uvt.nl/show.cgi?fid=134162

4 The 3x20 objectives are: i) to reduce emissions of greenhouse gases by 20% by 2020 taking 1990 emissions as the reference; ii) to increase energy efficiency to save 20% of EU energy consumption by 2020; iii) to reach 20% of renewable energy in the total energy consumption in the EU by 2020.

5 GHG: Green House Gases

6 Targets for 2030: i) 40% cut in greenhouse gas emissions compared to 1990 levels, main compulsory objective; ii) at least 27% share of renewable energy consumption compulsory at EU level; iii) at least 27% energy savings – indicative – compared with the business-as-usual scenario.

cultural aspects[7] that evolve slowly over time.

- *Renewables* development 2020 objective will be met, thanks to huge subsidies[8] paid for by end-users.
  With their increasing share in the electricity mix, renewables, because of their intermittent nature, are impacting negatively on grid stability, triggering the need for smart grids and mass electricity storage. Additional grid costs (empirically estimated at 30%[9]) have to be added to the renewables cost in order to make a fair comparison with schedulable generation.
  Despite the decreasing costs of renewables, they are still usually higher than other energy sources, especially when their intermittent nature is taken into account.

  In order to push for their deployment, the Energy Union (EU) put in place subsidies organized around feed-in tariffs (FiTs), which guarantee fixed revenues for renewable energy producers. These FiTs played a major role in renewables expansion but generated huge costs for consumers. For example, in 2015 German end-users paid €20 billion to green energy producers.

  In 2014, following Spain, Germany reformed its Energiewende[10] law, replacing FiTs with auctioned "feed-in premiums" and placed a cap on the amount of clean energy capacity eligible for subsidy payments. These new measures will give the German government more control over the integration of renewables.
  Following Germany, the EU has promulgated a similar reform that started to be applied in 2017.

  These reforms, which are lowering subsidies and relating them to market conditions, will probably slow down the progress of renewables. In 2016, investments in renewables stabilized in Europe at $60 billion after dropping in 2015.[11] [12] Aside from subsidy decreases, an important reason for these investments stabilizing is the average capital cost per installed capacity decrease: for photovoltaic (PV) projects, starting construction in 2016 were 13% lower than in 2015, while for onshore wind, the drop was 11.5% and for offshore wind, 10%. The main 2016 investments were in wind energy ($42 billion) and solar energy ($10 billion).[13]
  Although renewables (wind and solar) costs have decreased significantly already, they should continue to do so in the future.

  By 2025, the onshore wind levelized cost of electricity (LCOE) should fall by 26%, offshore wind (currently far more expensive than onshore wind) LCOE should fall by at least 35% and photovoltaic solar LCOE by 59%.

  Battery storage costs should fall from $227/kWh in 2016 to less than $190/kWh in 2020 and to less than $100/kWh by 2030.

  There is no doubt that falling storage prices combined with decreasing renewables costs will pave the way to transition to cleaner systems.

In 2016, investments in renewables stabilized in Europe at $60 billion after dropping in 2015.

Europe

7 A European household consumes an average of three times less electricity, excluding heating, than a household in the United States.

8 Hundreds of billions of euros since 2008

9 These costs depend on the grid status and the renewable share. They can lower but also bigger than 30%

10 Energiewende = energy transition

11 The subsidy reforms were already effective in Spain and Germany in 2015

12 Investments in renewables decreased by 18% in 2015

13 http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf

In 2016 and H1 2017, wholesale electricity markets remained chaotic.

- *Greenhouse gas emissions:* in 2005, the EU established the Emissions Trading System (ETS) enabling emissions rights exchanges and delivering market-related carbon prices. However, during the 2008-2010 crises, the European Commission (EC) granted too many emissions rights and has since, been unable to efficiently reform this rigid system. As a result of this emissions rights glut, carbon prices are at absurdly low levels (around €7/t in September 2017), with no incentive to choose carbon-free investments. No real effort is put into reaching a high enough carbon price because of opposition by coal-rich Member States (e.g. Poland, and to a certain extent Germany).
  Despite this, and thanks to renewables development, energy efficiency improvements, and also the economic crisis pushing energy-intensive industries to move to lower-cost countries outside Europe, the CO_2 reduction target will be reached and even surpassed in 2020. The 2030 objective of 40% reduction is also attainable.

In 2016 and H1 2017, **wholesale electricity markets remained chaotic.**
The combination of deregulating markets with the 2008 economic crisis and the Climate Energy package enactment created huge instability in electricity markets, pushing wholesale electricity prices to very low levels, thus endangering the Utilities' financial situation and destroying incentives for new dispatchable generation investment.
Despite increased oil and coal prices, and generation capacity retired from the market, electricity prices remained low in the first three quarters of 2016 (around €35/MWh[14]) with negative price intervals.
During winter 2016-2017, low availability from French nuclear plants[15] triggered spiking spot prices (around €100/MWh at end of 2016)[16] and worries about security of supply.
In 2017, wholesale spot prices fell again after that tense period.

As dispatchable generation capacity continues to be retired from the market and replaced by volatile renewables[17], security of supply remains a worry.

In many Member States, capacity markets, designed to ensure that sufficient reliable capacity is available during tense periods, have been functioning with different models[18].
The French capacity market finally had clearance from Brussels and started to operate in 2017. The first auctions were awarded at a price of €10/kW.
Work on electrical interconnections continued in 2016-2017 enabling increased electricity exchanges, enhancing solidarity between Member States and thus improving security of supply.

Nuclear energy:
Public opinion has concerns regarding nuclear energy safety and waste disposal, it is also more and more concerned by climate change related issues. Regarding this last point, phasing out nuclear energy, aside from safety reasons, is the wrong battle because nuclear is a good schedulable, carbon-free complement to renewables.

A few political decisions were announced in 2017:
On May 21, Switzerland voted to progressively phase out nuclear power in favor of renewable energies.
In July, Energy Transition Minister, Nicolas Hulot, said *France* might close as many as 17 reactors by 2025 as it seeks to reduce the share of nuclear power in its electricity mix to 50% (compared to 73% in 2016). In a subsequent interview, the French Prime Minister was more prudent, stressing that this decision would have to take into account not only technical elements but also expected levels of energy consumption and development of renewables.
This plan would be very costly as investment in existing reactors is largely amortized, and new large investments would have to be financed. It would also create big social problems with a significant number of job losses[19]. In addition, closing such a large number of plants while keeping the present low-carbon French economy level, is a huge challenge as renewable energies would need to be strongly boosted to replace nuclear generation plants; and even then, they would probably not be able to ensure security of

14 Excluding the winter spikes
15 Due to inspections requests from the French Nuclear Regulator.
16 CRE Observatoire des marches de gros
17 10.8 GW net dispatchable capacity was retired from the market. 26.5 GW renewable capacity was added (with a load factor around 25%)
18 Strategic reserves, capacity auctions, capacity obligations
19 The French industrial nuclear sector, which brings together 2,500 companies, employs nearly 220,000 people (directly and indirectly)

electricity supply.
For example, *Germany* decided in 2011, after the Fukushima accident, to immediately shut down half of its nuclear plants and to phase out the remaining ones between 2020 and 2022. From 2011 to 2016, the German Energy Transition “Energie Umlage” cost was €150 billion[20] and from 2016 to 2025, it could cost another €370 billion. These costly German decisions have decreased the country’s nuclear energy consumption share to 13% and increased the renewables share to 29% but polluting coal and lignite still have a 27% share. This explains why German GHG emissions decreased much less than the European average.

The European Commission is well aware of market instability and related issues and of the need to reform the ETS. This is why it proposes a new legislative package.

The Clean Energy for All Europeans package

This new package was released for consultation on November 30, 2016. Its ambition is to reach seamless electricity flows through European Member States, to pursue the renewable energies market integration and energy efficiency efforts, and to enable consumers to become more effective players in the market.

It endorses nearly all the 2030 energy-climate package quantified targets[21]. But the commitments apply to the Union as a whole and Member States should no longer have binding targets except for GHG emissions reduction.

However, with a high renewables share, the document’s ambitions are insufficient to restore sustained wholesale markets delivering significant electricity and carbon prices that would drive low carbon investments in areas where they are needed most.

The recommendations of this package should be adopted in 2017 for entry into force between 2020 and 2021.

The main recommendations are:

Deliver a fair deal for energy consumers

Thanks to smart meter deployment, smart grids, and electricity storage developments, consumers must be able to participate more fully in electricity markets both as self-producers and as suppliers of load shedding offers.

Suppliers should propose more systematic «dynamic» price offerings that better reflect wholesale market prices in real time. Also, customer information on suppliers’ offerings should be strengthened in order to increase switching rates.

Strengthen network operators and market governance

Transnational interconnections development, better harmonization of standards, and a stronger role for the Agency for the Cooperation of Energy Regulators (ACER) should help reduce border congestion and facilitate better wholesale price convergence.

National market rules (e.g. price caps) and state interventions should disappear as well as rules prioritizing the dispatch of certain installations as renewables[22].

For example, in day-ahead and intraday markets, wholesale price caps (generally around €3,000/MWh)

From 2011 to 2016, the German Energy Transition “Energie Umlage” cost was €150 billion and from 2016 to 2025, it could cost another €370 billion.

20 Düsseldorf University Economic Institute (DICE)

21 Achieving 27% renewable energy share in the EU’s energy mix, improving energy efficiency by 30%, and decreasing by 40% GHG emissions compared to 1990

22 In reality, as will be explained later, with the present market dispatch rules, renewables that have very low variable costs will still be called first despite the related national market rules abolition

must disappear unless they are set at the "lost load" value, which is in the order of €9,000/MWh.

It is doubtful that those measures would be sufficient as:

- In the medium / long term they will not trigger new investments in generation capacity necessary to ensure security of supply and to prevent closures of peak load capacities.
- In the short term, in the event of tension between supply and demand, the increase in price ceilings would not make it possible to gain access to additional production capacity especially if the CCGT[23] able to respond quickly to demand peaks have closed.

In any case these measures would not remove the need for capacity markets.

The new package recommends that these national capacity markets should be open to other Member States and to all technologies except the most polluting (coal), which should be totally excluded in the long run.

The package plans to stop subsidies for renewables. This support is no longer justified with the spectacular decrease in certain renewable costs

Improve renewables integration

The target of 27% renewable energy in the EU's final energy consumption by 2030 has appeared modest for observers compared to the past trend. Indeed, from 20% in 2020 to 27% in 2030 represents less investment than previously. However, account must be taken of the scarcity of economically attractive sites for solar and wind power, local opposition to land-based wind, and the announced reduction in subsidies.

The package plans to stop subsidies for renewables. This support is no longer justified with the spectacular decrease in certain renewable costs. In practice, the package will encourage calls for tender and recommends «technological neutrality», which will benefit lower-cost technologies and projects.

Increase energy efficiency

The package establishes an increased energy efficiency target from 27% to 30% by 2030.

It could be possible to reach that ambitious target if major efforts are made in buildings and transportation. Buildings account for 40% of total energy consumption in the EU and 75% of them have poor energy efficiency.

To accelerate energy savings and the penetration of renewables into the building sector, the Commission considers that Member States should finance a €10 billion fund dedicated to existing buildings renovation.

On July 6, 2017, the French Energy Transition Minister announced a dedicated €4 billion fund for energy efficiency investment in buildings.

However, the multitude of stakeholders (owner, lender, advisers, local subsidy providers, national subsidy providers) makes energy efficiency improvements in existing buildings a complex issue and progress up to now has been slow. In addition, with current low energy prices, these renovation projects offer a poor return on investment.

Similarly, development of electric vehicles is expected to reduce energy consumption in the transport sector, which still accounts for 30% of all consumed energy. According to various optimistic studies[24], in 2030, e-vehicles should have a 40-50%

23 CCGT : Combined Cycle Gas Turbine

24 Faurecia declarations

share of total vehicle sales on the worldwide market.

Carbon price

The Commission is clear that the European quota system (EU ETS) remains at the heart of the scheme to reduce GHG[25] emissions. Unfortunately, the price per tonne of carbon in 2017 (€7/t) is far too low to encourage carbon-free investment.

The objective of the EU ETS reform project, adopted in 2016 by the European Parliament for implementation in 2019, is to raise this price. However, the Market Stability Reserve (MSR) proposal uses quantitative criteria (number of emissions rights) to modulate the quota offer. When announced, this reform did not push up prices, demonstrating that it is not sufficient.

In order to establish a high enough and predictable carbon price, the criterion for the reserve intervention should be defined according to price thresholds and not quantities. This would ensure that the carbon price moves in a corridor between a floor price and a ceiling price, similar to what the UK did a few years ago by establishing a carbon floor price[26].

Outstanding issues

To restore sustained market performance and deliver price signals consistent with future investment needs, the package should have suggested reforming electricity pricing in wholesale markets. Today the «merit order» consists of calling plants in order of increasing variable costs, and renewables have very low (near to zero) variable costs.

With this merit order rule, the massive injection of photovoltaic or wind renewables pushed wholesale market spot prices down to very low levels with episodes of negative prices. This chaotic situation should be corrected; however, the measures contained in the package are not the right remedies.

As long as the problem of large-scale storage of electricity is not resolved, a complete review of the current logic of electricity pricing is needed. For example, variable cost pricing should be replaced by pricing based on average costs (including investment costs), which would reflect the real cost of electricity generation and drive the necessary investment.

The increase in self-consumption should also lead to reform of network access tariffs.
Today, these tariffs are based partly on subscribed power and partly on the amount of energy drawn.[27] For example, with this rule, PV self-consumers will only pay the network tariff "energy component" when they use electricity from this network, that is, when their solar system does not deliver. It is the other consumers, those who have not opted for solar installation, who will pay the PV self-consumers' part of the tariff.

To avoid these distortions, it would be necessary to review the network's pricing, for example by increasing the subscribed power share. The problem with this solution is that it would penalize small consumers. More sophisticated solutions could be implemented, for example by creating a special network tariff for self-consumers.

To restore sustained market performance and deliver price signals consistent with future investment needs, the package should have suggested reforming electricity pricing in wholesale markets

25 GHG: Green House Gas

26 In 2011 the initial carbon price was £16/t due to increase to £30/t. Later the UK government decided to cap the floor price at £18/t.

27 The share of power and the share of energy varies between countries. On average in Europe the power share is around 30% and the energy share is around 70%, but in Germany, for example, the power share is close to 80%.

The Utilities situation

This continues to give cause for concern. In 2016, Utilities' revenue decreased in parallel with electricity and gas spot prices during the first three quarters of the year[28]. With some exceptions (notably Nordic Utilities) profitability decreased and leverage ratio[29] increased. Consequently, stock prices underperformed in the Euro Stoxx 50 index.

Due to the closure of half of **German** nuclear plants, massive renewables deployment and consequent closure of gas-fired plants, as well as low wholesale electricity spot prices, German Utilities were in a difficult financial situation.

In November 2014, E.ON announced its decision to split in two separate companies.
New E.ON focuses on regulated businesses (renewables, energy networks), nuclear generation, and customer solutions while Uniper retains the conventional power generation plants and global energy trading businesses. In September 2016, Uniper started to be traded on the Frankfurt Stock Exchange.

RWE was in a better situation than E.ON. Whereas E.ON's assets are more nuclear (being phased out) and natural gas plants (that are not presently competitive), RWE is a big lignite firm. Lignite is a German natural resource and will be competitive for the next few years. In December 2015, RWE announced its plan to also split into two companies, but differently to E.ON. Nuclear, gas and coal generation remain in the firm still called RWE, while the new company, Innogy, focuses on renewables, grids and sales.

In October 2016, Innogy closed its Initial Public Offering (IPO) on the Frankfurt Stock Exchange, Europe's biggest IPO since 2011.

All four stock prices (E.ON, Uniper, RWE, Innogy) have increased since the IPOs, notably in June 2017 when the Karlsruhe Constitutional Court declared that the nuclear tax imposed by the government in 2010 was illegal. This verdict will allow nuclear operators RWE, E.ON and EnBW to claim billions of euros in refunded taxes.
However, they will have to finance a €24 billion fund for final disposal of nuclear waste, an amount higher than their related financial provisions.

In 2015, the large **French** Utility, Engie, announced an ambitious three-year transformation plan (2016-2018). Engie will focus its development on low CO_2 activities, integrated customer solutions, and activities not exposed to commodities prices. Based on a new organization closer to territories, this plan entails a €15 billion portfolio rotation program.
In 2016, Engie added a fourth component to its plan: digitalization. Over the three years, Engie intends to invest €1.5 billion in new businesses and digital technology. Its flagship digitalization projects span the whole value chain:

- *In customer relations:* online services for its domestic customers, ranging from energy self-management to online sales and digital billing.
- *In energy efficiency:* Engie has acquired a data analysis platform that conducts energy audits for companies, and helps them to reduce their energy consumption. Engie is also developing algorithms capable of optimizing the performance of urban heating and cooling systems. In addition, it offers services to residential customers and real estate managers that analyze buildings-related energy bills in order to identify opportunities for savings.
- *In renewables:* Engie is engaged in building a digital platform designed to optimize generation from its renewables sources in six European countries.

Thanks to higher electricity winter prices, higher carbon prices and increased forward electricity prices (more than €40/MWh for 2018), the 2017 first half results of many Utilities have improved. These players are also reaping the benefit of their cost cutting programs.
It is only in the next months that these improvements will be confirmed.

In the present tough situation, Utilities need to embrace more quickly the digital revolution in their core processes, as well as in their client relationships, and overcome related difficulties (such as skills, people employment, cyber-attacks).

This will allow them to improve their competitiveness, satisfy and retain customers, and add new service-related revenues that are not linked to fluctuating commodity prices.

28 In Q4 2016 electricity and gas prices were up because of the French nuclear plants' poor availability.

29 Leverage ratio: net debt/EBITDA. EBITDA = Earnings Before Interest, Taxes, Depreciation and Amortization

Conclusion

Successive European legislative packages, as well as massively subsidized renewables deployment, impacted strongly on electricity markets, which became unstable with concerns about security of supply. These directives also failed to deliver what was their first objective –benefits for end-users – as the latter are paying for renewables subsidies through specific taxes[30] and thus higher electricity prices.

As stated in the European Energy Markets Observatory 18th edition, energy market reforms are urgently needed.

The EC has issued, for consultation, a new legislative package "Clean Energy for All Europeans". While this package should bring some improvements it is not sufficient to restore a sustained market. More bold steps should be taken but reaching agreement between 28 countries with different energy mixes and domestic resources is very hard.

Brexit is only making the situation more complex.

In 10 years' time (or less), technology improvements and digitalization will enable non-subsidized renewables, combined with mass storage, to have a significant share of the electricity mix, contributing to decarbonized energy consumption.

Nuclear energy at competitive prices is a good dispatchable complement to renewables and should not be shut down except for safety reasons.

The question is, what will happen in the next 10 years? One thing is certain; the path from now to then will be bumpy for all players in this sector, and particularly Utilities.

In order to be winners in this tough environment, Utilities need to accelerate their transformation. To that end, they should take advantage, as quickly as possible, of today's digital revolution benefits.

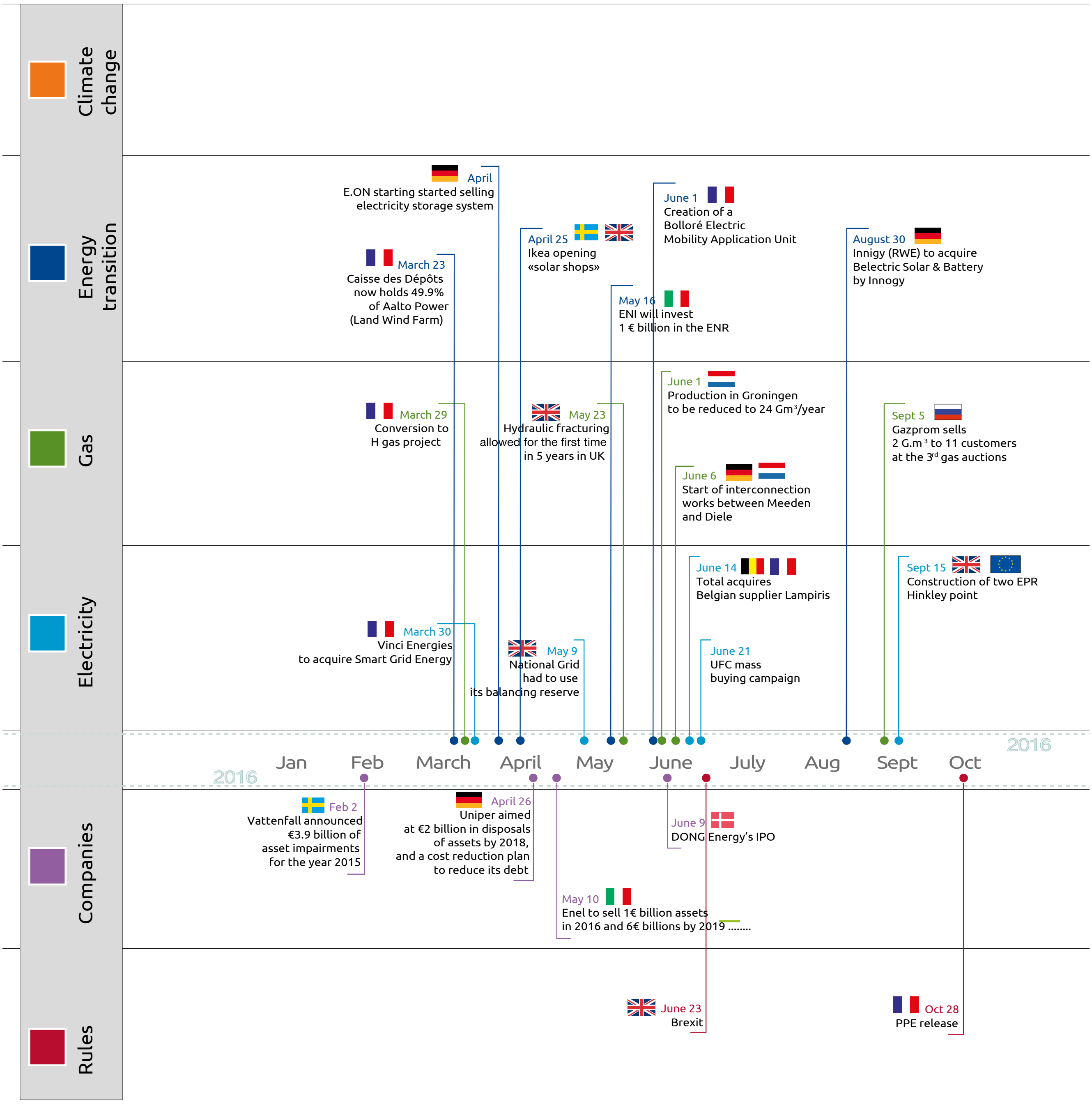
Colette Lewiner

Senior Energy Adviser to Capgemini
Chairman
September 2017

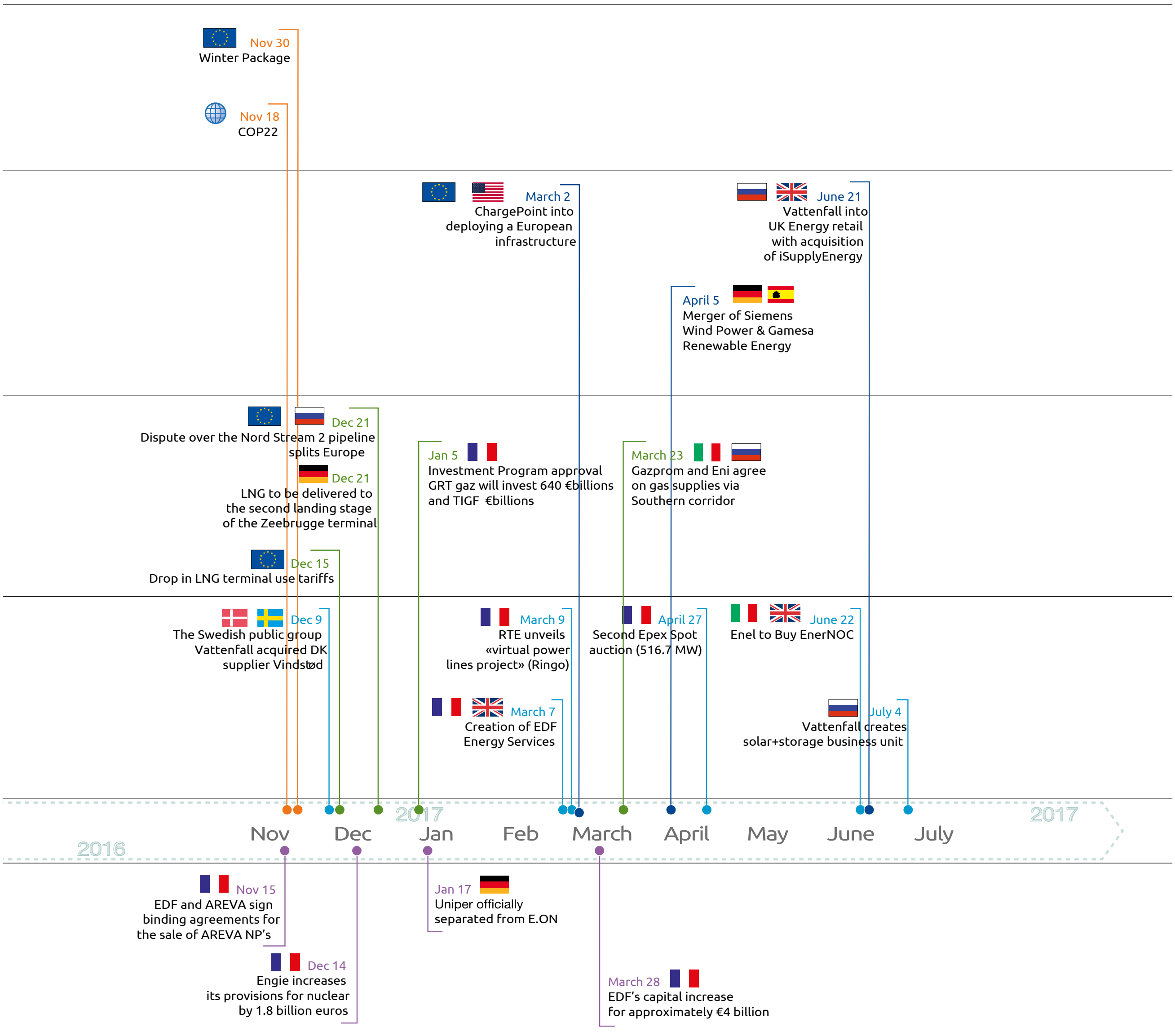
In 10 years' time (or less), technology improvements and digitalization will enable non-subsidized renewables, combined with mass storage, to have a significant share of the electricity mix, contributing to decarbonized energy consumption

30 For example, in Germany, EEG Umlage; in France, CSPE

Major energy events (2016 and H1 2017)



FITs: *Feed-in-tariffs*
EC: *European Commission*
EP: *European Parliament*
MS: *Member States*
Source: Various industry sources - Capgemini analysis, WEMO2017


Nov 30
Winter Package
Nov 18
COP22
March 2
ChargePoint into deploying a European infrastructure
June 21
Vattenfall into UK Energy retail with acquisition of iSupplyEnergy
April 5
Merger of Siemens Wind Power & Gamesa Renewable Energy
Dec 21
Dispute over the Nord Stream 2 pipeline splits Europe
Dec 21
LNG to be delivered to the second landing stage of the Zeebrugge terminal
Dec 15
Drop in LNG terminal use tariffs
Jan 5
Investment Program approval GRT gaz will invest 640 €billions and TIGF €billions
March 23
Gazprom and Eni agree on gas supplies via Southern corridor
Dec 9
The Swedish public group Vattenfall acquired DK supplier Vindstød
March 9
RTE unveils «virtual power lines project» (Ringo)
April 27
Second Epex Spot auction (516.7 MW)
June 22
Enel to Buy EnerNOC
March 7
Creation of EDF Energy Services
July 4
Vattenfall creates solar+storage business unit
2016
2017
Nov
Dec
Jan
Feb
March
April
May
June
July
2017
Nov 15
EDF and AREVA sign binding agreements for the sale of AREVA NP's
Jan 17
Uniper officially separated from E.ON
Dec 14
Engie increases its provisions for nuclear by 1.8 billion euros
March 28
EDF's capital increase for approximately €4 billion

Europe

Climate Challenges & Regulatory Policies

International context

After being signed in December 2015, the Paris Agreement, which sets out an international action plan to tackle global warming, entered into force in November 2016. More than 140 countries, accounting for over 80% of carbon dioxide emissions, ratified the Agreement in record time, establishing a new regime for efforts to achieve its three key objectives: limiting the rise in global mean temperature to well below 2°C with a zero-net emissions target by mid-century; promoting a low-carbon and climate-resilient economy; and making finance flows consistent with climate objectives. In 2017, the issue of climate change is still at the top of the international agenda.

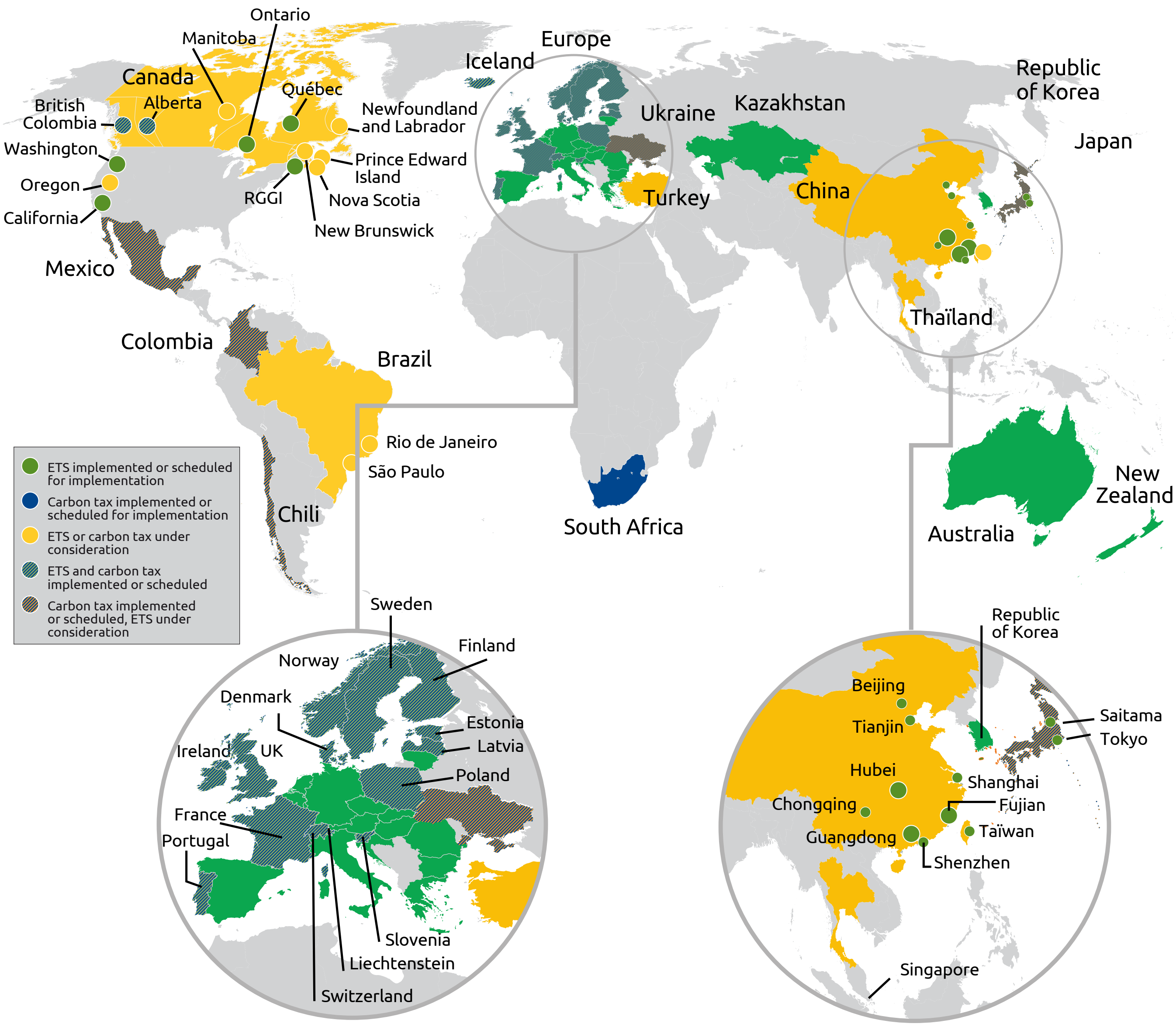
Three key trends observed in 2017

1. **The motivation of Member States on the implementation of the Paris Agreement remains strong. The USA's exit from the Paris Agreement will not have a strong impact on the dynamic of energy transition at USA or global levels.** The latest G7 and G20 meetings in 2017 cited climate change in their conclusions and called for action. Most G7 and G20 members, except the USA, have progressed in the definition of their national climate strategy. The implementation of the Paris Agreement is also essential for achievement of the sustainable development goals, and provides a roadmap for action on climate change for less economically developed countries.
2. **Private sector involvement in the transition towards a low-carbon economy is still growing.** The business community, including energy and industry, as well as financial sectors, has made concrete progress by mobilizing capital flows and developing low-carbon technologies or new business models to shift towards low-carbon and more climate-resilient growth. Coalitions of companies, in particular from the power and oil sectors, are calling on governments to increase their objectives and implement carbon-pricing policies all around the world, even in the USA.
3. **Carbon pricing is an essential part of action on climate change.** The report of the High-Level Commission on Carbon Prices, led by Joseph Stiglitz and Nicholas Stern and published in May 2017, states that carbon pricing policies are a necessary part of an effective strategy to reduce greenhouse gas (GHG) emissions. The Commission proposes an indicative price corridor of \$40-80/tCO_2 in 2020 increasing to \$50-100/tCO_2 in 2030. This level may differ from country to country and will be adjusted over time. However, carbon pricing alone is not enough. It needs complementary strategies such as innovation policies and appropriate regulations, in particular for renewable energies and energy efficiency, to facilitate the low-carbon transition by overcoming non-economic barriers and the consideration of long-term climate objectives.

State of global carbon pricing policy development in 2017

As at 2017, more than 40 national and 25 subnational jurisdictions have put a price on carbon, as shown in figure 1.1. Over the past decade, the number of jurisdictions with carbon pricing initiatives has doubled. These jurisdictions are responsible for about a quarter of global GHG emissions. On average, carbon-pricing initiatives implemented and scheduled for implementation cover about half the emissions in these regions. These numbers translate to a total of about eight gigatonnes of carbon dioxide

Figure 1.1 A global map of carbon pricing policy initiatives



Source : Carbon Pricing Watch, Ecofys, World Bank, May 2017 - WEMO2017

equivalent or about 15% of global GHG emissions.

Next steps in international climate negotiations

The first important step in implementing the Paris Agreement will come in 2018 with the facilitative dialogue. This aims to take stock of collective efforts towards limiting the global temperature rise to 1.5-2°C and to demonstrate that the transformation to a decarbonized, climate-resilient world is underway. This facilitative dialogue between countries, organized by the United Nations Framework Convention on Climate Change (UNFCCC), will be informed by a new Special Report by the Intergovernmental Panel on Climate Change (IPCC) on the impact of global warming of 1.5°C above pre-industrial levels and related global GHG emission pathways, expected to be published by spring 2018. The facilitative dialogue in 2018 will be followed by a global stocktake every five years, starting in 2023.

Europe

Key messages in 2017:

- **EU 2020 climate and energy targets on track to be achieved**
- **EU 2030 GHG policies are being negotiated among Member States:**
  - **In particular, the post-2020 EU Emissions Trading System (ETS) reform package is still under discussion and should be finalized before the end of 2017.**
  - **The EU 2030 "Clean Energy for all Europeans" package was published in November 2016, with legislative proposals on renewable energy, energy efficiency, the organization of the electricity market, and the governance of the Energy Union.**
- **Brexit is likely to have an impact but it is unclear when and what that might be.**

The 2020 climate and energy package: on track to be achieved

The 2020 climate and energy package sets three targets at European level, in terms of GHG emissions reduction, renewables and energy efficiency.

The target of a 20% reduction in GHG emissions by 2020 has already been achieved

- In 2015, GHG emissions in Europe had decreased by 22.1% compared to 1990 (figure 1.2).
- The projection of GHG emissions based on Member States' existing policy measures shows the EU is on track to reach the 2020 target.
- Emissions covered by the EU ETS were lower in 2016 than the goal for 2020. A significant surplus of emission allowances has built up, undermining the scheme's credibility (see next section).
- With regard to national ESD targets, 16 countries have already reduced their emissions and met their national targets. Emissions increased in three countries, but among them, only Malta went above its target; 10 Member States are still above their national reduction targets.

EU GHG targets and regulations

The European Union (EU) committed to a 20% GHG emissions reduction target by 2020 compared with 1990 levels, excluding GHG emissions from the land sector but including those from international aviation. There are two main policy instruments to achieve this target:

- **The European Union Emissions Trading System** (EU ETS), which limits GHG emissions from more than 12,000 heavy energy-using installations and EU airline flights (see below). Sectors covered by the EU ETS – except aviation – have to reduce their emissions by **21% by 2020 compared to 2005 levels;**
- The **Effort Sharing Decision** (ESD), which covers emissions from road transport, buildings, agriculture and waste. EU countries have taken on national binding targets for the period to 2020, which will collectively deliver a reduction of around **10% in total EU emissions from the relevant sectors compared to 2005 levels.** Targets range from a 20% emissions reduction by 2020 (from 2005 levels) to a 20% increase, reflecting differences in wealth and starting points. To achieve these targets, a linear path is defined for each Member State, which sets a maximum annual amount of emissions for each sector. However, Member States can resort to flexibility mechanisms, such as carry-forward or banking of emissions allocations, and transfers between Member States.

EU renewable energy target by 2020

The EU 2020 target for renewable energy sources (RES) is to increase the share of renewables in gross final energy consumption to 20% by 2020, with a specific target of a 10% share in the transport sector.

- Member States have adopted national targets under the Renewable Energy Directive, which vary according to each country's starting point and potential: from 10% for Malta to 49% for Sweden.
- Member States published National Renewable Energy Action Plans (NREAPs) in 2009, explaining how they intended to achieve their target. Each NREAP describes the national renewable energy targets for the different sectors (electricity, heating and cooling, and transport), the planned mix of different renewable technologies, and the policy measures to be implemented.

What drove the decline?

- Structural changes in the European economy have driven a decline in emissions since the 1990s.
- In 2008-2009, GHG emissions decreased sharply because of the reduction in industrial production during the economic downturn.
- Since 2010, improvements in energy efficiency and the development of RES have contributed greatly to the reduction of emissions.

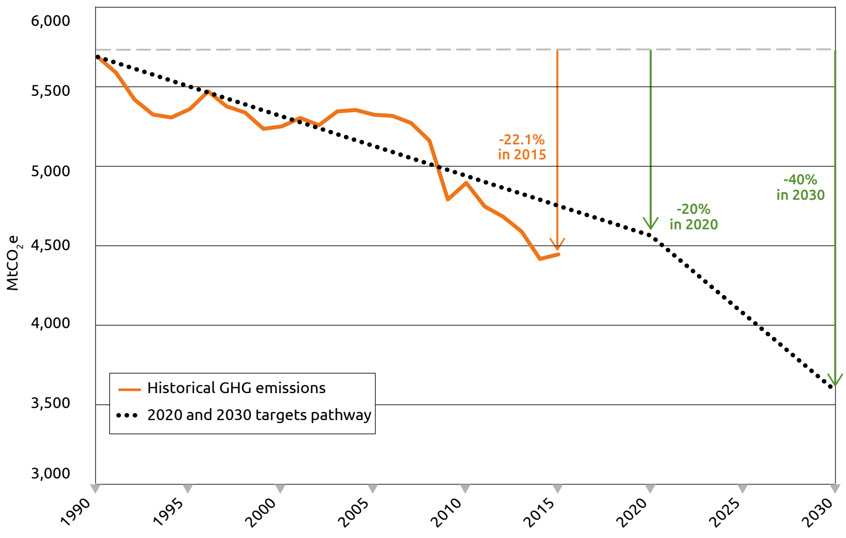
On track to achieve the EU target of a 20% renewables share by 2020

- The share of renewable energy reached 16.7% of gross final energy consumption in the EU in 2015, almost doubling its 2004 share of 8.5%.
- By 2015, 10 Member States had already met their 2020 targets, and the share of renewable energy in gross final energy consumption ranged from 5% in Luxembourg to 53.9% in Sweden (figure 1.3).
- This increase was mainly driven by support schemes and falling costs for renewable technologies.
- However, some recent restrictions in the support for new renewable energy projects reduced their profitability and created uncertainty for investors.[1]

What are the most important RES in Europe?

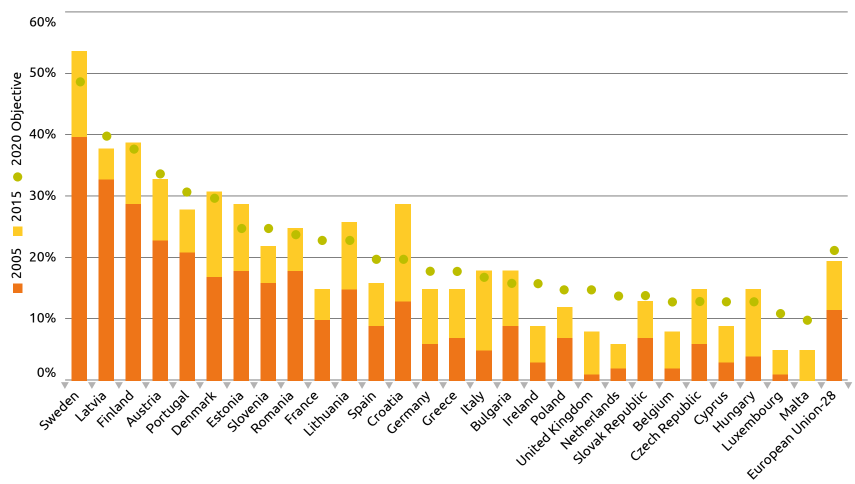
- Overall, biofuel remains the most important renewable energy source in the EU. In 2015, solid biofuels, renewable waste, biogas and liquid biofuels provided 64.4% of the total gross consumption of renewable energy.
- In the power sector, renewables grew steadily, accounting for 28.8% of electricity generation in 2015, compared with 14.4% in 2004. Hydropower remains the largest source, even though wind and solar power are growing the fastest.
- In the transport sector, renewables are increasing slowly, in particular because since 2011 biofuels have had to comply with sustainability criteria as defined in the Renewable Energy Directive, which were transposed into national law quicker in some Member States than in others. In 2015, the overall

Figure 1.2 EU-28 greenhouse gas emissions evolutions and targets to 2020 and 2030



Source: Institute for Climate Economics (I4CE) with data from the European Environment Agency and the European Commission, 2017.

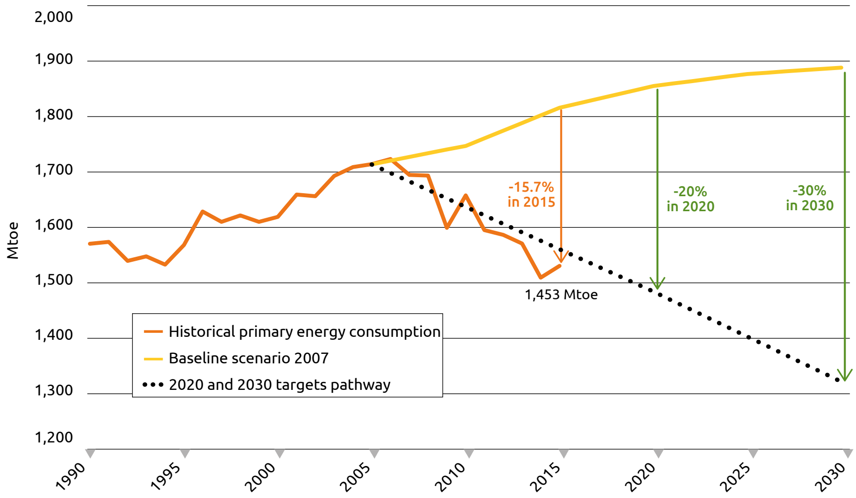
Figure 1.3 Share of renewables in the Member States' gross final energy consumption



Source: Institute for Climate Economics (I4CE) with data from Eurostat and the European Commission, 2017.

1 EEA, 2017, https://www.eea.europa.eu/publications/renewable-energy-in-europe-2017

Figure 1.4 EU-28 primary energy consumption evolution and targets to 2020 and 2030



Source: Institute for Climate Economics (I4CE) with data from Eurostat and the European Commission, 2017.
*Notes: * The EU baseline scenario 2007 starts with the 2005 base year and accounts for policies implemented until the end of 2006.*

EU Energy Efficiency target by 2020

The EU set a target of a 20% increase in energy efficiency by 2020, which corresponds to a decrease of 20% in primary energy consumption compared to a baseline scenario established in 2007 .

- The 20% reduction corresponds to an absolute target of total primary consumption below 1,453 Mtoe (million tonnes of oil equivalent) at the EU level (figure 1.4) or final energy consumption below 1,086 Mtoe. It is equivalent to a 13.4% reduction in primary energy consumption in 2020 compared to 2005 levels.
- The Energy Efficiency Directive (EED) also establishes a set of binding measures to help incentivize more efficient use of energy at all stages of the energy chain, from production to final consumption. Under the Directive, Member States have to draw up National Energy Efficiency Action Plans (NEEAPs) every three years, to explain their estimated energy consumption, planned energy efficiency measures, and expected improvements.

share of renewable energy in transport was 6.7 % in the EU.

Efforts on energy efficiency need to continue in order to meet the 2020 target

To reach the EU's 20% energy efficiency target by 2020, Member States have set their own indicative national energy efficiency targets. Among the more ambitious targets are those of Austria, Belgium, France, Germany, Malta, the Netherlands, Sweden and the UK.

- The sum of the 28 indicative targets amounts to a primary energy consumption of 1,526.9 Mtoe (million tonnes of oil equivalent) in 2020, which is only equivalent to a 17.6% decrease compared to the baseline scenario, and falls short of the 2020 target.
- An assessment[2] by the Commission in February 2017 stated that in spite of the slight increase in energy consumption in 2015 (after 2014 being a particularly warm year), the EU should be able to achieve its 2020 target.
- Efforts should not be decreased – particularly in the building and transport sectors.

The challenge of designing the 2030 climate and energy package: new proposals and first negotiations in 2017

Although the European Council agreed, in October 2014, a climate and energy framework for the EU until 2030 – and adopted targets for GHG emissions reductions, renewables and energy efficiency – discussions around the proposed legislation are still ongoing. These targets for 2030 were submitted to the UNFCCC on March 6, 2015 as the EU Intended Nationally Determined Contribution (INDC), but in 2017

2 Report by the Commission to the European Parliament and the Council – Assessment of the progress made by Member States towards the national energy efficiency targets for 2020 and towards the implementation of the EED 2012/27/EU as required by Article 24(3) of EED 2012/27/EU, downloadable from: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0056&from=EN

the EU debate is developing around European Commission (EC) proposals for each piece of this package.

A 40% GHG emissions reduction target by 2030

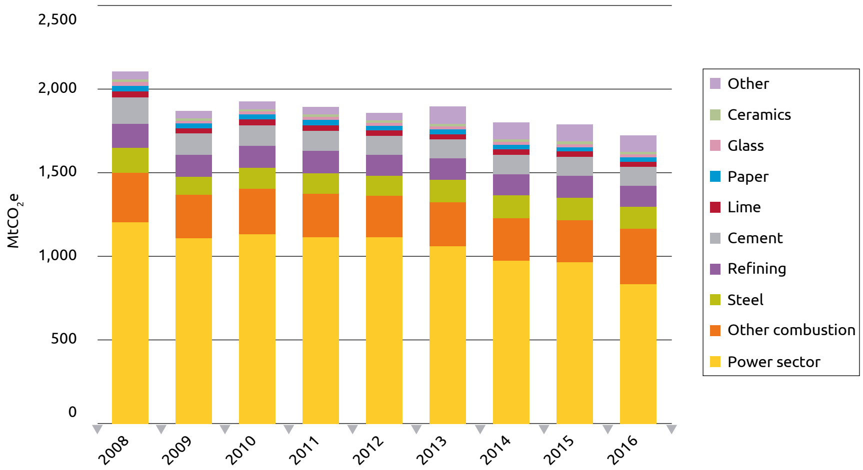
EU leaders have agreed to a target of a 40% reduction in GHG emissions by 2030, compared to 1990 levels, which is in line with the lower end of the long-term EU goal of an 80-95% reduction by 2050.

The 2030 target is to be delivered through:

- Reductions in ETS sectors (industry and energy sectors) with a 2030 target of 43% compared to 2005. The EU ETS is currently being revised for the post-2020 period (see below);
- Reductions in non-ETS sectors with a target of 30% compared to 2005 levels.

On July 20, 2016, the European Commission (EC) published a legislative proposal for an Effort Sharing Regulation for the period 2021-2030. This uses the same methodology as the current ESD and sets binding annual GHG emissions targets for Member States, covering non-ETS sectors of the economy. The proposed regulation maintains existing ESD flexibilities for EU countries and provides two new flexibilities: some eligible Member States would be allowed to achieve their national targets by covering some emissions in non-ETS sectors with EU ETS allowances that would normally have been auctioned; and Member States will be allowed to use some credits from the land use sector, with certain conditions, to meet national targets. While these flexibilities increase the cost-efficiency of the policy, they also decrease its ambition to a certain extent. The proposed national targets for emissions reduction range from 40% down to 0% in 2030 compared to 2005 levels.

Figure 1.5 GHG emissions in phases 2 and 3 of the EU ETS



Source: Institute for Climate Economics (I4CE) with data from EUTL, 2017

The Parliament voted on the proposal in June 2017; while negotiations have not succeeded yet in the Council.

Targets for renewables and energy efficiency are not intended to be nationally binding

In November 2016, publication of the "Clean Energy for all Europeans" package completed the EC's legislative proposals for the implementation of the 2030 Climate and Energy framework. In particular, the EC published legislative proposals on the Governance of the Energy Union, renewable sources of energy, energy efficiency, and the organization of the electricity market.

2030 targets for energy efficiency (30% in 2030, see figure 1.4) and renewable energy (27%, see figure 1.3) would be binding at European level, without being translated into national binding targets. An iterative process between the Commission and Member States described in the proposed Governance regulation is

The EU ETS

- Launched in 2005, the EU ETS covers more than 12,000 industrial plants and power stations in the EU and in Iceland, Liechtenstein and Norway, as well as aircraft operators for flights within this zone, representing approximately 45% of total GHG emissions.
- The EU ETS is now in its third phase, and is being revised for the post-2020 period.
- In this third phase (2013-2020), a single, EU-wide cap on emissions applies. The cap on power plants and other fixed installations decreases annually by an amount equivalent to 1.74% of the average annual total quantity of allowances issued by Member States in the period 2008-2012, which will lead to a 21% reduction in 2020 compared to 2005 levels. A separate cap applies to the civil aviation sector, equivalent to 95% of the average annual level of emissions in the years 2004-2006.

Twelve years after the EU ETS was introduced as the cornerstone of EU climate policy to promote reductions of GHG emissions in a cost-effective way, a significant surplus of allowances and continued depressed prices are questioning its credibility

meant to ensure that the EU is on track to meet its objectives.

The different pieces of this legislative package are currently under negotiation in both the Parliament and the Council.

The EU ETS

The EU ETS is on track to achieve its 2020 target but its credibility has been undermined

- GHG emissions from fixed installations within the scope of the EU ETS decreased by more than 18% in 2015 compared to 2008 and amounted to 1,734 $MtCO_2eq$ (metric tons of carbon dioxide equivalent), which is below the 2020 cap of 1,816 $MtCO_2eq$ (figure 1.5).

Why is the EU ETS carbon price so low?

- The decrease in emissions has been particularly sharp in the power sector, driven mainly by the increasing penetration of renewable energy sources.
- Current low European Emission Allowances (EUA) prices reflect that no additional emissions reductions are required to achieve the 2020 target. A surplus of allowances has been building up in the EU ETS since 2009, amounting to around 2.1 $GtCO_2eq$in 2013. In January 2017, it was equal to around 1.7 $GtCO_2eq$[3] as a consequence of backloading, which consisted of postponing the auction of 900 million allowances over the period 2014-2016 until 2019-2020. The deployment of renewables had a strong impact on emissions reductions, but as the renewables objectives were taken into account when the cap was set, only achievements in excess of those objectives have an impact on the surplus. However, the Energy Efficiency Directive, which was enforced in 2012, after the cap was set, was not taken into account, and neither was the use of international Kyoto credits[4]. The unforeseen economic downturn in 2008-2009 also had a significant impact on the surplus.
- Current low EUA prices do not reflect the long-term target. This surplus undermines the credibility of the EU ETS and its price signal. Low carbon prices (figure 1.6) may lead market participants to disregard early abatement options.
- Uncertainty around Brexit is another factor undermining the credibility of the EU ETS. It is not yet known whether the UK is actually exiting the EU ETS and, if it does, when this transition would take place and how the EU ETS design parameters would be adjusted.

3 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017XC0513(01)&from=EN

4 The Kyoto protocol defined two project-based mechanisms, the Clean Development Mechanism (CDM) and the Joint Implementation (JI), which generate carbon credits from CO_2 emissions reductions linked to projects implemented, respectively, in non-Annex B and Annex B countries. In the EU ETS, operators are allowed to use CDM and JI carbon credits between 2008 and 2020 for their compliance under some quantitative and qualitative limits.

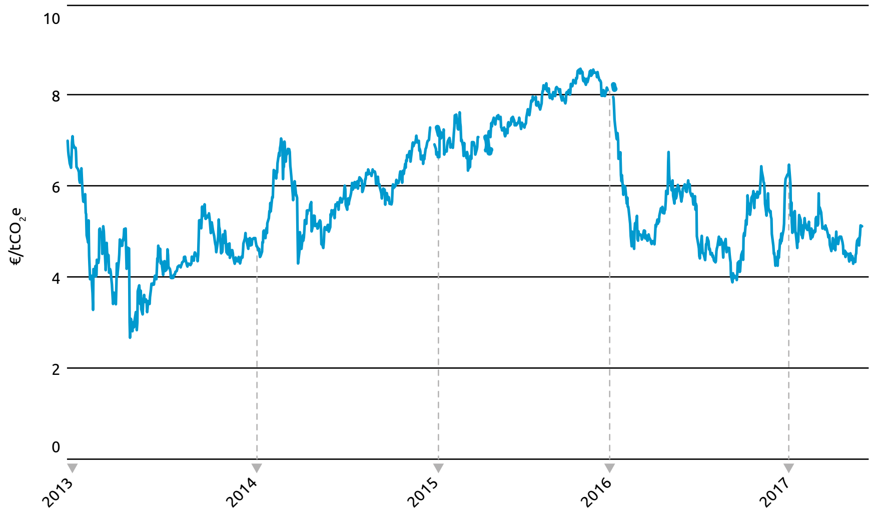
Towards phase 4: the post-2020 reform is still under negotiation

An initial step in the reform of the EU ETS was the backloading measure, agreed in 2014. A second step will be the implementation of the Market Stability Reserve (MSR), agreed in 2015, whose objective is to regulate the long-term surplus by applying thresholds for the total amount of allowances circulating in the market. The MSR will be implemented in 2019 but will not be sufficient to address the surplus, due to the interaction between the EU ETS and complementary climate policies.

Finally, as a third step, with the release of the proposal for a revised EU ETS directive in July 2015, the EC suggested new design elements for its fourth phase, for the EU ETS to drive the decarbonization of EU energy and industrial sectors beyond 2020.

In February 2017, the European Parliament and the Council adopted their respective positions on this post-2020 EU ETS reform proposal. The trilogue **between EU institutions started on April 4,** with negotiations focusing on strengthening the EU ETS and on carbon leakage. Given the divergence of opinion on a number of elements, there is still uncertainty on the possible outcome of the trilogue, which is expected to succeed in autumn 2017.

Figure 1.6 EUA spot prices in the EU ETS (2013 - 2017)

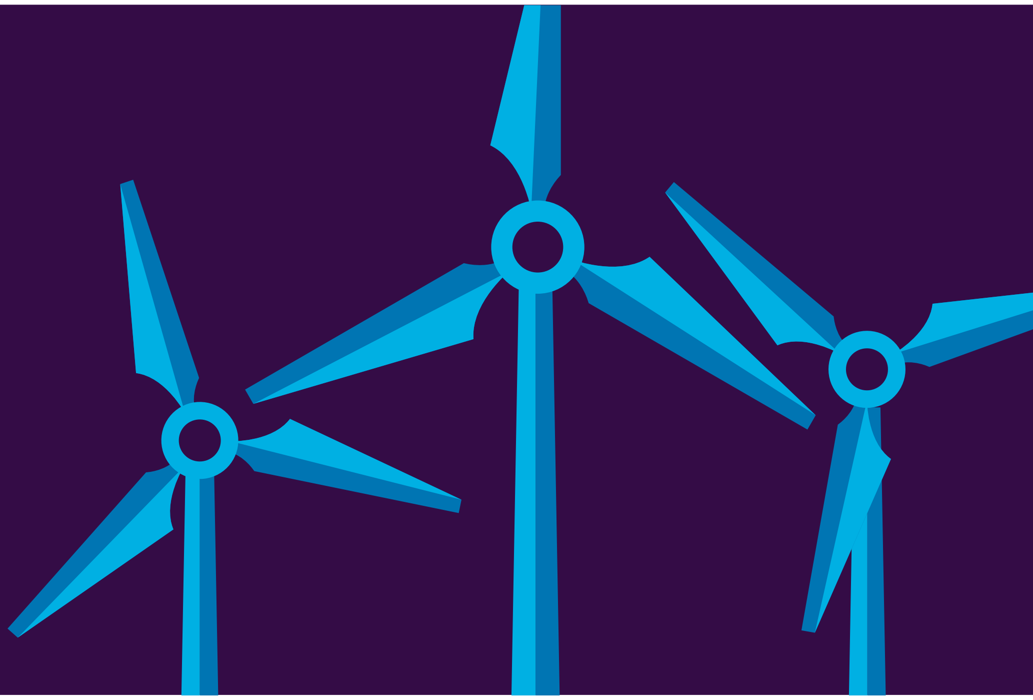


Source: Institute for Climate Economics (I4CE) with data from ICE Futures Europe, 2017

What are the key elements of the post-2020 EU ETS reform?

- An increase in the speed of decline of the annual emissions cap,
- A doubling of the MSR intake rate during its first years of functioning, compared to what was agreed in 2015,
- A cancellation of some of the allowances held in the MSR,
- Changes in the allocation rules regarding free allowances to industries deemed to be exposed to carbon leakage.

Energy Transition



More than

21 GW

of renewable power capacity was added in 2016 in the EU. This represents

90%

of the total power capacity added in Europe

Energy transition is moving to the top of the EU political agenda

A few months after US withdrawal from the Paris Agreement, Europe leads the way regarding energy transition

- Trump's decision to leave the Paris Agreement led to widespread condemnation and saw European members forging new alliances inside the EU but also with emerging economies.
- For example, during the EU-China summit of June 1-2, 2017, delegates decided to co-host with Canada a major ministerial gathering in September to advance the implementation of the Paris Agreement and accelerate clean energy transition.
- Similarly, India has reiterated its commitment to produce 40% of the country's electricity from renewable sources by 2040.

EU countries step up climate change efforts, launching renewables targets for 2030

- **The EU is on track to meet the 2020 renewable energy (RE) target aiming at a 20% RE share:** in a report published in 2017, the European Commission (EC) estimates that the EU achieved a 16% RE share of final energy consumption in 2015.
- **New target for 2030:** Member states have already agreed on a new RE target of at least 27% of final energy consumption in the EU by 2030[1].
- **New market reforms launched:** on November 30, 2016, the EC introduced a package of measures – "Clean Energy for All Europeans" – that will reform Europe's energy landscape (see figure 2.1). However, tripartite discussion between the Commission, the Parliament, and the Council is likely to continue and this package is not expected to be validated before 2019. After validation, the package will need to become part of national legislation.

Just one year into Brexit, the impact on the European energy sector is still unclear (see Topic Box 2.1)

- One year after the UK's decision to leave the EU, political uncertainty remains high. So far, the UK

1 November 30, 2016: The Commission published a proposal for a revised Renewable Energy Directive

Figure 2.1 Clean Energy Package – Renewables and Energy Efficiency

PROMOTE THE BETTER INTEGRATION OF ELECTRICITY PRODUCED FROM RENEWABLE SOURCES INTO THE MARKET: (1)

The recast Directive sets clear objectives for renewables with:

- An average of **27% share of renewables energy** at the EU-level by 2030 (binding target at the EU level but no individual member targets
- **The limitation of the use of biofuels** coming from food crops
- **A 1% increase** each year of the **share of renewable heating-cooling**
- **A streamlined permitting process** (»one-stop-shop»)
- **A support schemes** open to other Member States
- The **preservation of the guarantees of origin**

Renewable energy deployment facilitated through:

- A **support mechanisms** granted in an «open, transparent, competitive, non-discriminatory and cost -effective manner»
- A **new requirement** on the stability of financial support to ensure renewable energy projects are «not altered in a way that negatively impacts the rights conferred or the economics of supported projects»
- A **renumeration for surplus production** fed to the grid by renewable auto-producers (with conditions) which reflects the market value of the electricity fed in
- The **removal of the rules on priority grid access** for renewables (garantee given by TSOs and DSOs to connected renewable generators that they will be able to sell and transmit their electricity)

PROMOTE THE BETTER INTEGRATION OF ELECTRICITY PRODUCED FROM RENEWABLE SOURCES INTO THE MARKET:

Reinforcement of energy efficiency 2030 targets: (2)

- **30% binding energy efficiency target** at EU level, but no mandatory country-level target (only indicative national targets)
- Specific requirements for **energy savings** to be implemented and controlled

Extension of **consumer rights:** (2)

- **Competitively priced meters** reflecting actual energy comsumption
- **Accurate billing** and **consumption information**

New directive on the **Energy Performance of Buildings:** (3)

- Renovation targets, energy performance certificates, inspection, monitoring and control of energy use and the presence of electrical recharging points

(1) Proposal for a recast of the Renewable Energy Directive;
(2) Proposal for a revised Energy Efficency Directive;
(3) Proposal for a revised Energy Performance of Buildings Directive;

Source: Capgemini Consulting, WEMO2017

has played a significant role in influencing EU energy policies and has been at the forefront of liberalization initiatives. It is unclear how future European energy policies will develop.

- Regarding the UK policy, Brexit has created investment uncertainty in the energy sector and widespread fear that climate change targets will be lowered. The 2008 Climate Change Act required the country to reduce its GHG emissions by at least 80% by 2050 compared with the 1990 baseline. The future relationship between the UK and EU in relation to the Emissions Trading System (ETS) is particularly problematic (British installations included in the ETS represent around 9% of EU emissions).

The shift towards a more renewable energy mix continues, with important breakthroughs in 2016

- More than 21 GW of renewable power capacity[2] was added in 2016 in the EU. This represents 90% of the total power capacity added in Europe.

Europe

2 https://www.theguardian.com/environment/2017/feb/09/new-energy-europe-renewable-sources-2016

Topic Box 2.1 : Will Brexit necessarily disrupt the legal framework applicable to the British energy sector?

Christine Le Bihan-Graf

Since March 2017, following Britain's decision to withdraw the UK from the European Union (EU), the British government and EU institutions have been negotiating an agreement that sets out the nature of the UK's future relationship with the EU[3].

Notwithstanding the ongoing negotiations, some potential consequences of Brexit on the legal framework applicable to the British energy sector can be presented.

From a legal point of view, the main consequence of Brexit is the cessation of the application of European law in the UK. Naturally, EU institutions in charge of the design of European law or in control of its implementation[4] will lose their authority and power to decide on issues relating to the UK.

Consequently, the UK will be free to implement energy policies without regard to European regulatory requirements currently in force and with no overall control by EU institutions[5].The UK will still be subject to the requirements of previous directives because these have been transferred into national law, but it will be able to freely repeal them or modify their requirements.

At this time, it is difficult to predict how much British law will move away from European regulation (especially as it will probably depend on the political orientation of successive governments). That said, most observers consider the UK will probably continue to comply with the main European requirements[6], because it has always been a consistent supporter of EU energy sector initiatives.

However, the UK should be excluded from European mechanisms that have been created to regulate the energy market. For example, British industry should not be authorized to participate in the EU Emissions Trading Scheme or to access information set out in the REMIT system[7]. In addition, the British government recently announced the UK's withdrawal from the European Atomic Energy Community (Euratom)[8].

Brexit also poses significant challenges for energy infrastructure.

First, the UK should no longer be eligible for financial support from the European Investment Bank, which regularly funds power projects.

In addition, concerning UK interconnections, there are questions to be resolved regarding the application of European requirements regulating the operation of energy infrastructures (European gas target model, network code on interoperability and data exchange rules, etc.). However, the British government has indicated it wishes to continue the development of interconnections, as evidenced by recent approval of the interconnection project with France[9].

Beyond the legal framework specifically applicable to the energy sector, EU economic law will no longer apply in the UK (free movement of capital, prohibition of state aid, etc.).

However, similar requirements are often provided by other agreements, separate from the EU, such as the Agreement on the European Economic Area[10] or bilateral agreements with Member States.

Consequently, any appreciation of the effects of Brexit on the legal framework applicable to the British energy sector needs to take into account any agreements decided by the UK. This will require case-by-case assessment.

3 Brexit will be effective as of the date of entry into force of this agreement or, at the latest, in March 2019.

4 European Commission, European Parliament, European Court of Justice, etc.

5 Including the Agency for the Cooperation of Energy Regulators, which directly depends on the EU.

6 Control of the energy market by an independent authority; separation of ownership and operation of electricity/gas transmission systems from generation, production and supply interests; standards of transparency; non-discriminatory network access, etc.

7 Regulation on wholesale energy market integrity and transparency.

8 Euratom is a treaty agreed by all EU Member States but is separate from the EU. It aims to pursue nuclear research and training activities with an emphasis on continually improving nuclear safety, security and radiation protection within the framework of a centralized monitoring system.

9 In December 2016, because of Brexit, the French energy regulator (CRE) withheld its decision on the new interconnection project between the UK and France. The project was finally approved on February 19, 2017.

10 The EEA covers all the Member States of the EU and some other countries (such as Iceland, Liechtenstein and Norway).

Decarbonization of the energy sector is underway: Europe is on track to meet its 2020 targets but the path to 2030 remains uncertain

Temperatures are steadily increasing

- Analysis of European air temperatures confirms that 2016 was Europe's fourth warmest year on record, following 2014 and 2015 when records were also broken.
- In 2016, most of Europe was warmer than the long-term average using 1981-2010 as a baseline. The strongest warming occurred in the eastern part of Europe, with air temperatures reaching up to 2.5°C above the long-term average value[11].

CO_2 emissions stabilize during 2016

- Based on Eurostat estimates, CO_2 emissions from energy use dropped by 0.4% overall in Europe, following an increase in 2015. However, the trend differs greatly between countries: UK emissions dropped by 4.8% between 2015 and 2016, but emissions in Finland and Denmark increased by 8.5% and 5.7% respectively.
- The share of gas-fired generation increased, displacing coal and resulting in 48 Mt less CO_2 in the power sector[12].

Renewables investment still a key focus in decarbonization

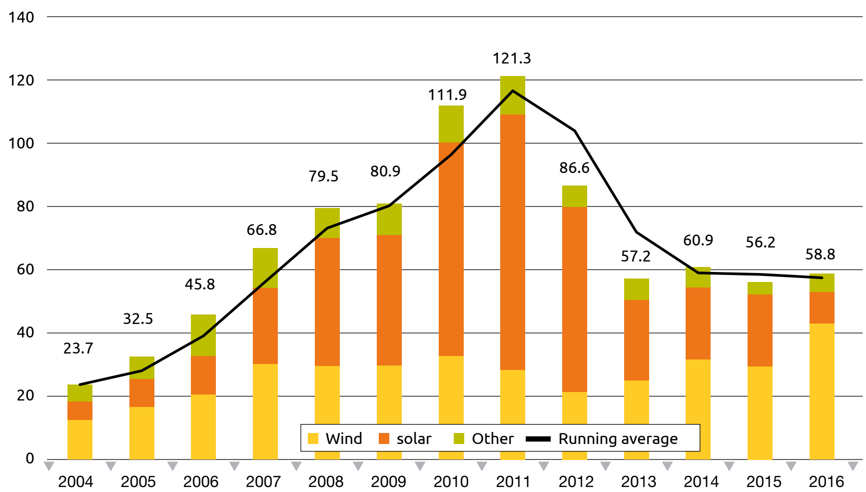
- Investment in renewables rose modestly to nearly €59 billion in 2016 compared to €56 billion in 2015, driven by wind and solar photovoltaic (PV)[13]. Low interest rates and enthusiastic international

• The renewable energy sector employed **1.1 million** people in Europe.

• The wind industry is **the biggest** employer with **330,000** employees

Europe

Figure 2.2 New investments in clean energy in Europe: 2004 - 2016 ($bN)



Note: 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).
Source: Bloomberg New Energy Finance

11 https://public.wmo.int/en/media/news/european-climate-2016-marked-warm-nights-and-major-floods

12 Energy transition in the power sector in Europe: State of Affairs in 2016, Agora Energiewende, January 24, 2017

13 http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf

investors supported a favorable investment environment.

- Europe's share in the global renewables market decreased from 47% in 2010 to 25% in 2016, ranking Europe as the second largest renewables market behind China with a 32% share of investment.

Renewables contribute significantly to job creation in Europe

- The renewable energy sector employed 1.1 million people in Europe based on 2015 reports (direct employment), which represents just over 10% of global renewable energy employment. Because of their large hydropower base, China, India and Brazil are the largest renewables employers.
- In Europe, the wind industry is the biggest employer with 330,000 employees. Recent austerity measures have undercut employment in onshore wind but the surge in offshore wind installations in the UK, Germany and Denmark is offsetting job losses.
- Employment in the solar PV industry has weakened in the context of a significant downturn in installations and fierce competition between European and Asian solar manufacturers: now with 114,450 employees (direct and indirect), it has lost two-thirds of jobs since 2011[14].

Europe exceeded its indicative renewable energy target for 2015 but achieving the 2030 RE targets will be more challenging[15]

- The share of renewable power generation in the European mix is increasing as cost-competitiveness improves and support policies are gradually reduced. In several countries in Europe (such as Portugal, Ireland), the share of renewable electricity exceeds 20-30% of total electricity consumption. In Portugal, renewable energy sources generated enough power to meet the country's demand over four days during 2016 (some fossil-fuel-generated power was stored in pumped hydro storage plants). From January to September, renewable sources supplied 61% of demand, mostly due to an increase in average production by hydropower plants and wind farms[16].
- While Europe is on track to meet its renewable heating and electricity targets, transport is lagging behind its 10% renewable energy target, with a 6% share of renewable sources in 2015. Part of the reason for this delay is political uncertainty over the sustainability of certain biofuels. Beyond 2020 the policy for renewable transport is unclear as there will be no binding renewable transportation target at Member State level.
- All but three Member States (the Netherlands, France and Luxembourg) have already exceeded their 2015-2016 indicative renewable energy targets.
- The electricity sector has seen the largest penetration of renewables share, which was estimated to reach 29.6% of generation in 2016.

---

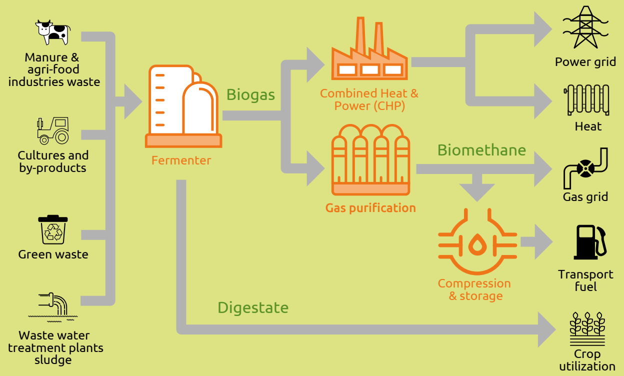
14 https://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Jobs_Annual_Review_2017.pdf

15 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0057&qid=1488449105433&from=EN

16 https://renewablesnow.com/news/wind-farms-in-portugal-break-peak-generation-record-548986/

Topic box 2.2 : Biogas, biomethane

Simplified process of biogas & biomethane production



Sources: Capgemini analysis WEMO2017

Biogas is produced by a process of keeping organic waste in an anaerobic digester for several days. This decomposing process creates biogas that can be transformed into electricity or cleaned, stored and transported to be burnt directly as gas. Biogas can also be upgraded to biomethane with a similar quality to natural gas and can be injected into natural gas grids.

So far, heat and electricity have been the largest segments of biogas usage. But the biomethane-to-grid sector has expanded significantly in Europe over the past few years, reaching 367 biomethane plants across Europe in 2014 with a total annual capacity of 310,000 m³/h.

Germany is the largest biomethane market, followed by the UK and Sweden.

- In Germany, a feed-in tariff (FiT) is applicable for electricity and heat from biogas, depending on the fuel. Bonuses are given for biomethane injected into the grid. The market is slowing down after reductions in FiT levels.
- The UK biomethane market doubled in 2016 owing to attractive incentives (see below).
- Despite its small size in terms of gas consumption, Sweden has been a pioneer in biogas, especially the use of biomethane in transport. The country dedicated 78% of its 1,303 GWh production as fuel for almost 50,000 vehicles in 2014[17]. Biomethane from farm-based biogas production is supported via grants (30% of investment cost reimbursed).
- In France in 2017, 31 units are injecting biomethane into the gas grid, bringing national production to 427 GWh/year[18]. In 2016, 215 GWh of biomethane was injected into the national grid, which represents a 165% increase. French energy agency ADEME estimates that by 2030, up to 30 TWh of biomethane could be injected into the gas grid by 1,400 installations.

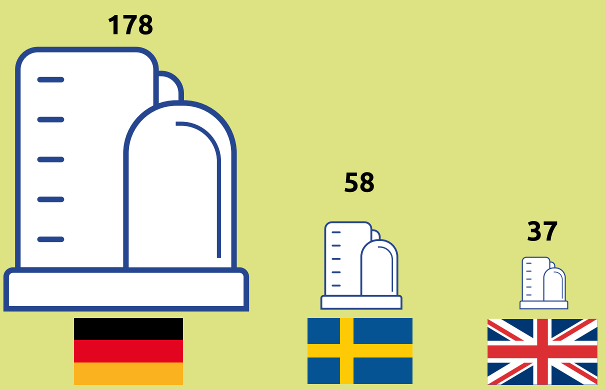
The UK is the fastest growing biomethane market in Europe

Gas is strategic as it accounts for around 40% of the UK energy mix. Fifty plants were completed by the end of 2015, injecting approximately 2.5 TWh/year of biomethane into the gas grid, enough to meet the heating and cooking needs of around 100,000 homes. Approximately 40 plants were completed by the end of 2016.

The main drivers are the Renewable Heat Incentive (RHI) and FiTs. The RHI offers premium payments for heat generated by renewable methods such as anaerobic digestion or biomethane.

However, incentives were reduced in early February 2017 and the industry expects a slowdown in installations.

Number of biomethane plants at end of December 2016



source: European Biogas Association, UK Anaerobic and Bioresources Association; France's Barometer Observ'ER at end of September 2016

17 http://european-biogas.eu/2015/12/16/biogasreport2015/

18 https://www.grdf.fr/dossiers/biomethane-biogaz/unites-injection-gaz-vert-biomethane-reseau

Renewables cost-competitiveness is improving fast

Renewable power generation sources are becoming cost-competitive against conventional sources

- Wind and solar energy are, with hydropower, the main contributors to renewable electricity generation. While renewable projects are still driven by countries' incentives due to EU targets, 2016 saw the first unsubsidized projects announced. CAPEX reduction (applying technology Moore's Law to technology) and productivity gains are some of the drivers leading to greater competitiveness in renewables.

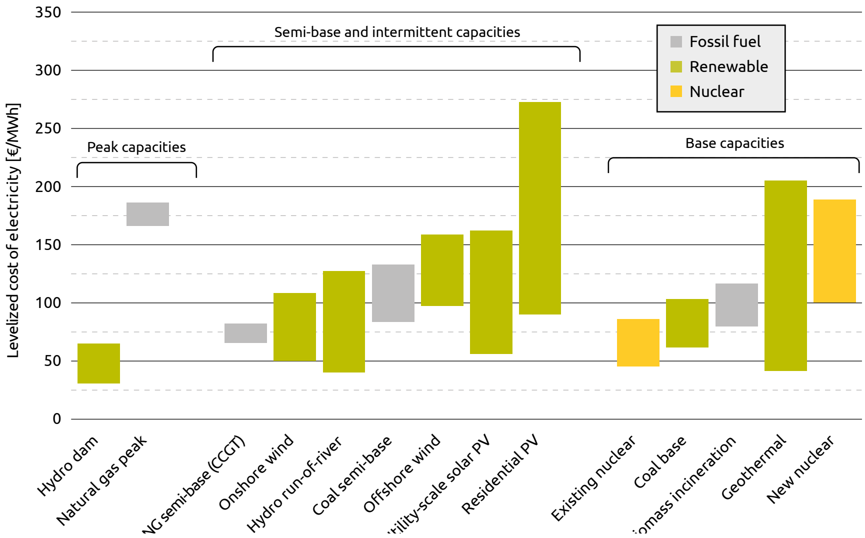
Onshore wind is the lowest-cost renewable power technology in Europe, averaging €75/MWh of LCOE in 2016

- Onshore wind is already cost-competitive with new combined cycle gas turbines (CCGT) being built across most European markets despite declining natural gas prices.
- Incremental technology improvement and larger turbines combined with improved availability explain the decrease in onshore wind LCOE.
- In Germany, bidding prices for onshore wind in the first 2017 tender averaged €57.10/MWh. According to the Spanish Ministry of Energy, 2,979 MW of the 3,000 MW supply of renewable energy will receive €43/MWh (see topic box 2.3 "Spain opens up the renewables market to meet the 2020 RE target"). In comparison, 2016 wholesale power prices averaged €36.6/MWh and €47.1/MWh in France and Great Britain respectively (see annex).

Record low prices in offshore wind tenders highlight steep reduction in offshore wind LCOE

- The offshore wind market continues to grow steadily with another 1.6 GW connected to the grid during 2016, bringing Europe's total offshore wind grid-connected capacity to 12.6 GW[19]. The most notable projects include Horn sea Project One and East Anglia ONE[20] (1,200 MW and 714 MW) in the UK, as well as three German projects over 380 MW (Merkur, Borkum and Arkona). As a result, the industry is maturing with greater standardization of the supply chain and higher investor confidence, enabling lower financing costs.
- The load factor continues to increase thanks to larger turbines – the latest generation of wind

Figure 2.3 Levelized cost of electricity (LCOE) comparison of selected power generation sources in Europe starting production in 2016-2017



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
Source: Capgemini Consulting, IRENA

19 https://windeurope.org/about-wind/statistics/offshore/european-offshore-wind-industry-key-trends-and-statistics-2016/

20 http://www.4coffshore.com/windfarms/east-anglia-one-united-kingdom-uk64.html

turbines are in the range of 10-13 MW whereas the previous generation was around 6-7 MW – and better technology: the load factor for the most recent projects exceeded 40% in the UK and reached almost 50% in Germany.
- Numerous recent auction results for offshore wind projects have attracted attention for the low price of winning bids. In Denmark, offshore wind bids as low as €49.9/MWh were accepted in the Danish Kriegers Flak auction[21]. In the Netherlands, bids for the Borssele III and IV auction were €54.5/MWh. In Germany, bids were approved in April 2017 to build the first offshore wind farms without subsidies. Average bidding prices were €44/MWh for plants to be operational between 2021 and 2025.

Prices of utility-scale solar PV continue to drop. In Europe, the first unsubsidized projects were commissioned in 2016

- In Italy, the Montalto di Castro project (63 MWp) is one of the first unsubsidized projects to be commissioned in Europe. The five plants won't receive any government incentive and will deliver energy to Italian power trader Green Trade for a fixed price under a biennial contract.
- In Germany, the average selling price of the power purchase agreement dropped from €91.7/MWh in 2015 to €69/MWh in 2016. In 2017, the second PV tender closed at €56.6/MWh[22].
- In France, average tariffs resulting from the second period of the invitation to tender for 500 kWp to 17 MWp are decreasing. In July 2017, 77 new winners were awarded a total of 508 MW. The average price was €55.5/MWh for 5-12 MW installations compared with €62.5/MWh in the first period.
- Part of the drop in solar prices arises from the collapse in global solar module prices – modules represent some 40% of CAPEX. In the context of global oversupply driven by a plunge in solar installations in China, solar module prices dropped by 26% during 2016.[23] Furthermore, financing costs are more advantageous than a few years ago due to increasing confidence in renewables projects and the development of alternative funding tools (green bonds, participative funding, etc.).

Figure 2.4 Average bidding prices awarded to large-scale solar PV installations between 2015 and 2017 (€/MWh)

Date	Germany	France
April 2015	91.7	
August 2015	84.9	
December 2015	80.0	
April 2016	74.1	
August 2016	72.5	
December 2016	69.0	
January 2017	65.8	
March 2017		62.5
July 2017		55.5

Source : Federal Network Agency (Bundesnetzagetur) & French Ministry for the Economy and Finance.

In Denmark, offshore wind bids as low as **€49.9/MWh** were accepted in the Danish Kriegers Flak auction.

Europe

21 http://www.4coffshore.com/windfarms/kriegers-flak-denmark-dk37.html

22 http://www.bmwi.de/Redaktion/FR/Artikel/Energie/la-loi-2017-sur-les-enr-adoptee.html http://www.erneuerbare-energien.de/EE/Navigation/DE/Technologien/Solarenergie-Photovoltaik/solarenergie-photovoltaik.html

23 https://renewablesnow.com/news/solar-module-prices-to-fall-another-20-in-2017-bridge-to-india-560621/

Lithium-ion (Li-ion) battery pack prices have seen remarkable cost reductions from $1,000/kWh in 2010 to less than $300/kWh in 2016.

Battery energy storage is ready for market take-off

Dramatic battery cost reductions coupled with changing regulatory frameworks are driving battery storage deployment in Europe, both behind the meter when coupled with solar PV and in front of the meter for grid services and renewables integration

Lithium-ion (Li-ion) battery pack prices have seen remarkable cost reductions from $1,000/kWh in 2010 to less than $300/kWh in 2016[24]. The trend is poised to continue as Asian manufacturers build up capacity and technology improves, driven by synergies between the automotive and power sectors. According to Bloomberg New Energy Finance, Li-ion battery pack prices will drop another 75% by 2030 to $73/kWh.

Li-ion has become the most attractive energy storage technology, capturing over 80% of investment in energy storage globally, and totaling nearly $1 billion in 2016[25]. This is the result of significant reduction in prices but also the versatility of the Li-ion technology allowing it to be used in a wide range of applications.

At the end of 2016, energy storage installations in Europe were estimated at 370 MW/520 MWh[26], doubling 2015 levels. This significant growth comes on the back of self-consumption and large-scale projects for grid services.

Self-consumption has become a major trend in Europe as retail electricity prices climb and governments increase subsidies:

- **Germany** issued an incentive program in 2013 to stimulate the adoption of PV-battery systems for self-consumption. Under the program, the state-owned KfW banking group provides loans and grants to help finance the acquisition. This program has been successful and was extended to 2018. In 2016, the German Energy Storage Association estimates that 25,000 systems[27] were sold in the country and expects that 200,000 will be sold by 2020. In addition, analysis of new PV systems sold in 2016 revealed that half of new PV installations were paired with batteries.
- In the **UK**, solar PV owners still receive a generation tariff premium even when they self-consume (up to 4.18p/kWh) – and continue to receive FiTs for surplus PV exported – which significantly improves the economics of retrofitting an existing solar panel with a battery. In addition, solar installers, severely affected by the slowdown in the residential solar PV market in 2015, are returning to their existing customers to offer batteries.
- The **Swedish** government finances up to 60% of system costs for residential storage (up to a maximum SEK50,000 or $5,600). The scheme will operate until December 31, 2019. To receive the finance, the energy storage system has to be paired with a grid-connected renewable power plant (e.g. wind, solar).

---

24 BNEF – Lithium-ion battery price forecast as of April 2017

25 IHS Markit – Global Energy Storage Outlook of January 2017

26 Battery storage is measured in power (MW) and in energy (MWh)

27 http://www.dfhk.fi/fileadmin/ahk_finnland/Projekte/Geschaeftsreise_PV-Aufdachanlangen_und_Solar_2017/Esitykset/13_Energy_Storage_in_combination_with_PV_and_Solar_Thermal_Energy.pdf

The success of utility-scale tenders for frequency regulation and capacity in the UK highlight the growing cost-competitiveness of Li-ion batteries:

- In 2016, the UK's National Grid awarded some 700 MW of battery storage contracts (Enhanced Frequency Response tender and Capacity Market Auction). These projects will be operational before 2020.
- Similarly, the German primary reserve control market has attracted strong interest, underscored by Eneco and Mitsubishi's announcement to build a 48 MW/50 MWh battery project in Jardelund in north Germany.

Interest in hydrogen surges, driven by fuel cell-based transportation; stationary applications remain at the R&D stage

The global hydrogen market surges, but installations in Europe are slowly advancing. Still significant advances were made in government funding, cost reductions[28], demonstration projects, and fuel cell sales in the European market.

In 2016 the global fuel cell market increased by 60% after years with no change[29], showing some degree of revival of interest for the hydrogen carrier, both in transportation and in stationary applications. As a sign of recognition, the recent proposal for the Clean Energy Package mentioned hydrogen as playing a key role in coupling the different sectors in Europe's energy system.

The combination of hydrogen and fuel cells, has attractive features, such as the ability to link power with gas. Compared to refueling an EV, with batteries that take hours to charge, refueling a fuel cell vehicle (FCV) takes a few minutes. Hydrogen can be stored for several days or transformed into gas ("power to gas") for vehicles and injection into the gas distribution network (under certain technical conditions). Still, in spite of high R&D investment, hydrogen has been outpaced by electric storage and mobility in recent years. Globally, the number of FCVs on the road in 2016 was equivalent to the number of EVs in 2009 – 2,312 FCVs were sold in 2016[30].

Policy focus on hydrogen has increased. The European Fuel Cells and Hydrogen Joint Undertaking (FCH JU) program is granting €1.33 billion over the 2014-2020 period[31] to support H2 developments. The program is working closely with Hydrogen Europe, the association of large industrials involved in hydrogen including Air Liquide, Daimler, Alstom and Air Products. In 2016 the FCH JU financed two projects for fuel cell buses: JIVE (Joint Initiative for hydrogen Vehicles across Europe) and MEHRLIN (Models for Economic Hydrogen Refueling Infrastructure). Only 91 fuel cell buses were operating in Europe previously. JIVE received support of €32 million to supply 144 fuel cell buses in six European countries. In parallel, the MEHRLIN project will deploy seven large hydrogen refueling stations in Europe with the support of a €5.5 million grant.

Hydrogen-based transportation is getting closer to market readiness and 2014-2016 saw noticeable commercial activity. But Europe is still lagging behind Japan and California in terms of sales.

- Globally, the fuel cell market for transportation jumped to approximately 300 MW (2016) from less than 30 MW (2014)[32].
- The Toyota Mirai entered the market in 2015 and accounted for 2,039 sales in 2016, mostly in California and Japan. Only 140 Mirai were sold in Europe.
- An unprecedented 92 H2 refueling stations opened in 2016[33]: 22 stations opened in Europe, 45 in Japan, and 20 in California. In Europe, it is now possible to travel in a FCV from Norway down to northern Italy. As of January 2017, 274 stations are now in service worldwide of which 106 are in Europe.
- Forklift trucks for logistics centers remain a major market: more than 10,000 fuel cell forklifts are in use, mostly in the USA. Europe is considering encouraging this usage.

Last, power-to-gas demonstration projects are developing, but economic viability remains unproven.

- Germany leads the way: 14 pilot and demonstration projects are in operation and 17 are under construction. The largest ones provide 6 MWe (Audi e-gas and Energiepark Mainz) and can produce over 1,000 m3 H2 per hour.
- In France, Jupiter 1000 (1 MW) is now in the permissions and construction phase and will be commissioned in 2018.

28 Notable technology progress was made allowing greater efficiency and cost reduction. According to the US Department of Energy's Fuel Cell Technologies Office, automotive fuel cell costs were slashed by 50% between 2007 and 2015 and the durability of fuel cells has quadrupled since 2006.

29 Source: E4tech, The fuel cell industry review 2016

30 http://ev-sales.blogspot.fr/2017/02/fuel-cells-2016.html

31 Source: http://www.afhypac.org/documents/newsletters/65/Hynovations65.pdf

32 Source: E4tech, The fuel cell industry review 2016

33 Source: LBST; TUV SUD; www.H2stations.org

Electric vehicles become more popular in Europe

New registration of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) reached a record high in 2016 with more than 200,000 sales in Europe (750,000 worldwide), representing a 10% increase compared to 2015. However, this represents only 1.5% of total European sales (13.5 million sold in 2016).

- ***PHEVs accounted for the largest share of EVs sold in 2016 at more than 70%;***
- ***EV installed bases in Europe grew by 47% compared to 2015.***

Support for EVs at EU level is driven by stricter policies for CO_2 emissions with a target of 95g CO_2/km for vehicles starting from 2021. In 2016 the EU published an update of its exhaust emission standards (EURO 6 issued in 2015 for new vehicle sales) for passenger cars and light commercial vehicles, to account for discrepancies between polluting emissions as measured in real conditions and those measured during the vehicle approval process. This update is likely to introduce a wave of initiatives to promote low-emission vehicles and encourage EVs.

Cities are becoming more involved in supporting the adoption of low-carbon transportation solutions, in particular EVs. The cities of Paris, Madrid and Athens announced plans at the end of 2016 to ban diesel cars and vans from the roads by 2025.

Among the main barriers to mass-market adoption are the availability of charging stations, battery autonomy, and charging time. Under the EU Directive on the Deployment of Alternative Fuels Infrastructure (EC, 2014), Member States were required to provide details of their electricity charging stations targets for 2020 by November 2016.

The table below shows key EV support policies in place in the most relevant EU Member States.

Norway still ranks first in Europe. 50,180 EVs were sold in Norway in 2016, making the country the leading market in Europe in terms of sales (previously in second place behind the Netherlands in 2015) thanks to a favorable policy environment which that relies on incentives ranging from tax breaks to road tolls and ferry fees (see figure 2.6). In 2016, Norway remained the country with the highest market share of electric cars worldwide (29% of new car sales), up 5% compared to 2015. The Mitsubishi Outlander PHEV was the most purchased electric vehicle in 2016, making it the first plug-in hybrid vehicle to lead this market.

Main applicable EV support policies in 2016 (non-exhaustive list)	
Norway	• No purchase tax and exemption from the 25% value added tax (VAT) on purchases of BEVs until 2020 • To promote PHEVs, further purchase bonuses and purchase tax incentives in 2016 (25% VAT exemption) • No road tolls or ferry fees • From 2016, free parking decided at municipal rather than central level
France	• Eco bonus-malus scheme calculated on a CO_2/km basis (bonus of €6,300 ($6,900) for BEVs and €1,000 ($1,100) for PHEVs; up to €10,000 ($11,000) for BEVs and €3,500 ($3,900) for PHEVs when returning an old diesel car) • Company-granted tax rebates for EVs • From 2017, government fleet commitment of 50% of renewals being EVs, and 20% for local authorities
Netherlands	• In 2016, exemption from registration tax for BEVs, and €6/g CO_2/km for PHEVs. In 2017, increase of registration tax to €20/g CO_2/km for PHEVs • Ownership tax exemption for BEVs, 50% discount for PHEVs (€400 to €1,200 for conventional cars) • Private use of a company car: taxation based on CO_2/km (in 2016: 4% income tax for BEVs; 15-21% for PHEVs) • EVs are considered as tax deductible investments for companies
United Kingdom	• Subsidy for 35% of the cost of a car, up to a maximum of £2,500 (PHEVs) or £4,500 (BEVs) • Tax incentives: fuel duty exemption, vehicle excise duty exemption for BEVs and discount for PHEVs, reduced taxation for company cars • Go Ultra-Low City scheme (pro ultra-low emission vehicles (ULEVs) measures in a number of UK cities, including London): e.g. exemption from congestion charge, electric vehicle supply equipment (EVSE) deployment, free parking, and bus lane access

Source: IEA - Global EV Outlook 2017

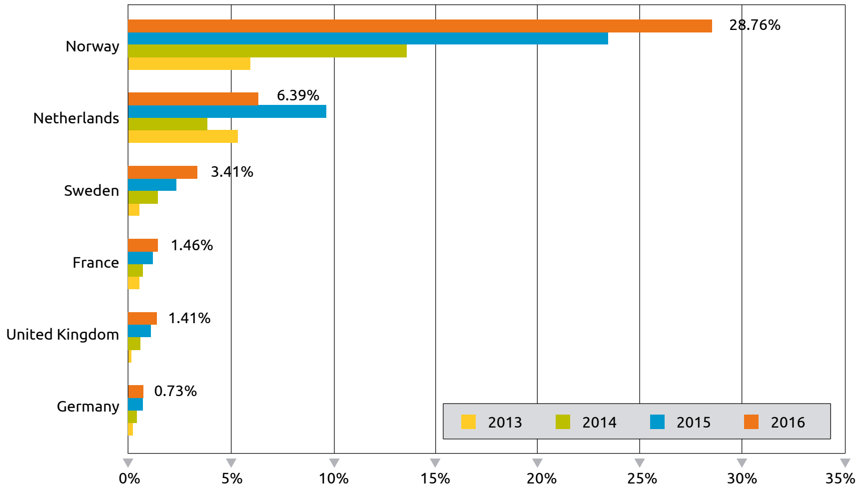
10,000 BEVs sold in the UK in 2016. The UK came second in 2016 for EV sales in Europe. Despite relatively modest growth for BEV sales (4%), new registrations for PHEVs increased by more than 40%. This trend is driven by the success of the Mitsubishi Outlander PHEV, which accounted for nearly 30% of the UK EV market in 2015.

BEVs lead the French market. France ranked second in Europe (behind Norway) for 100% electric vehicle (BEV) sales with 21,760 new registrations in 2016 (compared to a total of 2 million conventional vehicle sales). Renault's ZOE accounted for more than 50% of EVs sold in France. The share of BEVs is among the highest in the world (80%) thanks to specific incentives encouraging low emissions vehicles (CO_2/km-based eco bonus-malus scheme). Targets were set for charging station deployment (seven million charging stations by 2030), and at the local level, the city of Paris granted EV users access to its Autolib' charging points, as well as providing free and dedicated parking areas.

The Netherlands initiated a shift towards BEVs. The Netherlands experienced a significant drop in new EV registrations, with sales decreasing by 44% compared to 2015. Similarly, the market share was 3% lower than the previous year (9.74% in 2015 against 6.39% in 2016). This is mainly due to changes in taxation with policies to promote pure EV sales and decrease the PHEV share in the mix. As of December 31, 2015, road tax exemption ended and taxation on the private use of a company car increased for PHEVs ≤ 50g CO_2/km.

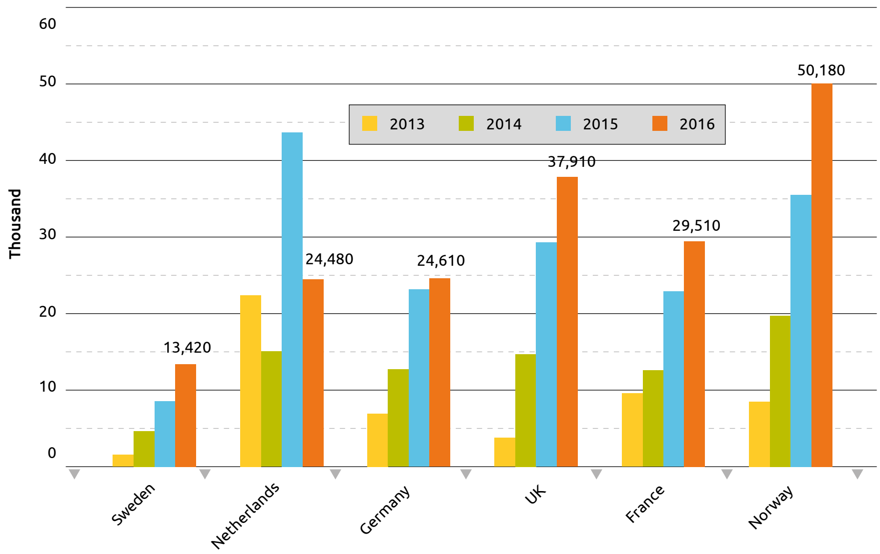
- BEVs sales increased by approximately 47% compared to 2015 (3,740 BEVs in 2016, 2,540 in 2015);

Figure 2.5 Sales Market Share of electric passengers cars (battery electric and plug-in hybrid)



Source: IEA - Global EV Outlook 2017

Figure 2.6 Sales of battery electric vehicles (BEV & PHEV) in Europe



Source: IEA - Global EV Outlook 2017

- PHEV sales decreased by almost 50% compared to the previous year (20,740 PHEVs in 2016, 41,230 in 2015);
- The Mitsubishi Outlander PHEV was the top-selling plug-in car in 2016.

Europe

Topic box 2.3 : Spain opens up the renewables market to meet the 2020 RE target

Spain focuses on large-scale renewables to ensure meeting its 2020 renewable energy target: 8 GW of contracts were awarded in two separate auctions with projects to be operational by December 31, 2019

Spain was a pioneer in the renewables market but faced unexpected capacity additions in 2010. This created immense financial burdens and operation challenges derived of the integration of renewable in the grid, leading the country to halt renewables subsidies in 2012.

At the end of 2016, Spain's installed renewables capacity stood at 47.9 GW[34], split between 23.1 GW onshore wind, 17.0 GW hydro, 4.7 GW of solar PV, 2.3 GW of concentrated solar, and 0.9 GW of waste and biomass.

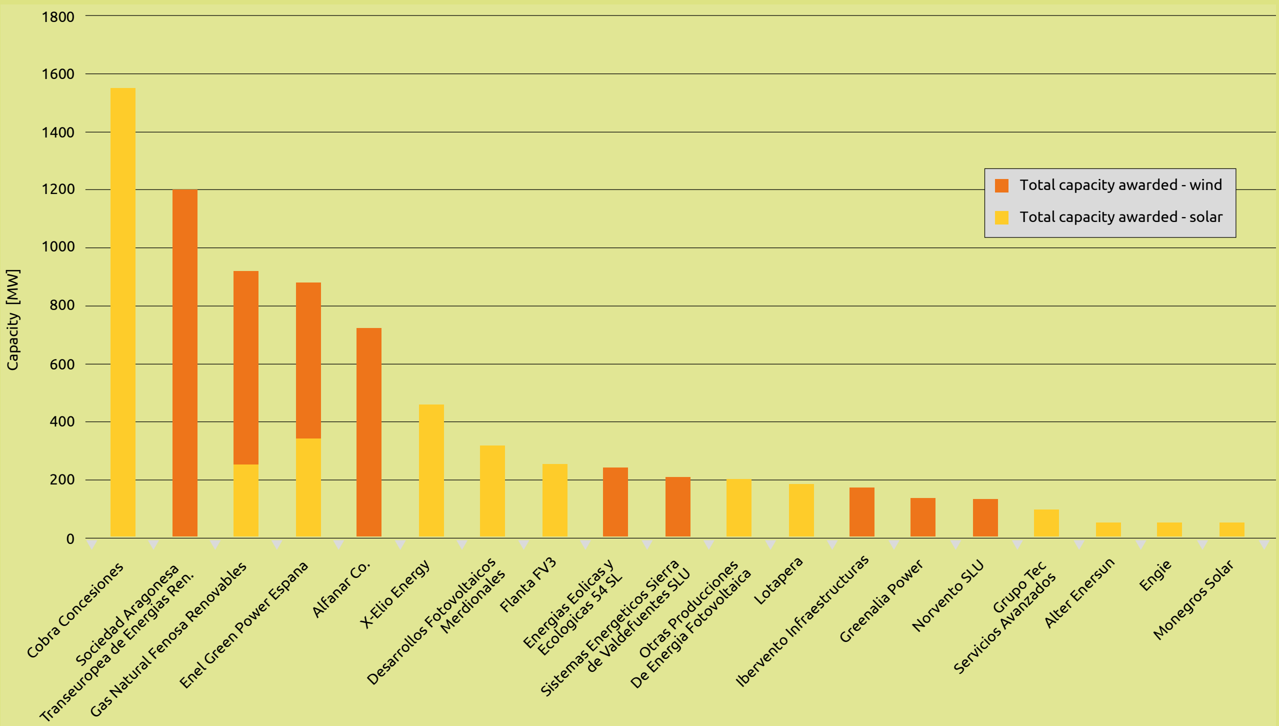
The Spanish Minister of Energy confirmed that the auctions awarded in May and July 2017 aimed to enable the country to meet its 2020 renewable energy target. Renewable support had been stopped since 2012 since the moratorium[35] on financial subsidies.

The auctions were hugely successful, with applications exceeding the initial capacity put out to tender: more than 8 GW of contracts were awarded with a mix of wind and solar technologies. A combination of local developers – Cobra, Sociedad aragonesa transeuropea de energias renovables – and local utilities – Gas Natural Fenosa, Enel Green Power – were the biggest winners, followed by Saudi Arabia-based EPC Alfanar and KKR-owned solar developer X-ELIO.

The design of the Spanish auctions is unique in Europe[36] as the bidding process is technology-neutral (i.e. all technologies compete at the same price), which pushes the lowest possible price and encourages larger installations. Remuneration comprises a payment on investment (€/kW) and a payment on operation (€/kWh). For new installations, payment on operation is based on wholesale prices. Bidders compete on the discounted value of the initial investment and the equivalent production hours (up to 82% for wind and 66% for solar PV in the second auction). As a result, the auctions minimize the burden for the Spanish government.

However, there could be unintended cost consequences as plants concentrate in congested areas, which will require additional grid investment. Also, regulatory

Total solar & wind capacity awarded May-July 2017 (renewables auction spain)



Sources: Capgemini analysis WEMO2017

uncertainty remains high. For example, the Spanish government has the right to revise the "reasonable rate of return" every six years, which could modify the tariffs.

Self-consumption remains limited despite high retail electricity tariffs and attractive solar resources

The Spanish government has curbed deployment of self-consumption to prevent grid defection (i.e. consumers using rooftop solar PV generation directly instead of buying from the main grid) with the adoption of the Royal Decree 900/2015 – the so-called "sun tax". The law imposed strict technical and administrative conditions on self-consumption installations and limited self-consumption to facilities smaller than 100 kW. As a result the market for distributed solar PV has stalled.

In July 2017, the Spanish parliament approved a new decree annulling the RD 900/2015. The impact of this is uncertain because it doesn't define the regulatory framework, leaving this responsibility to autonomous communities who will have to ensure the regulation doesn't affect the technical and financial balance of the electricity system. Nevertheless, the self-consumption market is gradually opening up, underscored by several announcements from battery manufacturers entering the market. Tesla expects its new battery Powerwall 2 to be on the market in September 2017. In addition, the economics for completely disconnected solar systems paired with diesel generators and batteries are improving. A solar-battery-diesel genset system installed in a farm in Toledo in 2016 is estimated to have a payback within four to five years.

A combination of local developers – Cobra, Sociedad aragonesa transeuropea de energias renovables – and local utilities – Gas Natural Fenosa, Enel Green Power – were the biggest winners

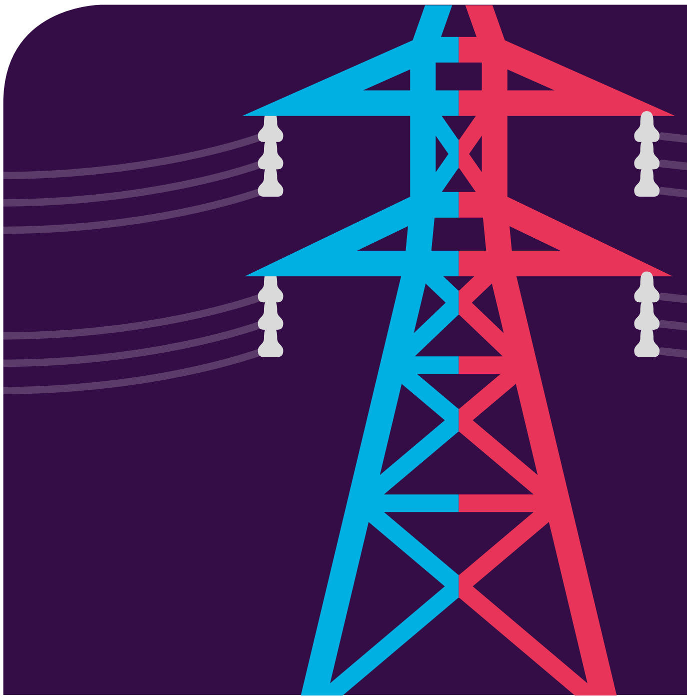
Conclusion

- Transformation of the European power mix continues – nearly 30% of European electricity consumption came from renewable sources in 2016 – but the pace of transformation varies across Member States with consequences on power markets networks and companies.
- Renewables are becoming cost-competitive against conventional sources of power generation. The first unsubsidized renewables projects have been signed off in Germany (offshore wind) and Italy (solar).
- Battery storage is becoming cost-competitive against conventional sources to provide grid services.
- The shift away from feed-in tariffs towards auctions to support renewables is accelerating and renewables developers are increasingly exposed to wholesale power prices.
- Renewables investment is stable and is likely to continue in Europe driven by steady onshore wind and PV additions, as well as growing offshore wind.
- The 2020 renewable energy targets will most likely be met but the 2030 targets will be more challenging to achieve.
- In a context of sustained renewables deployment, patchy market structure between EU members, and uncertain policy outlooks, incumbent Utilities are highly affected financially.

34 http://www.ree.es/en/statistical-data-of-spanish-electrical-system/renewable-energy-report

35 In 2012 Spain's Ministry of Industry, Tourism and Trade (MITyC) announced that it was closing the nation's feed-in tariff (FiT) program, including FiTs for wind energy, solar PV, and solar CSP, to new applicants

36 http://www.vectorcuatrogroup.com/en/new-renewable-energy-auction-to-be-held-in-spain-on-17-may-2017-are-you-ready/



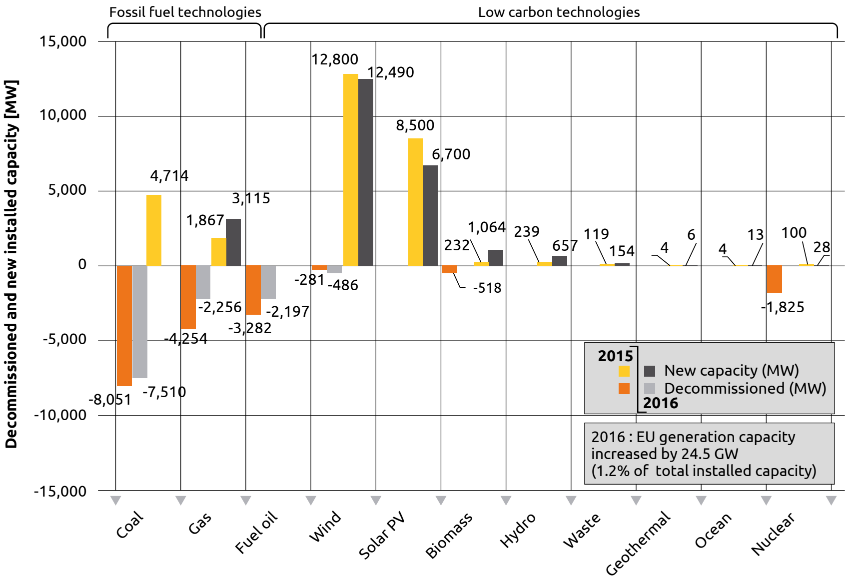
Infrastructures and Adequacy of Supply

The EU installed capacity increased by 24.5 GW in 2016 mainly driven by RES

Adequacy of supply was maintained during the period 2016 to H1 2017 despite a less controllable mix and growing consumption

Overall EU generation capacity increased by 24.5 GW in 2016, representing 1.2% of total installed capacity (figure 3.1)

Figure 3.1 Installed and decomissioned generation capacity per type of source (2016 versus 2015)



Source: WindEurope Annual Statistics 2016

This increase was mainly led by the commissioning of renewable generating capacities (+21.1 GW) while decommissioning of fossil fuel capacities continued (-12 GW).

- Renewable power generation increases were led by renewable energy sources (RES) wind and solar PV with, respectively, +12.5 GW and +6.7 GW in installed capacity.
  The increase in installed wind capacity was chiefly supported by Germany (+5.4 GW), but France (+1.6 GW), the Netherlands (+887 MW), and the UK (+736 MW) also contributed. Further significant projects have been commissioned during the 2016 and H1 2017 period:
  - In Germany, the offshore Gode Wind 1 & 2 (582 MW) and Sandbank (576 MW) wind farms;
  - In the Netherlands, the offshore Gemini (600 MW) and Westermeer (144 MW) wind farms;
  - In the UK, extension of the offshore Burbo Bank wind farm (258 MW);
  - In France, the onshore Eolien Catalan wind farm (96 MW).

- Despite a 21% year-on-year decrease compared to the 8.5 GW installed in 2015, solar PV still

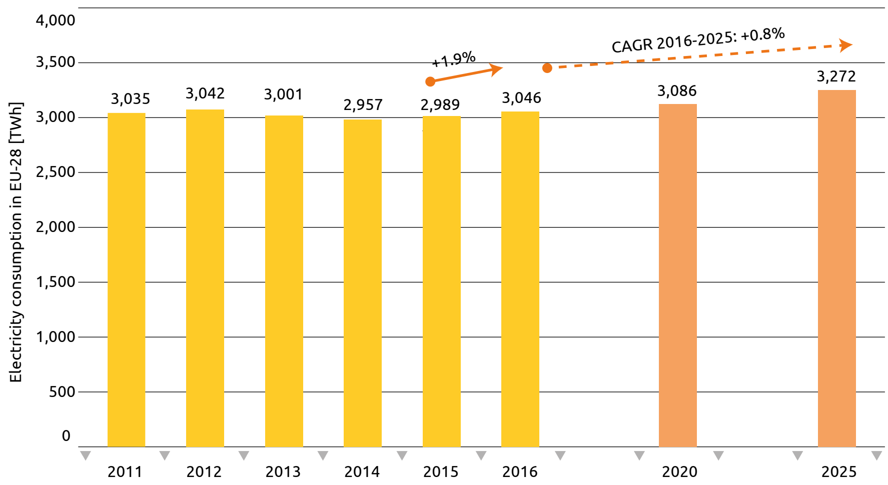
contributed 27% of the new EU installed capacity in 2017:
- The five leading countries for new PV installed capacity in 2016 were the UK (+2.37 GW), Germany (+1.48 GW), France (+559 MW), the Netherlands (+525 MW), and Italy (+370 MW). The UK commissioned its largest solar park in Shotwick, with 72.2 MW installed.
- Compared to global demand growth of 50% in 2016, EU figures might seem deceptive. The 2016 PV installed capacity in the UK and France faced respective year-on-year decreases of 37% and 38%; in the UK, this was due to the abrupt end of subsidies for solar, and in France, to regulatory instability during 2013-2014 combined with delayed publication of tenders and related results.

• Controllable power provided by fossil fuel capacity faced a net decrease of 8.8 GW in 2016, mainly led by decommissioning of coal capacity (-7.5 GW), followed by natural gas (-2.3 GW) and fuel oil capacities (-2.2 GW).
In the UK, three coal plants were closed in 2016 (Longannet, Ferrybridge and Rugeley) and a fourth (Drax 3) was converted to biomass, leading to a total decrease of 4.9 GW in coal installed capacity.

Electricity consumption increased by 1.9% in 2016 to reach 3,046 TWh

Electricity consumption increased for the second year in a row in EU-28, compared to growth of less than 1.1% in 2015 (figure 3.2).

Figure 3.2 Electricity consumption in EU-28 (2011 to 2016 and 2020, 2025 projections)



Source: ENTSO-E database – Capgemini analysis, WEMO2017

• This increase, observed in most European countries, was mainly driven by a cold winter and a continuous GDP increase since 2014 (1.9% in 2016 and 2.2% in 2015).[1]
• France thus saw a net increase in domestic power demand of 1.5% in 2016, mainly due to a colder winter (-0.8°C compared to 2015).[2]
• However, some countries, such as Italy, faced a year-on-year decrease in consumption (-2.7%), related to a cooler summer in 2016.[3]

Lignite and hard coal generation continued to fall (-11%) while gas generation increased (+51%) in 2016

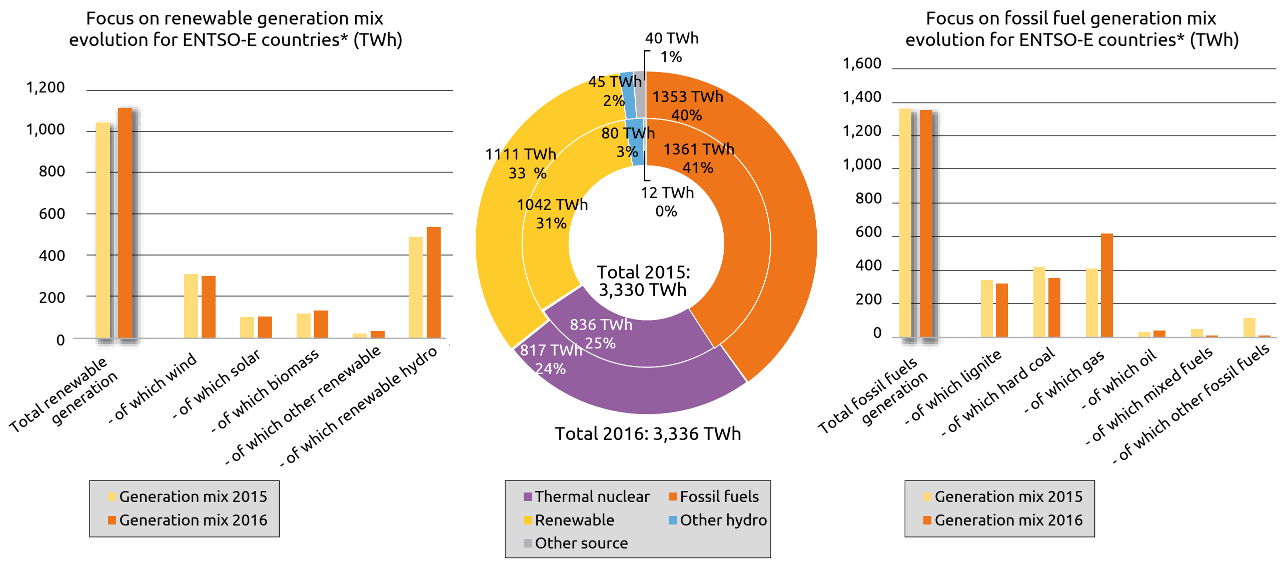
This led to a shift in the overall ENTSOE countries' electricity mix, with the coal and lignite share decreasing from 22.8% to 20% (-83.1 TWh) and the gas share increasing from 12% to 18% between 2015 and 2016 (+209.2 TWh).[4]

Electricity consumption reached
3,046 TWh
in 2016

Europe

1 World Development Indicators, The World Bank, 20/07/2017
2 RTE, Bilan électrique français 2016
3 Terna, Electricity consumption in Italy, Press release August 22nd 2016
4 ENTSO-E, Statistical Fact Sheet 2015 & 2016

Figure 3.3 Overview of 2015-2016 generation mix evolution in ENTSO-E countries (TWh)*



(*) Turkey excluded from 2016 data to remain on a comparable scope
Source: ENTSOE – Statistical Fact Sheet 2015 & 2016 – Capgemini analysis, WEMO2017

Lignite and hard coal generation continued to fall (-11%) while gas generation increased (+51%) in 2016

- The decrease in coal generation was led by the collapse of UK coal power plant generation (-66,8 TWh representing a 69% decrease)[5] mainly due to the closure of UK power plants and the UK's carbon price floor – £18/tonne – in addition to the EU Emissions Trading System (ETS).[6] In April 2017 the UK had its first coal-free day since the industrial revolution.[7]
- After a slight increase in 2015, nuclear generation fell in 2016 by 2.3%, with 21 out of 58 French nuclear reactors being shut down at the same time in October 2016,[8] representing an overall decrease of 8% of French nuclear production compared to 2015.[9]
- Overall, renewable energy production increased by 6.6 % mainly thanks to hydropower generation (+48.5 TWh):
  - Solar and wind production remained more or less stable with, respectively, an increase of 2.7% and a drop of 3.2%. Despite new commissioned capacities, this slowdown in the current growth of solar and wind generation was partly due to poor weather conditions in 2016.
- However, renewable energies quickly managed to partially or fully cover local power demand. For instance:
  - UK solar panels generated a record amount of 8.75 GW on 26 May 2017, meeting nearly one quarter of the domestic demand;[10]

5 ENTSO-E, Statistical Fact Sheet 2015 & 2016
6 https://sandbag.org.uk/project/new-data-eu-ets-emissions-2-7/
7 The Guardian: "British power generation achieves first ever coal-free day", The Gardian, 22/04/2017
8 Le Monde: "Un tiers du Parc d'EDF est à l'arrêt", Le Monde Economie, 18/10/2016
9 RTE, Bilan électrique français 2016
10 The Guardian: "Solar power breaks UK records thanks to sunny weather", The Gardian, 26/05/2017

– Danish wind farms' production managed to cover local demand for 317 hours in 2016.

Adequacy of supply was maintained during 2016 and H1 2017, despite difficulties caused by a relatively cold winter and low availability of controllable power generation capacities in Europe in 2017

- European countries managed to meet their domestic demand during summer 2016 as temperatures remained close to the seasonal average.
- During winter 2016-2017, a few European countries (in particular Italy, France, Switzerland, Belgium, Bulgaria, Romania and Greece) experienced adequacy problems, in particular in January 2017 because of the harsh cold periods combined with reduced available generation capacities:
  - Due to the cold spell in winter 2016-2017, peak load reached 554 GW in 2016, 1.9% more than in 2015, and almost as high as the record of 2012 (556 GW);
  - In December 2016 and January 2017, due to low availability of its nuclear capacity and higher demand caused by low temperatures (respectively +13% and 14% compared to December 2015 and January 2016) France's import balance was positive for the first time since 2012;
  - Italy solved its adequacy problems by leveraging a range of mechanisms such as restarting mothballed power stations or delaying maintenance works;
  - Bulgaria witnessed the worst cold spell since 1948, which had an impact not only on electricity demand, but also on generation capacities (due to coal and water freezing). To maintain adequacy of supply, the Bulgarian minister of energy limited power export between January 13 and February 9.[11]

After nearly a decade of falling prices, the recent tensions regarding adequacy of supply have caused a rise in the spot market price

Prices have decreased by almost 70% since 2008 and by 55% since 2015

Many factors led to this drop in wholesale electricity prices:

- The reduction of coal and gas prices, as they both contribute to setting the marginal costs of electricity in Europe;
- The development of renewables and the reduction of their marginal costs;
- The development and improvement of cross-border interconnectivity;
- The global decrease in electricity demand, which has been observed since 2008.

However, in Q4 2016 and the beginning of 2017, wholesale prices increased to an average of €55/MWh, in response to the combination of import pressure on coal from Asia, nuclear power, and lack of hydro-generation

- Coal and gas price increases led to the increase in electricity wholesale prices by 36% in Q4 2016 compared to the first quarters of 2016.
- In January 2017 – because many nuclear units were still offline and as a response to adequacy problems – a peak in spot prices was reached, especially in French, Belgian and Spanish markets where an average of €90/MWh was reached.
- The Nordic market was the only stable one in 2016 and 2017, with a slight increase in Q4 2016 and beginning of 2017.

Over the period 2016-2025, adequacy of supply will be increasingly threatened by a more intermittent mix and less predictable demand

A 10% increase in generation capacity is expected by 2025, mainly led by renewables

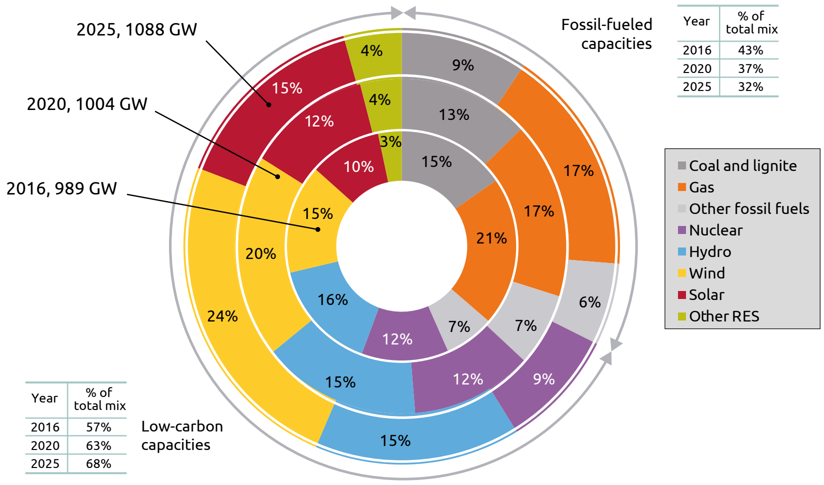
Net generation capacity is expected to reach 1,088 GW in 2025 (compared to 989 GW in 2016). This change will be mainly driven by the increase in low-carbon net generation capacity (31.4% between 2016 and 2025) despite the expected fall in fossil fuel net generation capacity (-17.9% over the same period).

- Nuclear installed capacity is expected to fall by 21.3% as many plants are likely to be decommissioned (almost 50%) over the coming decade despite the four ongoing construction projects and a planned project funnel of 29 GW new capacity.[12] The final investment decision was signed in September 2016 for the Hinkley Point C Project (2 EPR units of 1,600 MW in Somerset, UK) with construction planned to start in 2019.
- Net fossil fuel installed capacity is likely to decrease from 77 GW, mainly led by the downward trend in coal and lignite capacity (-32%), with a net decrease of 48 GW in installed capacity between 2016 and 2025.

11 ENTSO-E, Winter & Summer Outlooks 2016 & 2017

12 World-nuclear.org, "nuclear power in the European Union", 22/05/17

Figure 3.4 Current (2016) and future electricity capacity mix (2020, 2025)



Source: ENTSO-E database – Capgemini analysis, WEMO2017

> The generation mix is expected to be more and more intermittent with combined solar and wind capacity to increase from 25% to 39% of the total installed capacity between 2016 and 2025

- In March 2017, 26 EU member states committed to stop investment in new coal plants after 2020.[13] Only Poland and Greece, who generate 80% of their electricity with coal-fired plants, rejected the majority position;
- In November 2016, the UK government announced plans to close all remaining coal-fired power plants by 2025.[14]

• Over the same period net renewable installed capacity is likely to increase by 190 GW mainly driven by wind installed capacity (+114 GW) and solar capacity (+62 GW).
  - A total of US$43.8 billion[15] and US$10.2 billion[16] were invested in the European wind and solar sectors, respectively, in 2016, with US$25.9 billion dedicated to offshore wind projects;
  - The offshore wind project funnel contains 4.8 GW currently under construction, 24.2 GW with consent, 7 GW applying for consent, and an additional 65.6 GW planned[17];
  - Seven 1-1.3 GW UK offshore wind farms are at the “consented” stage of planning, having acquired the permissions needed during the proposal stage before construction can begin.

Growing share of intermittent power sources will be an increasing challenge for EU adequacy of supply in the medium/long term

Two main factors will put future adequacy of supply at risk: (1) the less controllable power generation mix and (2) the slowly growing and changing nature of electricity demand.

• The generation mix is forecasted to be less controllable as the installed fossil fuels generation capacity is planned to decrease (-80 GW), whereas the intermittent installed capacity will increase (+176 GW) over the coming decade. Thus, solar and wind are expected to form 39% of the generation capacity mix in 2025, compared to 25% in 2016 and the contribution of variable RES is expected to reach 19% of total generation in 2020, 25% in 2030 and up to 36% in 2050.
• In parallel, electricity demand is forecasted to increase modestly across Europe with 0.8% growth between 2016 and 2025.
• Moreover, patterns of consumption and the predictability of peak demand are expected to change due to the electrification of transport, industry and service

13 The Guardian.com, “The end of coal: EU energy companies pledge no new plants from 2020”, 05/04/17
14 The Guardian.com, “Britain’s last coal power plants to close by 2025”, 09/11/17
15 Bloomberg, Global trends in renewable energy investment 2017
16 Bloomberg, Global trends in renewable energy investment 2017
17 WindEurope, The European offshore wind industry – key trends and statistics 2016

sectors, as well as electric heating and cooling and smart appliances development. The share of Europe's total electricity consumption by electric vehicles (EVs) is expected to increase from around 0.03% in 2014 to 4-5% by 2030 while sensitivity analyses show that a million extra heat pumps or EVs can add up to 1.5 GW to peak demand.

Over the coming five years, adequacy of supply should be maintained despite a few local risks

The analysis made in the ENTSOE 2016 Mid Term Adequacy Forecast (MAF) shows that only a few countries could face significant adequacy issues.

- In the 2016 MAF second-sensitive case scenario analysis (based on day-ahead adequacy + real-time contribution of operational reserves to adequacy + high-voltage direct current (HVDC) forced outages), the UK, France, Finland and Poland reach a yearly loss of load expectation (LOLE)[18] greater than one hour.
- Analysis by RTE suggests that France could face adequacy issues during the winters of 2018 and 2019 with estimated LOLE reaching 6h45 and 6h15 in its "low thermal" scenario with respective capacity deficits of -2,500 GW and -2,400 GW.[19]
- In the short term, National Grid analysis shows that the UK de-rated margin is expected to increase during winter 2017-2018 reaching an estimated 3.7-4.9 GW (i.e. 7.2-9.9% of transmission demand), compared to 3.4 GW (6.6% of transmission demand) in winter 2016.[20]

The changing mix and nature of demand thus creates the need for additional levers to secure adequacy of supply, such as deployment of smart grid technologies; increased installed flexible capacity (an estimated 103 GW of new flexible capacity is needed, including 56 GW of batteries); more predictable demand and peak load through demand-side management; improved energy efficiency in buildings and industrial processes; and greater integration in the EU power market.

Increasing effort to speed up the pace of energy market integration

Major progress is ongoing at regulatory level

Over the 2016 to H1 2017 period, several achievements were made in energy market regulation, with the publication of the winter energy package, due for approval by the end of Q1 2019, and there was significant progress in development and implementation of network codes.

- The European Commission published the "Clean Energy for all Europeans" package on November 30, 2016 with the objectives of planning for future changes in the energy mix, completing the internal market for electricity, and implementing the Energy Union.
  - This set of legislative proposals covers several aspects of the EU energy sector, including the power market design with a

New levers will be needed to secure future adequacy of supply such as smart grid deployment, increased installed flexible capacity, demand side management measures, improved energy efficiency of buildings and industrial processes & greater integration of the EU power market

Europe

18 LOLE is the number of hours in a given period (year) in which the available generation plus import cannot cover the load in an area or region (ENTSOE)
19 RTE, Generation Adequacy Report 2016
20 National Grid Winter Review and Consultation 2017-2018,

Figure 3.5 Winter energy package proposals – focus on common power market design

ESTABLISH A COMMON POWER MARKET DESIGN THAT RELIES ON:

A Common Rule for the Internal Market on Electricity which. (1)

- Ensures **market-based** (supply) **pricing**
- Gives consumers access to **real-time pricing, smart metering,** and **detailed billing**
- **Sets new roles for the DSOs** regarding digitalization & data use, coordination with TSO, submission of network development plan and facilitation of the integration of EVs
- **Clarifies TSOs' provisions** for energy storage, ancillary services and the new regional coordination centers (ROCs)
- Grants **National regulatory authorities (NRAs)** additional powers for dispute/penalties

A Regulation on the Electricity Market which ensures: (2)

- **Power prices** are formed based on **supply and demand**
- **Free access** for all market participants to balancing markets
- **Market-based approach for dispatching** of power generation
- **Financial compensations** for renewable projects subject to **curtailment**
- The introduction of a concept for **bidding zones borders**
- Distribution tariffs reflect the **cost of use of the distribution system** by system users
- **Capacity Mechanisms** can be introduced by Member States
- The introduction of **regional operating centers** for TSOs to facilitate regional balancing

A Regulation on Risk-preparedness in the Electricity Sector which: (3)

- Provides a methodology to **evaluate security of supply** and to **identify crisis scenarios**
- Provides a framework to establish **risk preparedness plans**
- **Manages crisis situations** in relation to the Union's electricity system and resource adequacy and security of power supply

A definition of the ideal Capacity Mechanism which requires:

- **Openness to all capacity providers** (both domestic and foreign)
- A **competitive price-setting process** to minimize the price paid for capacity
- **Interconnections** and **protection against overcapacity** and trade distortions

(1) Proposal for a recast of the Internal Electricity Market Directive

(2) Proposal for a recast of the Internal Electricity Market Regulation

(3) Proposal for a Regulation on Risk-Preparedness in the Electricity Sector and Repealing the Security of Supply Directive;

Source: Capgemini Consulting, WEMO2017

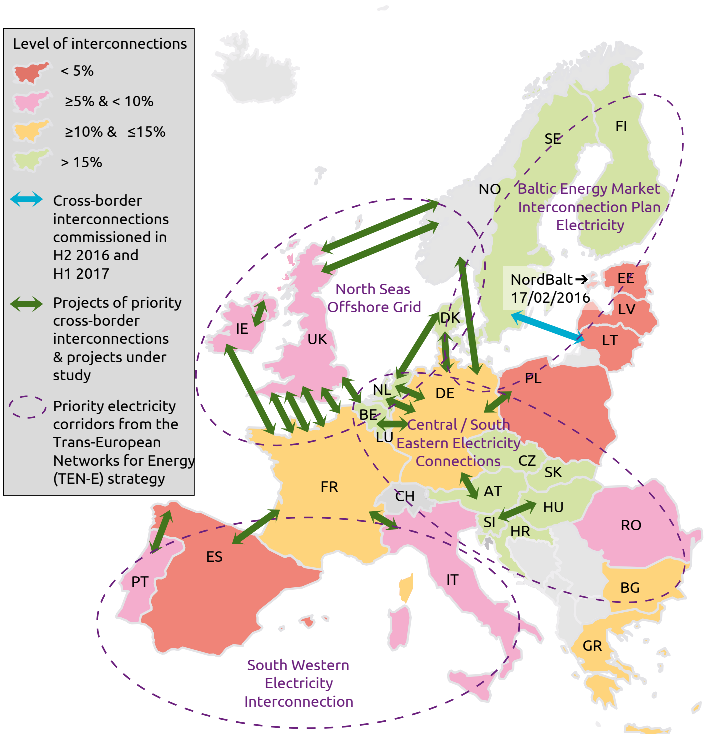
detailed set of propositions – see figure 3.5;

– From the TSO perspective, it introduces several significant changes such as the role of Regional Operation Centers (ROCs) with responsibilities that were formerly TSO prerogatives, such as coordination of capacity calculation and security analysis at region level or regional sizing of reserve capacity.[21]

- In parallel, development and implementation of network codes planned by the Third Energy Package[22] made significant progress during 2016 and H1 2017.
  – As of summer 2017, two of the eight codes (emergency and restoration requirements and procedures, and electricity balancing rules) have been approved by member states but still need to be validated by the European Parliament and Council before entering into force;[23]
  – The remaining six codes (system operations, forward capacity allocation, HVDC, demand connection, requirements for generators, and CACM) have already entered into force;[24]
  – Three European Stakeholder Committees, one per family of codes (Market codes, Operational codes, and Connection codes), have been set up to monitor, coordinate and facilitate the implementation of the network codes.[25]

21 Elia: 20170330_Presentation_CLEAN_ENERGY_PACKAGE_UG.pdf
22 ENTSO-E.eu, network code development / network code implementation
23 ENTSO-E.eu, network code development / network code implementation
24 ENTSO-E.eu, network code development / network code implementation
25 ENTSO-E.eu, network code development / network code implementation

Figure 3.6 Map of interconnections levels and interconnections projects (2017)



Countries	Projects of cross-border interconnections	Expected date	Capacity increase
DE - NL	Wesel (DE) / Doetinchem (NL)	2017	1,500 MW
UK - FR	Coquelles (FR) – Folkestone (UK) ElecLink	2018	1,000 MW
DK - DE	Ishøj / Bjaevershov (DK) - Bentwisch (DE)	2018	400 MW
ES - PT	Fontefria (ES) - Vila Nova de Famalicão (PT)	2018	-
UK - BE	Richborough (UK) / Zeebrugge (BE) – NEMO link	2019	1,000 MW
NL - DE	Meeden (NL) / Diele (DE)	2019	> 300 MW
DK - NL	Endrup (DK) / Eemshaven (NL) – COBRA cable	2019	700 MW
IE - UK	Woodland (IE) / Turleenan (UK)	2019	600 MW
FR - IT	Grande-Ile (FR) / Piossasco (IT)	2019	1,200 MW
DE - BE	Lixhe (BE) / Oberzier (DE) – ALEGrO Project	2020	1,000 MW
DE - PL	Vierraden (DE) / Krajnik (PL)	2020	> 1,000 MW
NO - DE	Tonstad (NO) / Wilster (DE)– NordLink	2020	1,400 MW
FR - UK	Tourbe (FR) / Chilling (UK) - IFA2	2020	1,000 MW
NO - UK	Kvilldal (NO) / Blyth (UK) - North Sea Link	2021	1,400 MW
FR - UK	Menuel (FR) / Exeter (UK) – FAB Project	2021	1,000 MW - 1,400 MW
FR - UK	Dunkerque (FR) / Kingsnorth (UK) - GridLink	2022	1,400 MW
UK - DE	Greystines (UK) / Conneforde (DE) - NeuConnect	2022	1,400 MW
UK - NO	Boddam (UK) / Simadalen (NO) - NorthConnect	2022	1,400 MW
DE - AT	Isar (DE) / St Peter (AT)	2024	> 2,000 MW
FR - IE	La Martyre (FR) - Great Island / Knockraha (IE) - Celtic Interconnector	2025	700 MW
FR - ES	Cubnezais (FR) / Gatica (ES) - Golfe de Gascogne	2025	2,000 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, WEMO2017

Significant increases in interconnection levels across EU countries are expected over the coming decade

Despite very little commissioning in 2016-2017, the interconnection level should increase by 2025 thanks to increasingly supportive regulation and a growing number of transmission line projects.

- Regulators remain strongly committed to fostering interconnector development.
  - Following the 10% objective set for 2020, the EU Parliament strongly advocates an interconnection level that reaches 15% by 2030: an expert group was launched in October 2016 to provide technical advice on how to refine this objective at regional and local level taking costs into consideration;[26]
  - At EU level, the TEN-E strategy identified four priority electricity corridors[27] to be reinforced based on a list of projects of common interest (PCIs) to be awarded access to a total of €5.35 billion of funding from the Connecting Europe Facility (CEF)[28]. The second list, published in 2015, included 132 electricity transmission and storage projects[29] and a third list of PCIs is due to be published in H2 2017. During 2016, seven interconnection PCIs were awarded EU CEF support of €176 million.[30]
- Many ongoing projects are suffering delays causing a low level of recent commissioning.
  - In 2016 and H1 2017, only one interconnector was commissioned, the Nordbalt cable (700 MW) between Lithuania and Sweden. One additional interconnector should be commissioned by the end of 2017: the Wesel-Doetinchem cable (1.5 GW) between Germany and the Netherlands;
  - Many projects are facing delays in their original schedules. ACER

26 European Comission: http://ec.europa.eu/energy/en/news/commission-launches-new-electricity-interconnection-targets-expert-group
27 European Comission: https://ec.europa.eu/inea/en/connecting-europe-facility/cef-energy/projects-by-common-interest
28 European Comission: http://ec.europa.eu/energy/en/topics/infrastructure/projects-common-interest
29 European Commission, DG Energy, "Regulation on guidelines for trans-european energy infrastructure & Connecting Europe Facility", 2014
30 European Comission: http://ec.europa.eu/energy/en/news/eu-invests-444-million-euros-energy-infrastructure

Topic Box 3.1 : Electricity distributors face the energy transition paradigm shift

Energy transition is transforming the formerly linear operation of power grids. Previously, electricity travelled from centralized sources to the consumer, but the development of more decentralized renewable energies has brought production closer to the point of consumption. Changes in everyday electricity consumption have led to the emergence of local generation sources and micro-grids, which are profoundly transforming the use of distribution networks and, in some countries, even their nature.

The main factors in this development are the evolution in the technological maturity of renewable energies, particularly small-scale solar energy, and also energy transition policies, which are today the main triggers for transformation of the value chain and power grids. An underpinning factor, which is less quantifiable but equally important, is increasing public appetite for the "small is beautiful" concept, which drives end-users to reorient themselves towards local production and consumption patterns, including electricity.

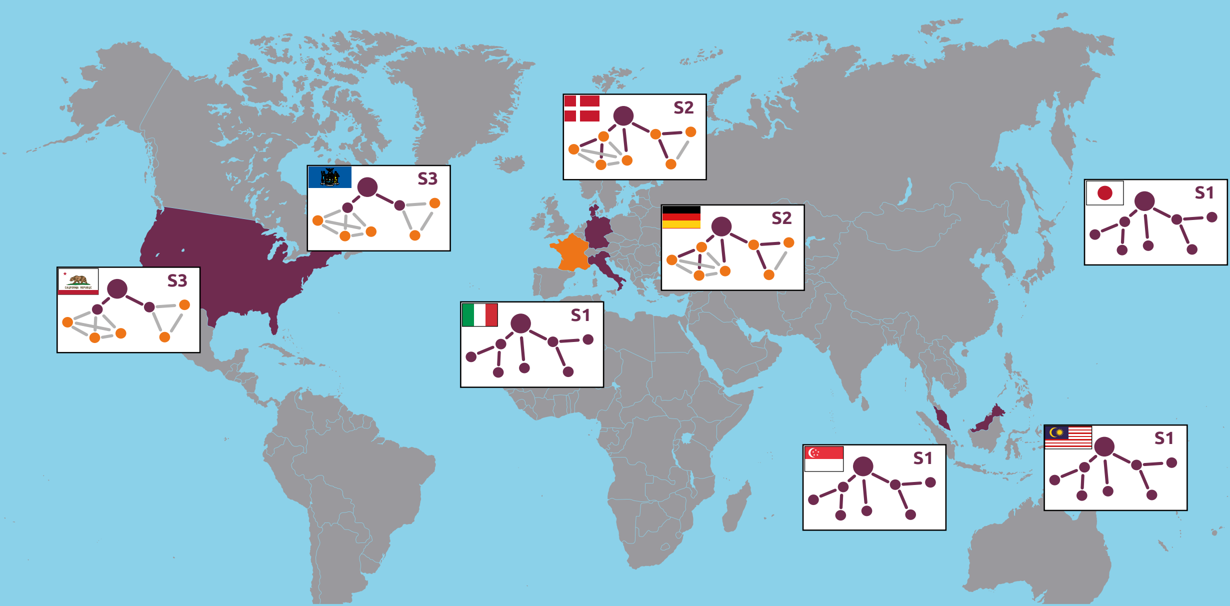
Microgrids are also proliferating in some areas. A microgrid is basically a system containing a distributed source of energy, a storage capacity, and a portion of network to operate. Microgrids can be autonomous or connected to a network, and are attractive to eco-neighborhoods, business centers seeking to improve the service to their occupants, or public structures seeking security of supply (hospitals, prisons, etc.). Regional incentives have enabled periods of strong growth, and the market for micrograds is expected to grow significantly. This will strongly impact on mainstream distributors who can expect significant customer defection.

Four possible scenarios for the evolution of distribution networks

The implementation of an international comparative analysis has made it possible to formulate four scenarios showing what disruption in electricity networks might look like in approximately 10 years' time:

- S1 **"Enhanced centralized"**: The first scenario sees the network slowly evolve along existing lines: the system continues to rely mainly on centralized electricity production. The distributor then acts as a market facilitator, increasingly involved in demand response and flexibility piloting;
- S2 **"Decentralized"**: The second scenario envisages much greater distortion of the network, which becomes very decentralized. Massive development in solar and storage encourages self-consumption and the notion of "prosumerism" becomes meaningful. In its distribution activity, which is reduced (in terms of volume of energy supplied) and more demanding (injection of renewables-generated energy, local balance, system integration), the distributor will nevertheless take part in development and exploitation of microgrids;

Capgemini Consulting conclusions for 2025 scenarios



Source: Capgemini Consulting, WEMO2017

- S3 **"Decentralized and disintermediated"**: Here, the infrastructure concession model is obsolete. Municipalities or other public and/or private structures take charge of the operation and maintenance of infrastructures, thus creating islands of autonomous networks. The distributor then loses contact with the consumers within these islands and is relegated to the entrance of these locally owned and operated distribution grids. The established distributor may then become a systems integrator;
- S4 **"Unregulated distribution"**: This scenario is specific to emerging economies. It is an unregulated distribution model where the hitherto nonexistent or very basic network is built from scratch. Power generation facilities, where they exist, are decentralized and geographically independent. Microgrids become "quality islands". It is a very different scenario compared to Europe and developed economies.

A redefinition of the distributor's trade

Whatever the level of disruption envisaged by these scenarios, the impact of distributed generation (sometimes intermittent) and microgrid development on the distribution industry will be significant. From the value chain considered traditional, the network may evolve towards a constellation of connected microgrids. Balancing this network of distributed generation sources and microgrids will therefore be one of the key areas where distributors, rather than transmission grid operators, will be the major players in systems operation.

According to the scenarios, the activity of the distributor will be increasingly challenged, including services that have been a natural historical monopoly. On the other hand, new services should also emerge from this change: systems operation, demand response, management of electric vehicle charging infrastructure, provision of storage capacity, telecommunications solutions and services, data management on behalf of stakeholders, and so on.

The most negative configuration for the distributor would be scenario 3, decentralized and disintermediated. In this situation, the distributor would be limited to providing maintenance and engineering services, and ensuring the supply of emergency power when needed. The distributor could also inherit parts of the grid not used by alternative operators. Tariff equalization would then be much more difficult to exercise.

The impacts of scenarios 2, 3 and 4 on distributors are fairly straightforward. With unchanging tariffs and networks, the distributor's remuneration decreases (less energy conveyed), but the costs remain constant or even increase. The network remains the same but should be modernized. Which of course would mean increased transmission and distribution (T&D) fees for some or all consumers.

Prospects for disruption in distribution networks

In order to identify trends in network disruption, an international benchmarking exercise has analyzed the following regions: Europe (Denmark, Germany, Italy), North America (New York and California), and East Asia (Malaysia, Singapore). Analysis of these countries/regions tends to show that network disruption is inevitable. Only the pace of change varies, according to the geographical zones:

Within the European Union, the network has already experienced some disruption, notably in Denmark and Germany, which are likely to end up in the decentralized scenario 2 in 2025. Italy, mainly due to poor economics, shows a markedly slower trajectory and should remain in a centralized scenario.

As a comparison:
- In South-East Asia, the countries studied will still be in a predominantly centralized scenario, in particular because their ambitions for renewables in the energy mix will be too low;
- In the USA, California and New York State should see their distribution networks change much more rapidly than in European countries, leading to scenario 3, decentralized and disintermediated. Economic or regulatory incentives for microgrid development are stronger than elsewhere. Solar plus storage offers will be particularly challenging for incumbent Utilities.

The longer-term analysis (2035-2040) is more difficult, in particular because not all countries have yet set their ambitions for energy transition and digitization. But we can be sure that there will be no return to the centralized scenario.
This transformation seems to be unstoppable. And its pace will vary between regions, depending on the development intensity of energy transition and microgrids. DNOs (tomorrow's DSOs), their stakeholders (grid owners), and public authorities (regulatory bodies, state energy departments) should launch projects now to assess impacts, consider the degree of urgency required moving forward, and look at transformation measures, including adapting tariffs, dealing with quality management, modernizing networks, improving efficiency (again and again), adapting competencies, and developing additional services for stakeholders and end-customers.

reports that commissioning dates for half of the PCIs have been put back by one or two years between 2015 and 2017. Delays are often due to technical difficulties or issues faced in the permit granting process.[31] Hence the German SuedLink grid project has been delayed to 2025, as the cables must go underground[32] The France-Spain Biscay Gulf interconnector project is also facing technical delays,[33] while both the Germany-Netherlands interconnector between Niederrhein and Doetinchem, and the Woodland-Turleenan interconnector between Ireland and the UK, have been delayed by the permit granting process.

- The need for power grid development across Europe, however, is driving a full pipeline of projects from 2017 to 2025 with several significant developments currently ongoing.
  - The additional interconnection capacity currently planned between the UK and other European countries exceeds 14.5 GW, split between Norway (2.8 GW), Germany (1.4 GW), Belgium (1 GW), Ireland (0.5 GW), Denmark (1 GW), Iceland (1 GW), and France (6.8 GW). The UK's total interconnector capacity will increase from a current 4.5 GW to 18.5 GW if all the projects above are completed;
  - Several interconnection projects will also reinforce German borders in the coming years with planned additional capacity of more than 1.8 GW with the Netherlands, 0.4 GW with Denmark, 1 GW with Belgium, 1 GW with Poland, 1.4 GW with Norway, 1.4 GW with the UK, and more than 2 GW with Austria. To support its power grid development, German regulator BNetzA opened consultation in August 2017 on a US$59 billion 2030 plan with the aim of confirming the 2,150 km of new HVDC cable projects and 2,500 out of the 5,750 km AC line improvements proposed by the four German TSOs.

In addition to efforts conducted at European and regional level, shaping the future European power market is also progressing at local level by DSOs.

At local level, DSOs are still aiming for 80% smart meter rollout while preparing to renew their role within the energy market

Current smart metering systems rollout projects are expected to reach close to full deployment in the next few years.

- In Germany, smart meter rollout started in 2017, focusing on customers with an average annual consumption of more than 10,000 kWh; in 2020 this will be lowered to 6,000 kWh. After completion of the rollout in 2027, around 20% of all electricity customers should be equipped with smart meters.
- In the UK, the government expects to replace more than 53 million gas and electricity meters with smart meters by 2020. However, rollout has been slower than initially planned and DNOs have asked to delay the 2020 deadline. In 2016, an estimated 1.65 million smart electricity meters were installed by the large energy suppliers, making a total of 3.5 million electricity customers equipped across the UK.
- In France, Enedis announced the replacement of 5 million electricity meters in July 2017, with an estimated 20 000 meters replaced each day expecting to reach eight million by the end of the year.
- In Spain, the European Investment Bank (EIB) confirmed in June 2017 a loan of more than €500 million to Iberdrola, granted to further modernize and digitalize Spanish smart grids.
- In Italy, the EIB will also be lending €1 billion to E-Distribuzione, an Enel subsidiary, to deploy 41 million second-generation smart meters, of which 32 million will replace existing first-generation devices.

Building on the possibilities offered by smarter grids and ongoing evolution in consumption at local level (developments in distributed energy resources (DER), smart appliances, EVs and microgrids – see dedicated topic box), DSOs are expected to take on new responsibilities in the energy system, as data managers or distribution constraint officers, for example.

31 ACER, Consolidated Report on the progress of electricity and gas Projects of Common Interest for the year 2016
32 Platts.com, "German Suedlink Grid project delayed to 2025 as cables go underground", 28/09/2016
33 ACER, Consolidated Report on the progress of electricity and gas Projects of Common Interest for the year 2016

TOPIC BOX 3.2 – Market Designs tackle Energy Transition
When will power market strategies be consistent with those of energy transition – and equally profitable for all players?

Wholesale markets no longer work for providing long-term investment signals

Since the liberalization of Europe's power sector, spot and forward markets have seen considerable growth allowing better coordination and more flexibility for players in the short term, with progressive harmonization of market rules, notably through the setting up of market coupling and the so-called network codes.

However, a group of national electricity associations (in 2016: UFE, Assoelettrica, BDEW, EAI, Elecpor, Energy UK, FEBEG and Unesa) has issued a joint statement saying that prices in these markets are failing to finance investment.

According to UFE in France and BDEW in Germany, low prices in power markets are the result of energy efficiency measures adopted by European states, decreased energy consumption in Europe due to the financial crisis, the low carbon price, development of RES, and the low prices of thermal inputs (coal, gas and oil).

Are capacity market initiatives the right complementary solution?

Those factors, considered permanent by some[34], led to the adoption of capacity markets in some major European countries, notably Spain, 1997; the UK, 2014; France, 2017; Italy, 2017; and Germany, planned for 2018. These markets are aimed at remunerating capacity providers, both generators and demand response operators, who contribute to the security of supply.

The pros and cons are debatable. Pros: Many market players pushing for capacity markets cite the following reasons:

- Longer-term price signals will benefit investment in new generation capacity (Eurelectric, 2016)[35];
- Capacity markets allow "missing revenue" to be covered in current markets;
- Capacity markets increase generation adequacy and security of supply (Eurelectric, 2011)[36];
- Capacity markets facilitate the development of new entrants (e.g. curtailment, storage; UFE 2016)[37];
- Capacity markets reduce price volatility (price spikes), benefiting consumers.
- Cons: Some players express reservations about capacity markets:
- They could impact on market integration and restrict development of a unified energy market in Europe (European Commission, 2016);

The possible coexistence of several designs of capacity markets in Europe (countries with capacity markets and others with pure energy markets) could create investment distortions with neighboring countries;

- The coexistence of different designs of capacity markets in order to respond to different objectives in Europe could add complexity to the system;
- To be fully effective, the design of the mechanism implies developing a standard framework for cross-border participation, thus raising the issue of coordination of security of supply policies in Europe.

The new market model should reconcile potentially divergent objectives

The design of the new market architecture should aim to combine its main components (wholesale market, capacity markets, network codes, energy policies, etc.) into a consistent whole in order to:

- In the short term, ensure the best allocation of generation and flexibility;
- In the long term, ensure a fair financial return for Utilities and energy players;
- Facilitate renewables integration and decarbonization;
- Develop an energy mix consistent with national energy policies;
- Respect physical constraints of the power system, across borders and locally;
- Improve security of supply in Europe;
- Allow efficient transformation of networks, ensuring good localization and optimal arbitrage between production, network and smart flexibility;
- Allow fair competition between players and technologies to guarantee the best price for consumers;
- Establish clear and simple market rules.

The challenge for the winter package released by the European Commission in November 2016 will therefore be to address existing market failures by putting in place a new market architecture able to respond to each of these objectives.

Europe

34 For instance, Artelys' study achieved for UFE and BDEW shows in 2015 that the expected return for peaking power plants in a pure energy market is too uncertain for investors

35 Eurelectric, "Winter package solutions: Eurelectric's key policy recommendations", 2016

36 Eurelectric, "RES Integration and Market Design: Are capacity remuneration mechanisms needed to ensure generation adequacy?", 2011

37 ufe-electricite.fr, "EU power associations call for an updated EU energy market design", 17/05/2016

Gas Markets

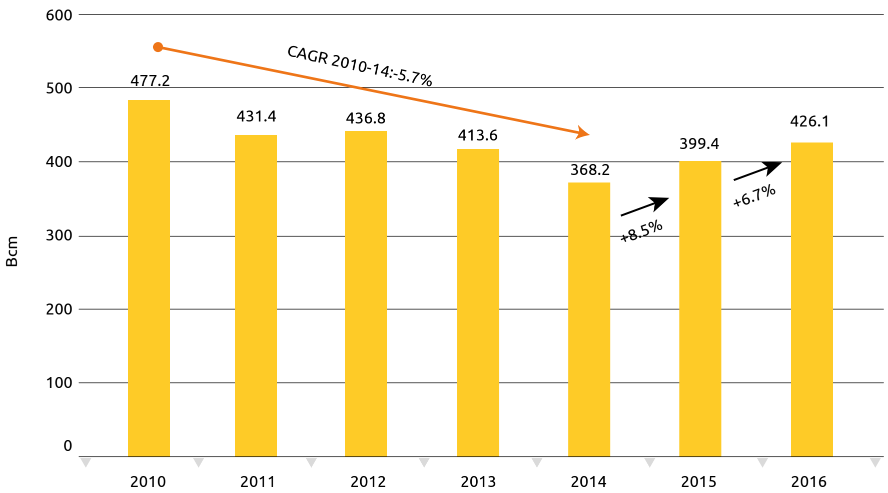
Natural gas consumption rose again in 2016, with dependency on piped and LNG imports continuing to increase due to steady depletion of EU gas reserves. Security of supply remains uncertain, with Russian imports now representing 45% of EU gas consumption.

New gas-fired power plants started to operate in Germany due to competitive prices and the progressive phase-out of nuclear plants.

A revival in industrial activity, along with rapidly growing use of gas in power generation, supported the growth of gas consumption in the EU

With a second consecutive annual increase (+6.7%), EU gas demand reached its highest level since 2013. Year on year, EU gas consumption increased slowly in the first three quarters of 2016, but growth accelerated in the last quarter. A cold 2016-2017 winter set the trend for 2017.

Figure 3.7 Gas consumption in EU-28 (Bcm) 2016



Source: BP Statistical Review 2017, National sources - Capgemini Analysis WEMO2017

Gas regained ground thanks to an increased market share in power generation and a confident revival of industrial activity in Europe.

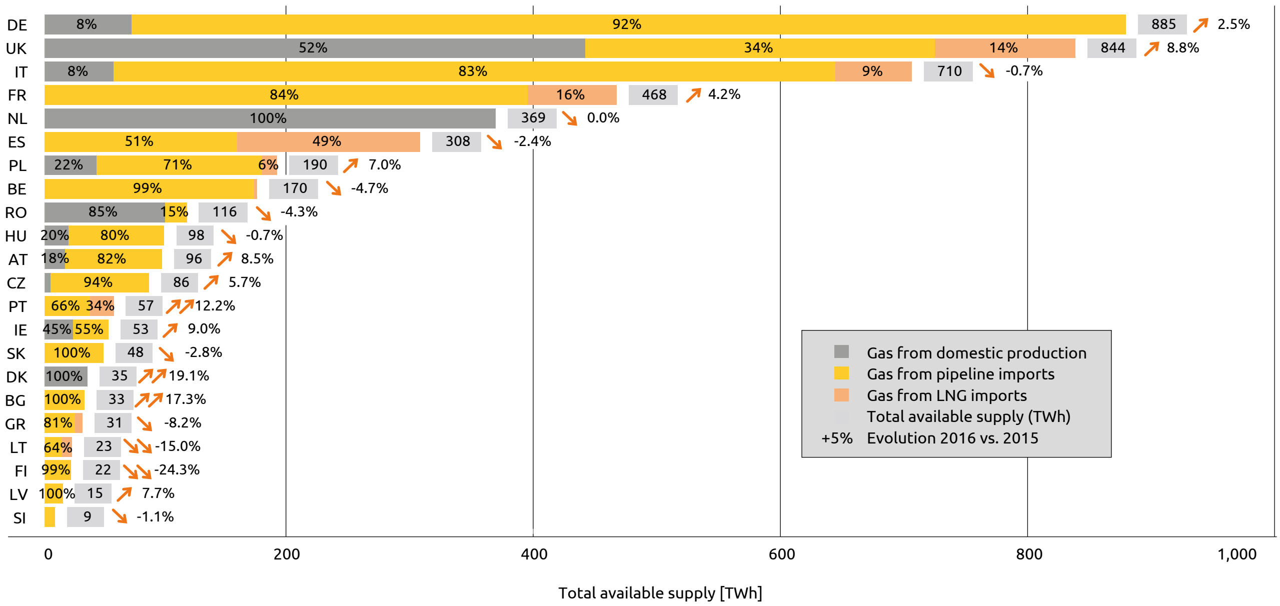
- Gas supplied for power generation in the EU as a whole has consistently shown a year-on-year increase. Growth rates were most significant in France, Greece, the UK, Italy and the Netherlands. In contrast, gas supplied for power generation in Spain and Belgium, for example, decreased slightly (-1% to 2%[1]).
- Relatively low temperatures also contributed to the growth in gas consumption.
- Industrial demand was boosted in particular by the weaker euro in 2016, benefiting Europe's export-oriented industries. Overall, EU-28 GDP (1.9% for year 2016[2]) remained around the same level as in 2015.

Thanks to improving economics for gas, the UK and Germany showed the biggest growth in consumption in 2016 in absolute terms: these two countries represent more than half of the annual growth in EU gas demand. France, Italy and the Netherlands also experienced significant increases towards the end of the year compared to the same period in 2015. The situation of the EU's three biggest gas consumers was as follows:

- In Germany, new gas-fired power plants started to operate due to competitive prices and the progressive phase-out of nuclear plants. Clean spark spreads were on the rise and reached their highest levels since 2011 (peaking at €15/MWh in January 2017[3]). As a result of this improving competitiveness, the share of gas-fired power generation doubled in

1 Source: Eurostat
2 Source: Eurostat
3 Source: Platts and ENTSO-E Data

Figure 3.8 Domestic gas production versus piped and LNG imports (2016)



Source: BP Statistical Review 2017, National sources - Capgemini Analysis WEMO2017

Q3 2016 and continued to rise in Q1 2017 (representing around 15% of power generated).

- In the UK, gas gained ground in power generation at the expense of coal:
  - Clean spark spreads remained high, averaging nearly €30/MWh[4] in Q4 2016. The continued impact of carbon pricing support mechanisms and the retirement of a large portion of coal-fired power generation capacity resulted in a decline in coal use;
  - With gas increasingly competitive and the closure or conversion of some coal-powered plants, the share of gas in power generation increased from 29.5% in 2015 to 42.4% in 2016. April 21, 2017 was the first working day since the industrial revolution without coal in the UK electricity mix, according to National Grid.
- In France, gas demand for power generation more than doubled from January 1 to mid-December, 2016. Closure of coal-fired plants, and safety assessments of French nuclear power plants, allowed gas to increase its share of the electricity mix by the end of 2016.

Apart from industry and power generation, the revival in natural gas demand is also, to a smaller extent, driven by increased use of compressed natural gas (CNG). Gas remains a cost-effective lever for reducing emissions quickly. Throughout Europe, the number of natural gas vehicles grew by 9% in 2016 compared with 2015, although it remains a very small proportion of vehicles globally.

4 Source: Platts and ENTSO-E Data

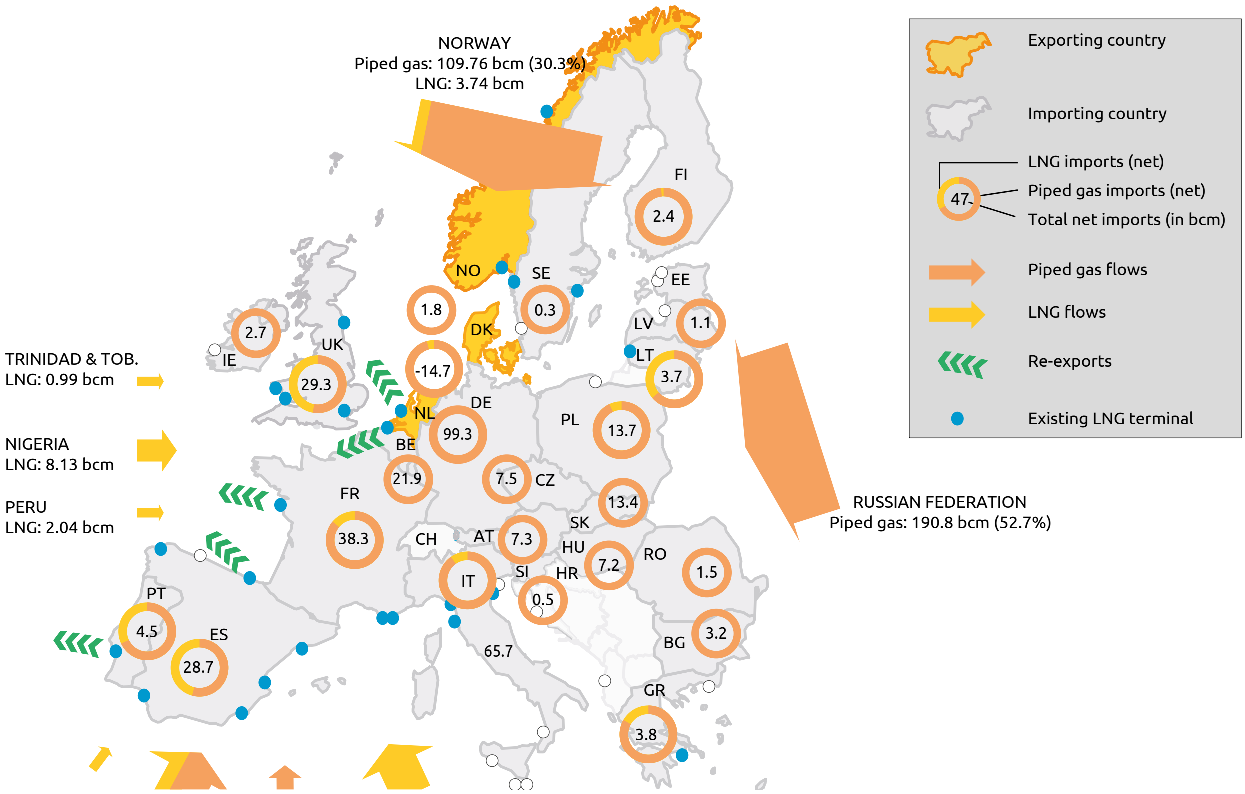
E U-28 natural gas production continued to decline, by 4% to 110.7 bcm in 2016, led by Dutch production plummeting, although UK natural gas production increased by 3.2%

The European share of global gas production continued to fall with a loss of 0.15% in 2016 (to 3.1%), not a significant figure compared to the 0.4% loss in 2015. This stabilization of the European share is occurring while the increase in world production is slowing down (0.3% in 2016, with the average annual rate of decrease being 2.4% per year between 2015 and 2010), particularly due to production in the USA falling for the first time since 2005[5].

Despite the positive trend, all European countries except the UK saw their production decrease, resulting in a global loss of 4% to 110.7 bcm in 2016.

- For the second year in a row, UK production grew in 2016 (by 3.2%), overtaking the Netherlands as the largest gas producer in the EU for the first time since 2008. However, the Oil & Gas Authority (OGA) estimates that UK production is returning to a downward

Figure 3.9 Map of gas imports (2016)



*Note: * Others = Oman and Equatorial Guinea*
Source: BP statistical review of world energy 2017, GIIGNL – Capgemini analysis, WEMO2017

5 BP Statistical review 2017

Figure 3.10 LNG imports to Europe in bcm (2016)

	Algeria	Angola	Australia	Egypt	Equatorial Guinea	Nigeria	Norway	Oman	Peru	Qatar	Trinidad& Tobago	USA	Yemen	Re-exports received	Re-exports loaded	Net imports	% of total Europe	% ch. 2016/15
Spain	2.9104	0.0952	-	-	-	4.8824	0.7752	-	1.7952	2.7064	0.7616	0.068	-	-	-0.1768	13.8176	30.8%	15.1%
UK	0.204	-	-	-	-	0.1904	0.2584	-	-	9.8736	0.0816	-	-	0.0952	-0.5168	10.1864	22.7%	-25.1%
France	6.0928	-	-	-	-	1.7408	0.4216	-	0.1632	0.7208	-	-	-	-	-1.5912	7.548	16.8%	27.3%
Italy	0.204	-	0.068	-	-	0.0952	0.1632	-	0.0816	5.6304	-	-	-	-	-	6.2424	13.9%	6.5%
Portugal	0.2448	-	-	-	-	1.1424	0.0816	-	-	0.4624	-	0.0952	-	-	-0.2584	1.768	3.9%	19.3%
Lithuania	-	-	-	-	-	-	1.36	-	-	-	-	-	-	-	-	1.36	3.0%	212.5%
Poland	-	-	-	-	-	-	0.0816	-	-	1.0336	-	-	-	-	-	1.1152	2.5%	NA
Belgium	0.0068	-	-	-	-	-	-	-	-	2.4208	-	-	-	0.0136	-1.36	1.0812	2.4%	-57.3%
Greece	0.7208	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7208	1.6%	17.8%
Netherlands	-	-	-	-	-	0.0816	0.68	-	-	0.5168	0.1496	-	-	-	-0.9248	0.5032	1.1%	-41.3%
Sweden	-	-	-	-	-	-	0.1904	-	-	-	-	-	-	0.136	-	0.3264	0.7%	-20.0%
Norway	-	-	-	-	-	-	0.1496	-	-	-	-	-	-	0.068	-	0.2176	0.5%	NA
Finland	-	-	-	-	-	-	0.0136	-	-	-	-	-	-	0.0136	-	0.0272	0.1%	NA
Europe	10.3836	0.0952	0.068	0	0	8.1328	4.1752	0	2.04	23.3648	0.9928	0.1632	0	0.3264	-4.828	44.914	100%	2.71%
% of total Europe	23.1%	0.2%	0.2%	0.0%	0.0%	18.1%	9.3%	0.0%	4.5%	52.0%	2.2%	0.4%	0.0%	0.7%	-10.7%			
% change 2016 vs. 2015	11.2%	0.0%	0.0%	0.0%	-100.0%	33.8%	31.8%	-100.0%	64.8%	-13.5%	-31.8%	0.0%	0.0%	26.3%	-2.7%			

Source: GIIGNL – Capgemini analysis, WEMO2017

trend[6] despite new fields coming on stream, such as Cygnus (in December 2016[7]) – the biggest discovery in the last 25 years within the Southern Gas Basin.

- Dutch production (-7.1%) is still affected by seismic activity in the Groningen field due to the depletion of the field following 54 years of exploitation leading to the collapse of empty underground pockets close to the surface[8]. Since 2014, the Dutch government has been capping production in order to minimize the risk of further earthquakes. For 2017, the Dutch government plans to reduce the Groningen low-calorific natural gas (L-gas) production cap by 10%[9].
- Production by all the other European players is decreasing. For example, Italy experienced a drop of 15.1% and in Germany production fell by 8.1%.

Despite the EU-28 fall in production, piped gas and LNG imports enabled Europe to meet its needs

In Q1 2017, EU-28 gas imports increased by 12% compared to Q1 2016[10]:

- Piped gas imports from Russia to the EU-28 have increased. As shown in figure 3.9, Russia remains the EU's leading supplier with 190.8 bcm (45% of total EU consumption) of piped gas in 2016. This represents an increase of 17% compared to 2015[11]. In Q1 2017:
  - 41% of natural gas imports from Russia came via Ukraine (+17% of transit volume compared to Q1 2016);
  - 30% came from Nord Stream (+22% compared to Q1 2016);
  - 26% were from Belarus (+15% compared to Q1 2016)[12].

6 Oil & Gas Authority, February 2017
7 Oil & Gas Journal, December 2016 ; ENGIE (UK)
8 Oilprice
9 ICIS, April 18, 2017
10 ENTSO-G data
11 European Commission, Quarterly Report, Q4 2016
12 European Commission, Quarterly Report, 2017 Q1

USA LNG exports don't benefit EU LNG markets to any great extent and they don't effectively compensate for the EU's dependency on Russian gas

- Piped gas imports from Norway grew in 2016 (+3%) to 109.8 bcm.
- Algeria and Libya exported 37.1 bcm and 4.4 bcm respectively of piped gas to Europe in 2016.

Nord Stream 2 pipeline out of the headlines

- In December 2016 the European Court of Justice suspended the European Commission's approval to give Gazprom 90% of the OPAL pipeline capacity after an appeal from Poland's state-run gas firm PGNiG[13]. Consequently, Gazprom's access to the OPAL pipeline – connected to the Nord Stream – was reduced to 50%. The European Court of Justice canceled this restriction on July 24, 2017[14].
- On June 15, 2017, the US Senate voted for sanctions against companies that invest in Russian energy pipelines[15]. The second Nord Stream pipeline, to be 50% financed by Engie, Shell, Uniper, Wintershall and OMV, is directly affected by this new threat[16].

Early stages of renewal in the Iranian gas sector

- International sanctions against Iran, which possesses the second largest reserves of natural gas in the world,[17] were lifted in January 2016. This change in the political and diplomatic climate paved the way for Iran to access the EU gas market. The agreement in June 2017 between French company Total, the China National Petroleum Corporation (CNPC), and Iran's Petropars, regarding Phase 11 of the South Pars gas field, illustrates this new attitude.
- However, gas produced from South Pars will only supply the Iranian market[18]. In addition, Iranian production infrastructure and gas transport capacity remain underdeveloped and Iran is not likely to become a major natural gas supplier to the EU in the near future. Optimistic forecasts suggest that exports could reach 25-35 bcm by 2030[19].

Unequal competition between USA and Russian gas

USA LNG exports don't benefit EU LNG markets to any great extent and they don't effectively compensate for the EU's dependency on Russian gas.

- The top 10 buyers of USA LNG are Mexico, Chile, Japan, China, Argentina, Jordan, India, Kuwait, South Korea and Turkey.
- Also, the main European countries that import USA LNG are Spain, Portugal and Italy, none of which is dependent on Russian gas[20].

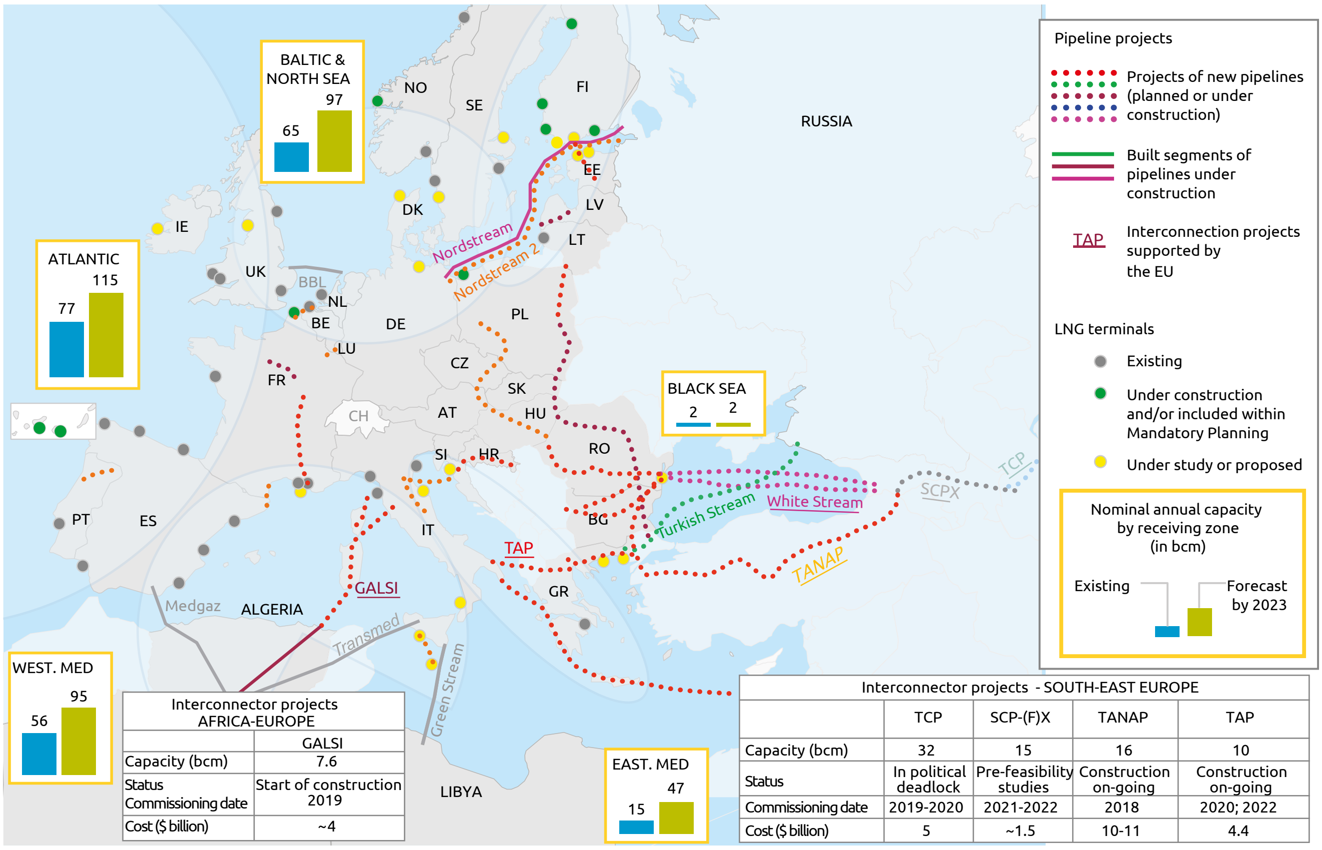
LNG import and demand

LNG imports to Europe increased slightly (2.5%) with total new imports of 45 bcm:

- France and Spain were the countries with the biggest increase in importation:
  - France experienced a 28% net increase; in addition, its LNG re-exportation tripled making it Europe's leader in LNG re-exportation instead of Spain;
  - Spain increased its dependency on LNG (net LNG imports rose by 15%).

13 Reuters
14 Intellinews
15 Platts, June 20, 2017
16 Les Echos
17 CIA, world factbook
18 Le Monde, July 3, 2017
19 IENE
20 Politifact, interview with Jason Bordoff, Director of Columbia University's Center on Global Energy Policy

Figure 3.11 Map of pipelines and LNG terminals projects (as of June 2016)



Interconnector projects AFRICA-EUROPE

	GALSI
Capacity (bcm)	7.6
Status	Start of construction
Commissioning date	2019
Cost ($ billion)	~4

Interconnector projects - SOUTH-EAST EUROPE

	TCP	SCP-(F)X	TANAP	TAP
Capacity (bcm)	32	15	16	10
Status	In political deadlock	Pre-feasibility studies	Construction on-going	Construction on-going
Commissioning date	2019-2020	2021-2022	2018	2020; 2022
Cost ($ billion)	5	~1.5	10-11	4.4

Source: GIE GLE, European commission projects of common interest – Capgemini analysis, WEMO2017

- The UK and Belgium were the two markets with the strongest net imports decrease:
  - Despite greater gas demand in the UK, LNG net imports fell by 26%. The shortfall was mainly met by increased indigenous gas production and piped gas.
  - Belgium's 58% decline was mainly driven by an overall decrease in gas demand.
- The LNG share in overall demand is expected to increase, driven by growing interest in gas as a cleaner source of energy and a good combination with renewables.

In Europe, LNG will be increasingly used in the transport sector, for both maritime and heavy trucks. This reinforces its position as a clean and economic fuel for maritime transportation.

- Maritime transport is considered a potential market for LNG (a 63.6% CAGR from 2014 to 2025[21]) as LNG offers a cleaner source of energy (a reduction of 90-95% in sulfur oxide emissions):
  - In 2016, the International Maritime Organization (IMO) confirmed the 2020 sulfur cap of 0.5% (compared to 3.5% in 2017)[22], which can be met with LNG fuel.

21 SBWire, July 20, 2017

22 International Maritime Organization, Press briefing, October 28, 2016

– An increasing number of shipping companies (such as Shell and Total) and vessel operators are switching to LNG bunker fuel.

Europe, the second largest market for small-scale LNG, is proceeding with building LNG fueling infrastructure aimed at heavy trucking[23], such as the Blue Corridors project:

- This project, launched in 2013, is close to being able to support 150 LNG-fueled heavy-duty trucks (exceeding the initial objective for 2017 of 100 trucks)[24];
- The project includes the establishment of fueling stations; for example, Italy is aiming to have 20 stations in service by the end of 2017.

LNG investment and prices

In the EU, LNG is considered essential for security of supply, not only in energy supply diversification, but also for having more competitive prices and cleaner energy sources.

The European market is aiming to become more flexible, which would allow USA shale gas to provide a further source of supply (6 new LNG terminals are underway, see figure 3.11).

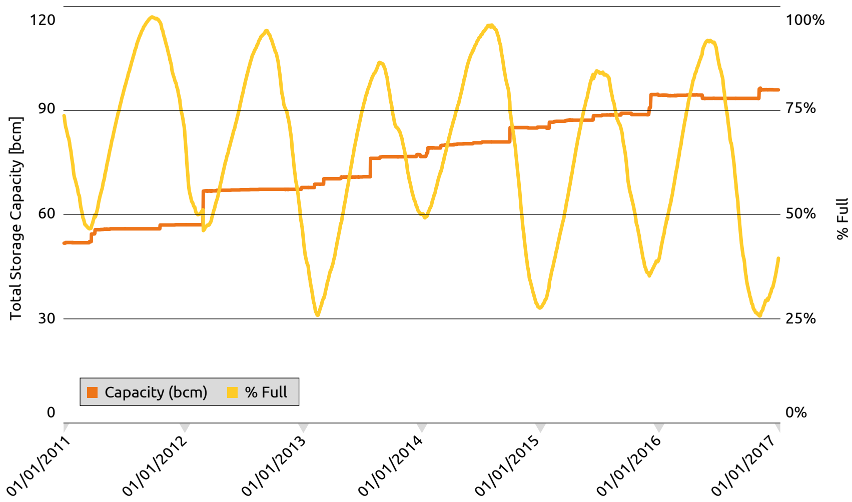
Europe's northwestern storage market is still oversupplied

Gas storage capacity remains a key factor for security of supply. Nonetheless, investment in gas storage facilities is still facing low cross-border availability of stored gas between Member States[25] as well as unfavorable market conditions.

Due to mild weather and low gas spot prices during winter 2015, EU storage levels were at their lowest (36%) on March 30, 2016. As a consequence the filling percentage at the beginning of 2016, at 92% of capacity, was significantly higher than during the same period in 2015 (+12%). A cold 2016 winter, high gas use for power generation, and low LNG imports contributed to a high level of withdrawals and a very low storage level (26%) at the end of March 2017.

- For the UK, closure of the Rough storage site, representing more than 70% of the UK's 50 TWh capacity, will reinforce dependence on foreign supply through the Belgium-UK interconnection pipeline. In the meantime, the falling pound will lead to expensive imports. This situation is likely to continue because only one new storage site is under construction[26].
- In France, the storage market is under pressure due to the monopoly of two players and a decision to regulate new storage prices still pending. Suppliers have been slow to fulfill their storage quota and at May 29, 2017, only 35%[27] of storage capacity had been filled (39% in EU-28).
- Overall EU-28 storage capacity remains level at around 95 bcm with no major facilities coming into use and only 43.5 TWh of capacity under construction, with planned start-ups spread over 2023.

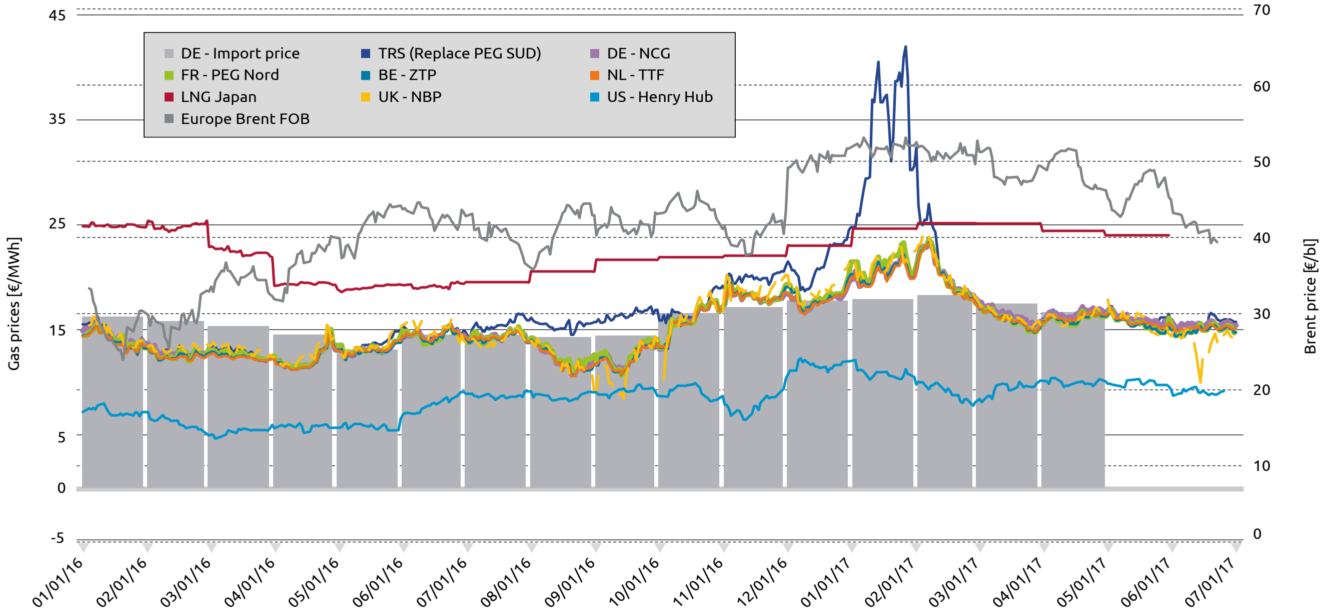
Figure 3.12 Gas storage inventories in EU-28 (2011-2017)



Source: GIE GSE – Capgemini analysis, WEMO2017

23 Market Research Future, July 2017
24 LNG World News
25 Entsog transmission capacity data sheet 2017
26 GIE website
27 Storengy and TIGF

Figure 3.13 Gas spot prices (2016 and H1 2017)



Source: Gas Exchanges web sites, World Bank, BAFA – Capgemini analysis, WEMO2017

Following commodities price trends, gas prices peaked in early 2017

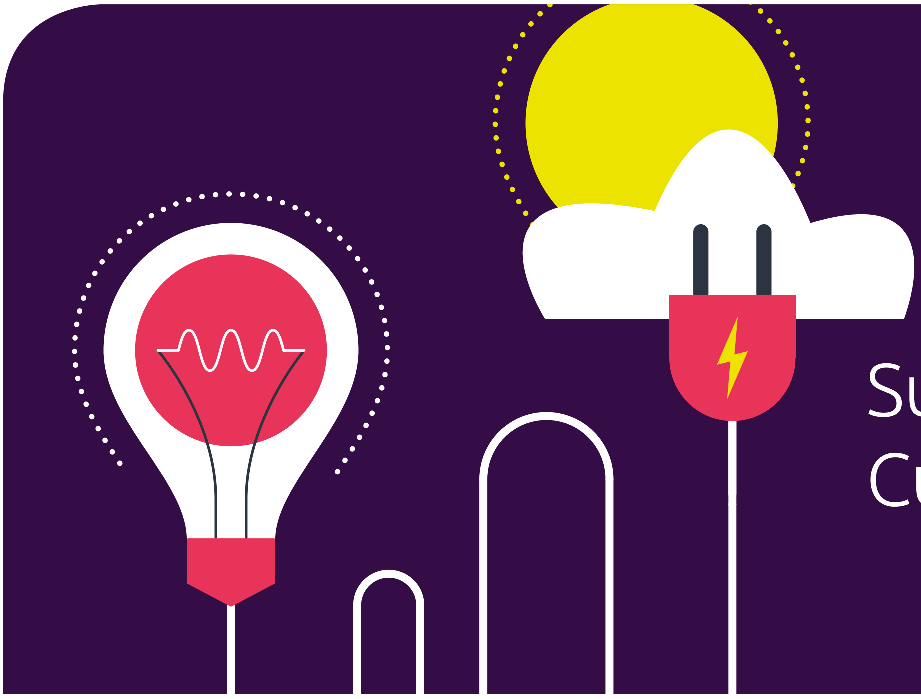
After reaching a low in Q1 2016 due to falling oil prices and reduced gas demand in the EU market, gas prices started to increase in April 2016. The combination of factors such as cold weather, strong demand in the power sector, low LNG imports, Rough storage issues, and rising oil prices led this trend up to February 2017. At that point, mild weather and a rise in LNG imports halted any further increase. Even though the average Brent price in Q2 2017 was around €45 per barrel (compared to €30 in Q1 2016), the average gas price in Q2 2017 of around €15/MWh was identical to Q1 2016. This confirms that oil-indexed gas contract prices can no longer be considered as price setters, particularly with increased EU storage capacity and LNG imports.

The spread between the main EU marketplaces remains low, continuing the trend started in 2016.

- The Dutch Title Transfer Facility (TTF) and the UK's National Balancing Point (NBP) markets were similar in Q1 2016 covering 43% and 44% of overall exchanged volumes. In Q1 2017, TTF volumes remained stable whereas NBP volumes decreased to 39%, with the main cause likely to have been sterling volatility and uncertainty around Brexit[28].
- In France, in January 2017, a spread of €20/MWh occurred between Trading Region South (TRS, which replaced PEG Sud) and PEG Nord, due to low LNG imports at the Fos terminal and persistent low capacity in the north-south pipeline[29]. This confirms the need for unification of the French gas market plan at the end of 2018 with the start-up of the Val de Saône pipeline[30].
- International gas prices diverged at the end of 2016 when both European and Asian prices grew substantially[31]. The trend reversed in February 2017. The ratio of the Japanese LNG price and the USA's Henry Hub decreased to 2.3 in May 2017, having previously been at 2.9 in November 2016.

In France, a spread of €20/MWh occurred in January 2017 between Trading Region South and PEG Nord, due to low LNG imports at the Fos terminal and persistent low capacity in the north-south pipeline.

28 Quarterly report on European gas market Vol. 9 and 10
29 CRE June 8, 2017 press release
30 GRT Gaz
31 Quarterly report on European gas market Vol. 9 and 10



Supply and Final Customer

Energy retail prices evolution

Average European retail energy prices fell in 2016 for both gas and electricity

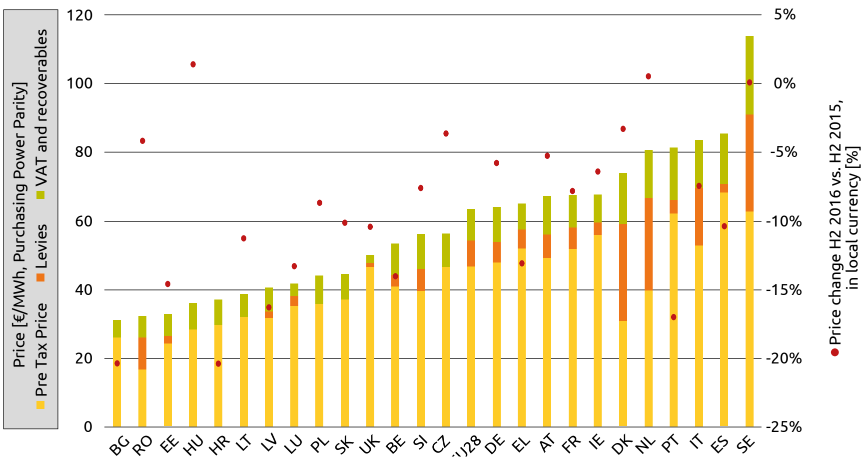
- **Gas and electricity retail prices decreased in H2 2016 compared to H2 2015, driven by**
  - Commodities wholesale prices, which remained very low until the end of Q3 2016 (see appendix);
  - Increased competition between retailers.

Figure 4.1 Average European gas & electricity prices in 2016

	Industrials			Residential		
	Change price between H2 2016 and H2 2015	Min (€/MWh)	Max (€/MWh)	Change price between H2 2016 and H2 2015	Min (€/MWh)	Max (€/MWh)
Gas	↓ From -10.0% to -16.4%	13.6	67.1	↓ -10.5%	31.1	114.2
Electricity	↓ From -4.0% to -8.3%	47	268.7	↓ -2.3%	93.8	308.4

- **Average gas prices in Europe[1] decreased significantly in H2 2016 compared to H2 2015 both for industries** (from -10.0% for very small industries to -16.4% for medium and large industries) **and for households** (-10.5%) to reach, respectively, a minimum of €13.6/MWh (VAT excluded) and €31.1/MWh (all taxes included).
- **Average electricity prices also decreased but to a lesser extent both for industries** (-4.3% for very small industries, -4.0% for small to medium industries, and -8.3% for medium and large industries) **and household segments** (-2.3%).
- **The industry segment is typically characterized by significant price spans according to size** (the bigger, the cheaper): very small industries pay on average about twice the price paid by medium to large industries. However, for a given size of industry, price spans across European countries are always under a ratio of 3.0 compared to residential price spans, which are higher than 3.0.

Figure 4.2 Residential gas prices in Euro – all taxes included (H2 2016 compared to H2 2015, in local currency)



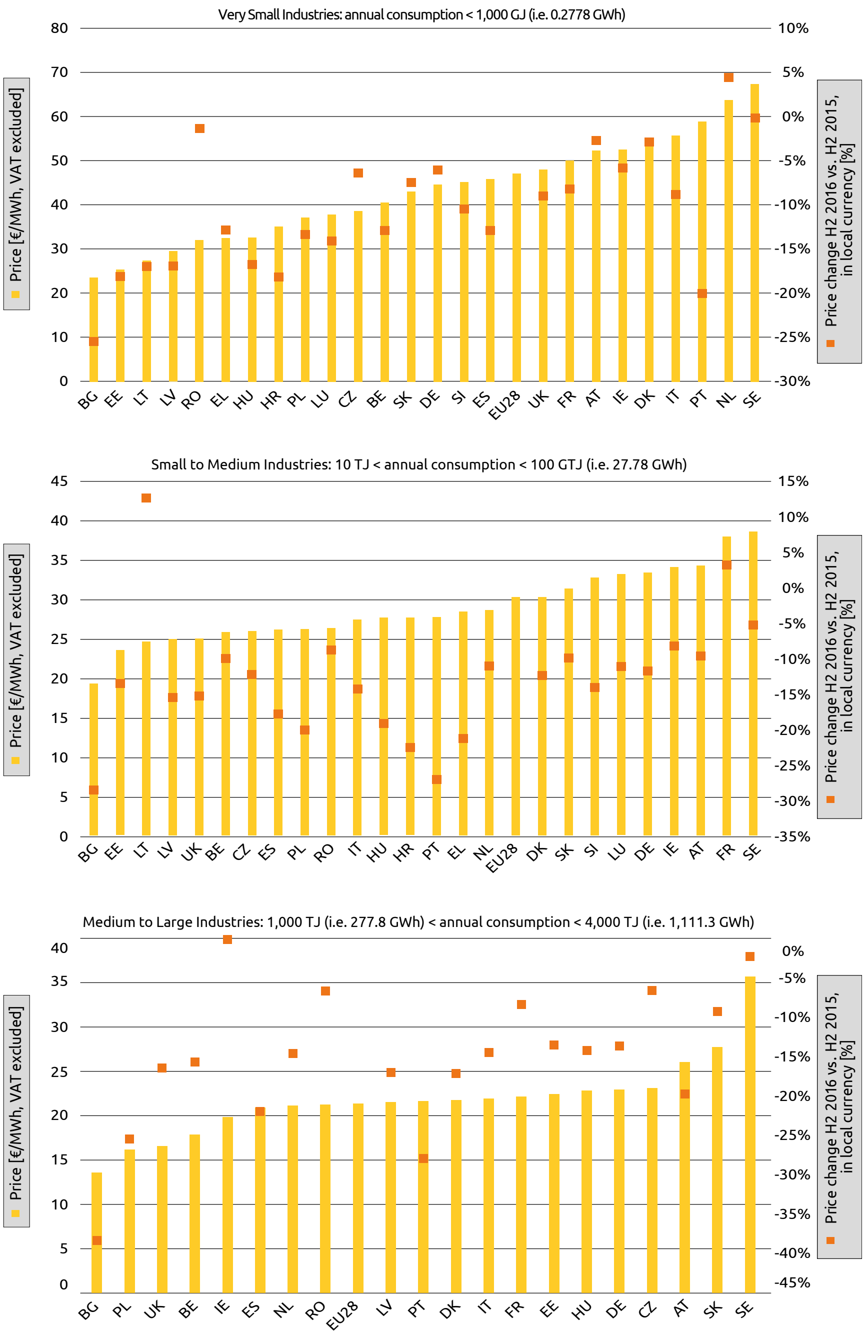
Note: EUROSTAT – Annual gas consumption between 20 GJ (i.e. 5,557 kWh) and 200 GJ (i.e. 55,566 kWh)
Source: EUROSTAT – Capgemini analysis, WEMO2017

1 In this chapter, average prices in Europe are those calculated by Eurostat by weighting national prices in euros with the latest available national consumption for either the household sector or the industrial sector.

Residential and industrial gas prices speed up their downward trend

- **The downward trend observed in average residential gas prices** year-on-year **since 2014 accelerated in 2016, to reach €63.6/MWh[2] in H2 2016.**
- **There are still significant differences in retail gas prices across the EU:** in H2 2016, household prices varied between less than €35/MWh (Bulgaria, Estonia and Romania) and €114/MWh in Sweden, resulting in a price differential ratio of 3.7 between the cheapest and the most expensive country. Although this ratio is rather high, it shows a declining trend since H2 2011 when it was 4.2.
- **Industrial prices started to decrease in 2013 and this trend continued in 2016 for all sizes of industry.** The highest fall was observed for medium to large industries (-16.4%) since their prices are more closely linked to wholesale market prices.
- The average estimated price was €46.9/MWh for very small industries in H2 2016 (VAT and other recoverable taxes excluded), €30.1/MWh for small to small medium industries, and €21.4/MWh for medium to large industries.
- The most significant price decreases between H2 2015 and H2 2016 were experienced in Bulgaria (between -25% and -38%) and Portugal (between -20% and -28%)[3].

Figure 4.3 Industrial & Commercial gas prices in Euro – VAT excluded (H2 2016 compared to H2 2015, in local currency)

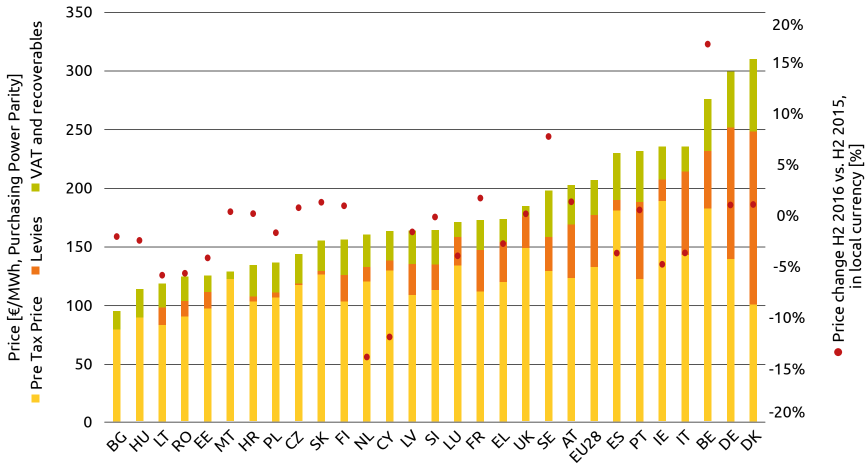


Source: Eurostat – Capgemini analysis, WEMO2017

2 for consumption band D2 which includes most household consumers (between 20 GJ and 200 GJ)

3 In this chapter, price changes in H2 2016 compared to H2 2015 for a given country are calculated in local currency to overcome the issue of fluctuating exchange rates in non-EU countries.

Figure 4.4 Residential electricity prices in Euro– all taxes included (H2 2016 compared to H2 2015, in local currency)



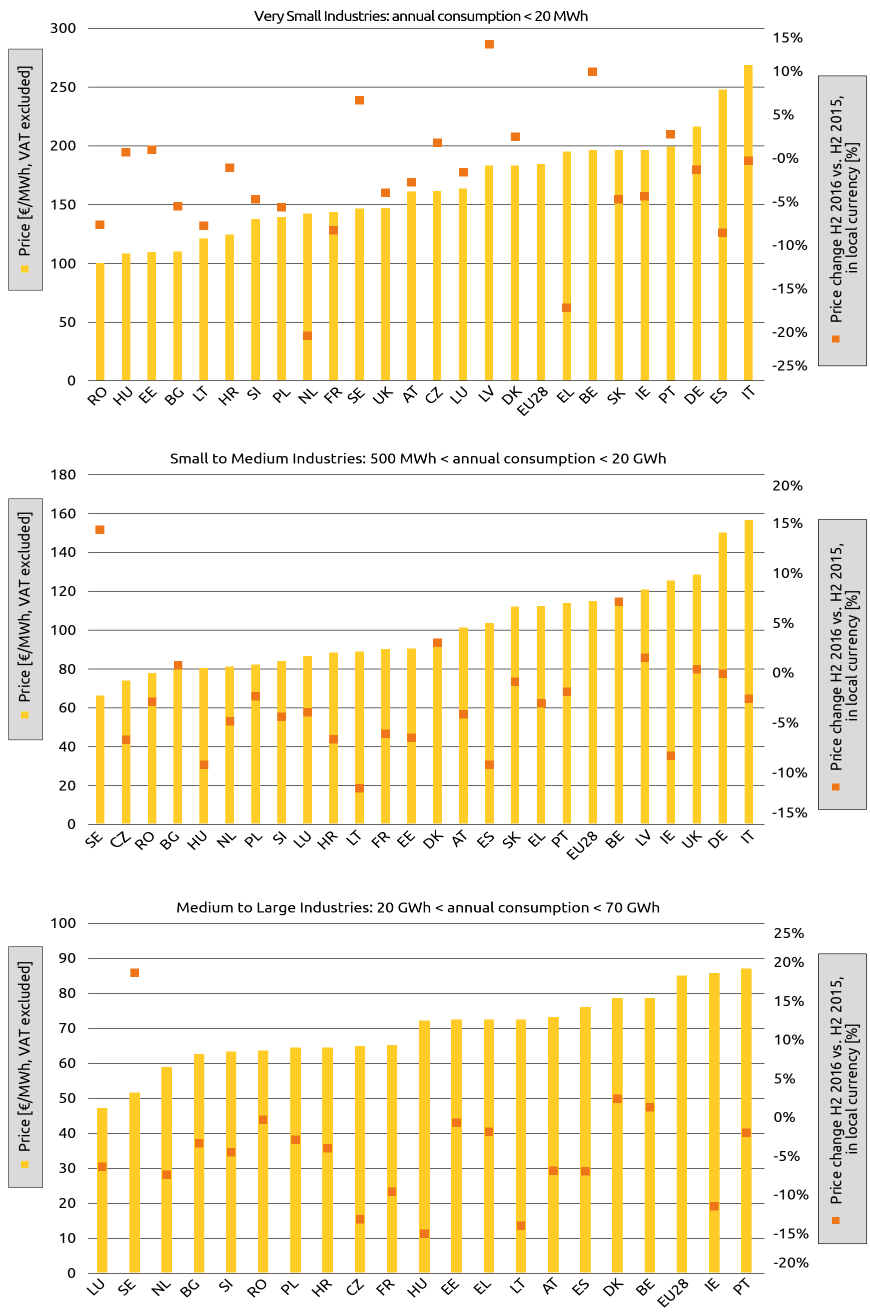
Note: Annual electricity consumption between 2,500 kWh and 5,000 kWh
Source: EUROSTAT – Capgemini analysis, WEMO2017

- The price differential ratio between the lowest prices (Bulgaria) and the highest prices (Sweden) increased for each industrial segment: 2.8 for very small industries (+20%), 2.0 for small to small medium industries (+4%), and 2.5 for medium to large industries (+48%).

Moderate decrease in electricity prices

- **Average residential electricity prices decreased by 2.3%** in H2 2016 compared to H2 2015, after an increase of 1.4% between H2 2014 and H2 2015, masking significant disparities between countries: **the Netherlands (-13.8%) and Cyprus (-11.8%) experienced strong decreases,** but **Belgium saw a significant increase (+16.7%) linked to the end of the free kWh allocated to families in Flanders.**
- Denmark (€308/MWh) and Germany (€297/MWh) have the highest prices due to the level of taxes, whereas Bulgaria has the cheapest electricity price (€94/MWh).
- In France, residential prices increased by 1.7% despite the first decrease since 2000 in regulated tariffs for households in August 2016 (-0.5%), which still apply to 87% of households. This decrease did not compensate for the increase in the fixed component of the bill and the CSPE tax increase of €3/MWh to support energy transition costs.
- In Germany, the moderate increase of 1.1% can be explained by:
  - State-guaranteed prices for renewable energy producers paid by households through **the renewable energy surcharge (EEG tax), which rose by 3% to €63.5/MWh in 2016** after falling by 1.1% in 2015;
  - Investment in the electricity grid which led to a 4% increase in grid fees to reach €70.1/MWh (about 25% of a household electricity bill) in 2016.

Figure 4.5 Industrial & Commercial electricity prices in Euro – VAT excluded (H2 2016 compared to H2 2015, in local currency)



Source: Eurostat – Capgemini analysis, WEMO2017

- **In H2 2016, average industrial electricity prices decreased, in line with the trend observed since 2014.** For small to small medium, and medium to large, industries, Lithuania experienced significant decreases (-12% and -14%) while Sweden had substantial increases (+14% and + 19%). In Germany, prices fell sharply (-14%) for medium to large industries but remained stable for smaller industries: energy-intensive industries, largely exempt from levies, benefited fully from decreasing wholesale prices until the end of Q3 2016.

Energy prices deregulation is ongoing

- **Market deregulation is due to continue in countries that are not yet fully deregulated,** with, for instance, the likely imminent end to residential regulated tariffs for gas in France, deemed contrary to European Union law by the Council of State in June 2017. In Italy, the ending of gas and power regulated tariffs for households and SMEs, initially planned for 2017 and then 2018, has been delayed again to 2019. In 2016, there was still price regulation for households in more than half of Member States, and price regulation for industries in 11 of them[4].

[4] The economic impact of enforcement of competition policies on the functioning of EU energy markets http://ec.europa.eu/competition/publications/reports/kd0216007enn.pdf

Customer expectations – European household customers have evolving expectations and ways of buying: they are more and more demanding

Customers are more actively involved regarding energy sources

- **The appetite for green electricity continues to grow in most European countries:**
  - 42% of consumers are prepared to pay a small additional amount (€4 every month) to purchase renewable electricity according to a European Commission study[5];
  - 38% of French citizens consider it essential to have renewable electricity[6];
  - In the UK, 27% of consumers are willing to pay an average of £6 (ca. €8.50) more per month to fund renewable energy[7];
  - In the Netherlands, there were about four times more new green energy contracts than other new contracts in 2016 (with green deals already representing about 60% of all existing contracts);
  - Overall, more than 15 million consumers in Europe have already opted for a green electricity tariff with a 100% renewable fuel mix[8]. However, there is still an intense debate about whether the green electricity sold to consumers is actually green since there is no direct correlation with the fuel mix.

- **Several signals across Europe suggest that the will to buy locally produced energy is increasing.** For instance, 36% of French citizens consider it essential to buy electricity from a provider within their region[9].
- The ultimate sign is the **enthusiasm for self-consumption**, illustrated by the development of solar photovoltaic roofs and energy storage solutions (see chapter 5).

Customers increasingly seek price efficiency, transparency and simplicity

- **For several years, a new trend has emerged of customers buying their energy collectively,** whether they are residential or professional customers, or communities (municipalities, hospitals, etc.). These collective energy-switching plans are often led or facilitated by a consumer organization or local authority, but also by the media or other interested parties. They negotiate low prices with energy suppliers through reverse auctions and consumers who had registered with the initiative then decide whether to switch.
  - In France and the Netherlands, in 2016, around 107,000 and 78,000 residential customers respectively switched through collective initiatives (organized by UFC-Que Choisir and Consumentenbond), saving more than €40 million[10] per year.
  - In Belgium, almost 240,000 residential customers registered with an initiative in 2016. These initiatives varied a lot in terms of size (from less than 1,000 potential customers to more than 100,000).
  - The UK also proved to be dynamic, with several examples of large-scale collective switching, such as the Collective Big Energy Switch or the Big Energy Switch in Scotland.

- **Customers want transparency in order to make their choice.** Price comparison websites, which compare tariffs from multiple suppliers and often offer to manage the switch, are increasingly used by consumers.
  - **In Europe, 21 countries had price comparison tools for electricity (16 for gas) at the end of 2015.** The UK, France, Germany, Belgium, the Netherlands, and Austria are the most transparent markets with three or more tools for gas and electricity[11].
  - **The UK market is particularly active.** In the first six months of 2015, price comparison websites accounted for around 30% of domestic customer acquisitions by three of the Big Six energy suppliers, and around 63% of the domestic customer acquisitions by three of the mid-tier suppliers.
  - In the Netherlands, switching through price comparison sites

5 The European Commission's Energy Consumer Trends 2010 – 2015, SWD (2015) 249 final, November 2015. The study covered the Czech Republic, Germany, Spain, France, UK, Italy, Lithuania, Poland, Sweden and Slovenia.

6 Ifop study for Synopia, "Les Français et l'électricité", January 2017

7 Building4change - http://www.building4change.com/article.jsp?id=2633#.WbFUAbIjGpo

8 BEUC – The European consumer organisation

9 Ifop study for Synopia, "Les Français et l'électricité", January 2017

10 BEUC – The European consumer organisation

11 CEER, Annual report 2016

represented 10% of switches in 2016 (compared to 8% in 2014). They were used as information channels before switching in 41% of all switches (compared to 36% in 2015)[12].
  - The success of these websites has led suppliers to pay a sizeable fee (prices generally vary from €30 to €80 per contract) to these websites in order to acquire new customers through them.

- **The development of dual fuel offers** – gas and electricity bundles – is still highly diverse across Europe (from almost every household in the Netherlands or 80% in the UK, to a minority in France). However, customers' growing appetite for simplicity tends to increase the number of such offers in countries where dual fuel offers remain underdeveloped.
- Customers are ready to reward better experiences with increased spending. Capgemini research[13] The Disconnected Customer found that **73% of customers are willing to pay more for a better digital customer experience.**

Competition evolution – Competition continued to increase: more new suppliers entered the market and new offers and services were developed, especially to meet the growing willingness of some consumers to be actively involved in their energy supply

Suppliers from various spheres continued to enter the market

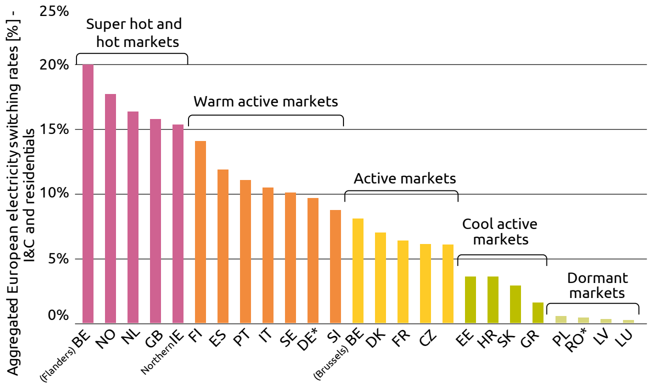
- Competition has increased in European retail energy markets in recent years, characterized by the arrival of **new players. This trend has continued over the last 18 months (2016, H1 2017) in almost all major European countries.**
- **Focus on the electricity market – New entrants have diverse profiles and various ways by which they enter the market**:
  - **Strong Utilities already established in other segments or geographies:** In the UK, ENGIE and Vattenfall, already active in the UK B2B energy market, entered the B2C market. To do so, Vattenfall acquired iSupplyEnergy, a small supplier with 120,000 customers. In France, the Italian company Eni, which already supplied gas to households and businesses in France, entered the B2B and B2C markets.
  - **Oil majors:** Total entered the French market in 2016 by acquiring Lampiris and has announced ambitious plans. In the UK, Shell launched a B2B electricity offer in August 2017.
  - **Specialized players (niche, startups):** Examples are widespread throughout Europe. In France alone, five small new players entered the household market in 2016 (ekWateur, ilek, Plüm Énergie, Énergies du Santerre, ENERGIE D'ICI).
  - **Players from other sectors:** In H1 2017, the well-known **retailer** Casino entered the French market under the brand GreenYellow as well as the French low-cost **telecoms company** Budget Telecom.

- **Many diverse factors explain the attractiveness of the B2C retail energy market, despite low margins** (see below): **increasing churn rates** (boosted by deregulation, government regulators information campaigns, development of comparison tools); **poor image associated with incumbents in some countries** (the UK and Spain are good examples); **recent technology innovations** – including smart meter deployment – **enabling the proposition of disruptive offers** (innovative pricing, peer-to-peer, etc.); and **the modest effort needed in terms of time and money to set up as a supplier** using a similar approach to mobile virtual network operators (MVNO) (no need to acquire any production or transport infrastructure).

12 ACM; NL regulator for energy market

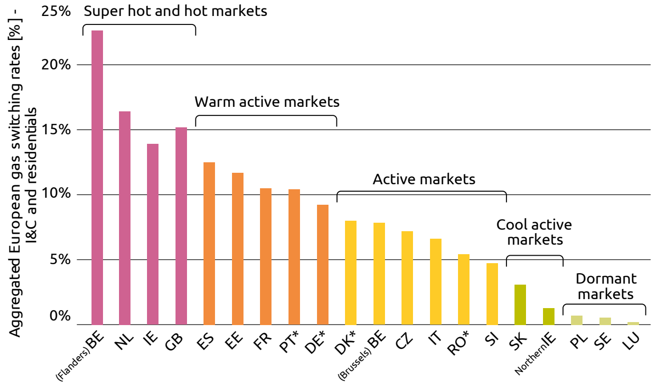
13 Capgemini, the Disconnected Customer: What digital customer experience leaders teach us about reconnecting with customers

Figure 4.6 Aggregated European electricity switching rates (2016)



* 2015 figures
Source: VaasaETT Utility Customer Switching Research Project – Capgemini analysis, WEMO2017

Figure 4.7 Aggregated European gas switching rates (2016)



* 2015 figures
Source: VaasaETT Utility Customer Switching Research Project – Capgemini analysis, WEMO2017

Both incumbents and new players have continued to develop green offers, innovative tariffs and energy savings solutions as well as new services

- **Low-cost and digital offers:** Most new players arriving in the market are natively low cost and digital, although incumbents are also enriching their offers portfolios in this segment.
- **Innovative tariffs and discounts:** In the UK, ENGIE offered a 100% green energy tariff at no additional cost, as well as an offer guaranteeing the cheapest available tariff when their contract expires. French startup Plüm Énergie offered to double the amount of money customers saved through energy efficiency measures, while GreenYellow offered cash back on its retail business loyalty program for new subscribers.
- **Energy efficiency solutions:** ENGIE reinforced its position on the energy services for the municipalities in the UK by acquiring the renovation specialist Keepmoat.
- **Energy services:** Many examples of smart homes, smart buildings, smart mobility, and smart city solutions are provided in chapter 5.
- **Other services linked to energy:** Centrica (British Gas) developed a platform for consumers to contact local craftspeople for their electrical, heating or plumbing jobs, a few months after the independent retailers First Utility and OVO Energy.
- **"Self-service" supply:** Scottish Power launched PowerUp in 2016, a platform that enables customers to buy electricity or gas in packages up to six months in advance at a set price.
- **Energy mix à la carte:** In the Netherlands, ENGIE enabled customers to choose their energy sources from both local and global producers (e.g. Dutch wind, hydro from France).
- **"Peer-to-peer" energy marketplace:** Vattenfall launched Powerpeers, a marketplace and community where customers can decide who they receive their energy from and who they supply their self-generated energy to. In France, independent start-up ilek offers consumers the chance to buy energy from local renewable producers. Meanwhile, several players that have emerged in recent years in this segment continue to win new customers (see chapter 5).

The upward trend in Europe's switching energy landscape was favoring alternative suppliers

- **In 2016, there were significantly more countries where switching rates increased rather than decreased compared to 2015, especially in electricity markets.**
- The **Belgian region of Flanders retained its number one spot in Europe:** churn rates increased from 16.4% in 2015 to 20.1% in 2016 for electricity and from 17.7% to almost 22.6% for gas. Other significant changes in customer activity were seen in the electricity market in **Great Britain** (from 12.5% to 15.8%), **Northern Ireland** (11.3% to 15.4%), and **Norway** (13.4% to 17.8%), and in the gas market, in **Austria** (from 3.4% to 5.0%) and **Great Britain** (12.4% to 15.2%).
- **Switching in the French electricity market increased in 2016 (from 4.7% to 6.1%),** boosted both by a slight upturn in the household segment since

mid-2016 and by the level of churn in the industrial segment, which remained higher in Q2, Q3 and Q4 2016 than it was in Q1, Q2 and Q3 2015. (The churn rate in Q4 2015 and Q1 2016 was abnormally high due to the end of regulated tariffs for medium to large industries on January 1, 2016.[14])

- A gradual increase in customer switching in the Greek electricity market (from 0.4% in 2014 to 1.6% in 2016), is helping it move up from the "Dormant markets" category to "Cool active markets", and showing positive signs of increased competition four years after full liberalization of the electricity market.
- **Ireland was the only market in Europe where a significant downward trend was observed:** the gas churn rate decreased by 2.4% to reach 13.9%, which might be partly explained by the high levels of customer satisfaction. Electricity churn rates decreased by 0.8% in Denmark and in Sweden, while gas churn rates decreased from 6.2% to 4.8% in Slovenia after experiencing the opposite trend the previous year.
- Switching mainly benefits new players across Europe. **Non-incumbent players are winning market share against incumbents, but many markets are still concentrated** – the market share of the three largest suppliers still exceeds 60% in 14 Member States – **and incumbents remain strong.** The electricity market in the UK is a good example: in Q1 2017, the Big Six still held 83% of the residential electricity market, compared to more than 99% in 2012[15]. In Ireland, the market share of the three largest electricity suppliers fell from 99.23% in 2012 to 89.9% of households in 2015 and the market share of the three largest gas suppliers fell from 98% in 2011 to 88.4% in 2015[16].

Incumbents remained strong but the future is uncertain

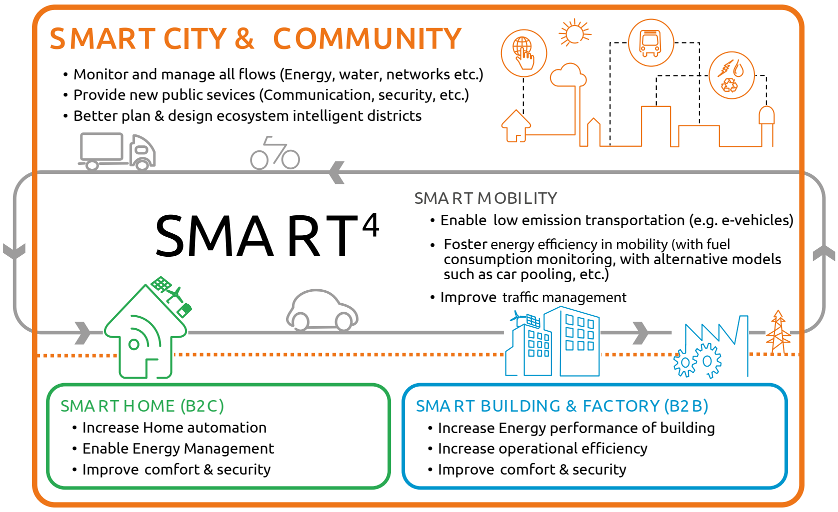
- **Several reasons can explain why incumbents remain strong:**
  - Incumbents benefit from the fact that **many customers are still unaware they can switch.**
  - They have proved their **ability to follow the trend in proposing innovative offers and services** through their **own brand**, through their **subsidiaries** (for instance Oxxio (Eneco) in the Netherlands), or through **start-ups** they own, acquire or are in partnership with.
  - Incumbents have a **financial base that enables them to implement significant growth strategies** when entering a market and **to stabilize their customer base** through big retention campaigns.
  - **Incumbents may benefit from higher competitiveness in operations** driven by the number of customers they serve. They also benefit from **efforts made in improving customer experience.**
  - **In the context of low margins, incumbents benefit from greater resilience to sudden price surges than independent retailers.** Independent retailers have neither their own generating capacity nor a large choice of hedging products (given their size) to limit their exposure to wholesale market prices. For example, when the electricity wholesale price began to rise in late 2016, the UK independent retailer GB Energy – with 160,000 gas and electricity customers – went bankrupt.
- **Future evolutions in retail markets are uncertain and driven by a few major potential game changers:**
  - Would new players be able to keep on gaining market share at the expense of incumbents if wholesale prices were to rise again?
  - Among all the new services and business models, which ones will enable suppliers to increase their revenues and margins?
  - Will players coming from other sectors (such as telecoms, retail) continue to enter the supply market? Could they drive development of one-stop-shop approaches – bundle offers, for instance energy plus telecom plus broadband – which are still in their infancy?
  - Will other groups, such as internet players – who are already developing smart homes, smart buildings, and smart mobility services (see chapter 5) – also enter the supply market in the near future?

14 Commission de regulation de l'énergie
15 Ofgem
16 Commission for Energy Regulation

Market Transitions and Innovation

Many different players are developing value propositions enabling energy transition for end-users around four smart areas. Since 2016, transition levers such as self-consumption, storage, energy management platforms, and peer-to-peer marketplaces have been growing dynamically

Figure 5.1 The SMART4 approach – the 4 smart areas of the energy transition downstream



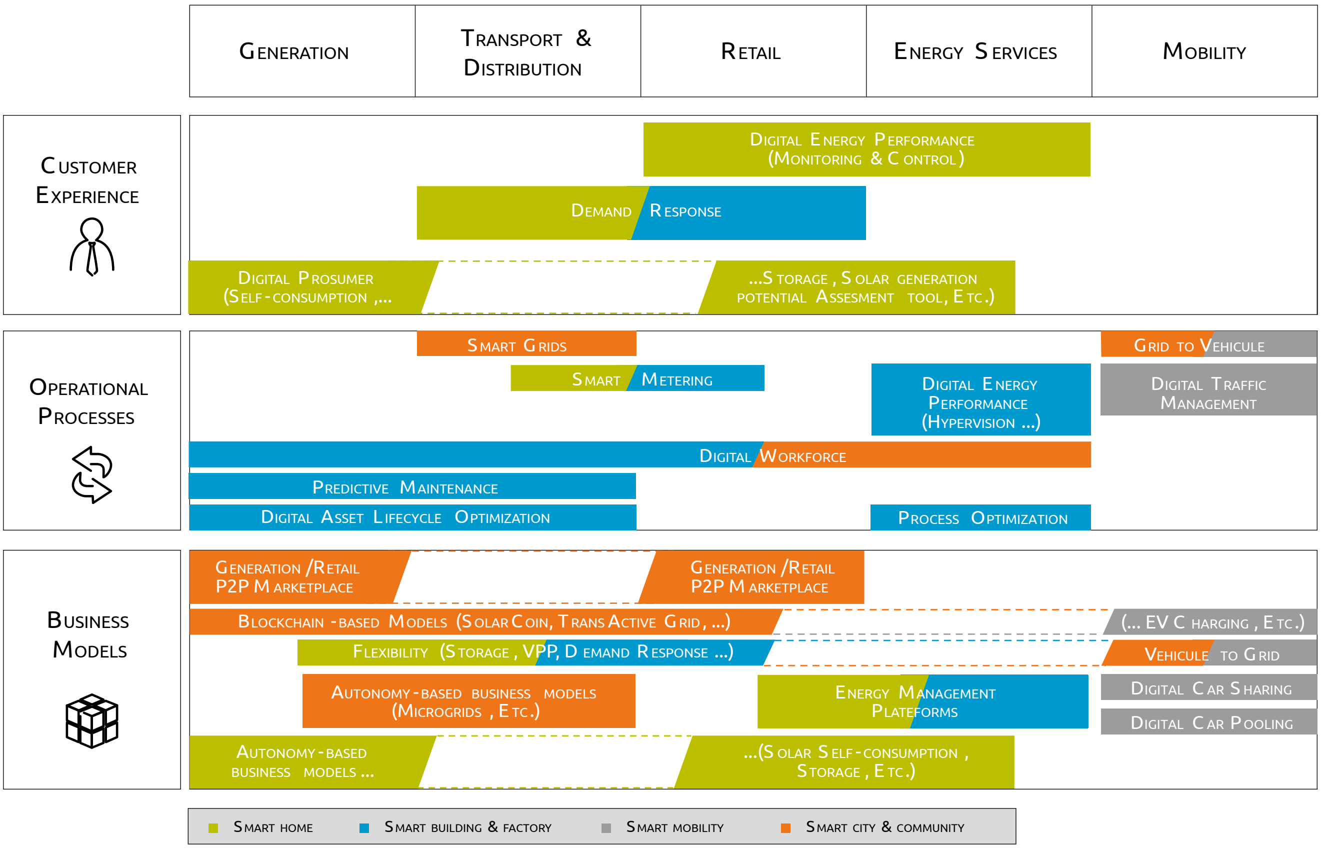
Source: Capgemini Consulting Analysis

- Downstream energy transformation stakes gravitate around four "smart" areas: smart homes, smart buildings and factories, smart mobility, and smart cities and communities (see figure 5.1).
- "Smart" is often used in the energy sector to mean "digital". Energy transition (as a goal) is enabled by digital transition (as a means to an end): figure 5.2 shows the main digital levers for energy transition.
- Some of these energy and digital levers are particularly active, such as solar self-consumption[1], storage solutions, blockchain[2], energy

1 Solar self-consumption: consumption of solar-generated electricity directly at the point of generation (the house, the building), or storage of this energy for local usage later on.

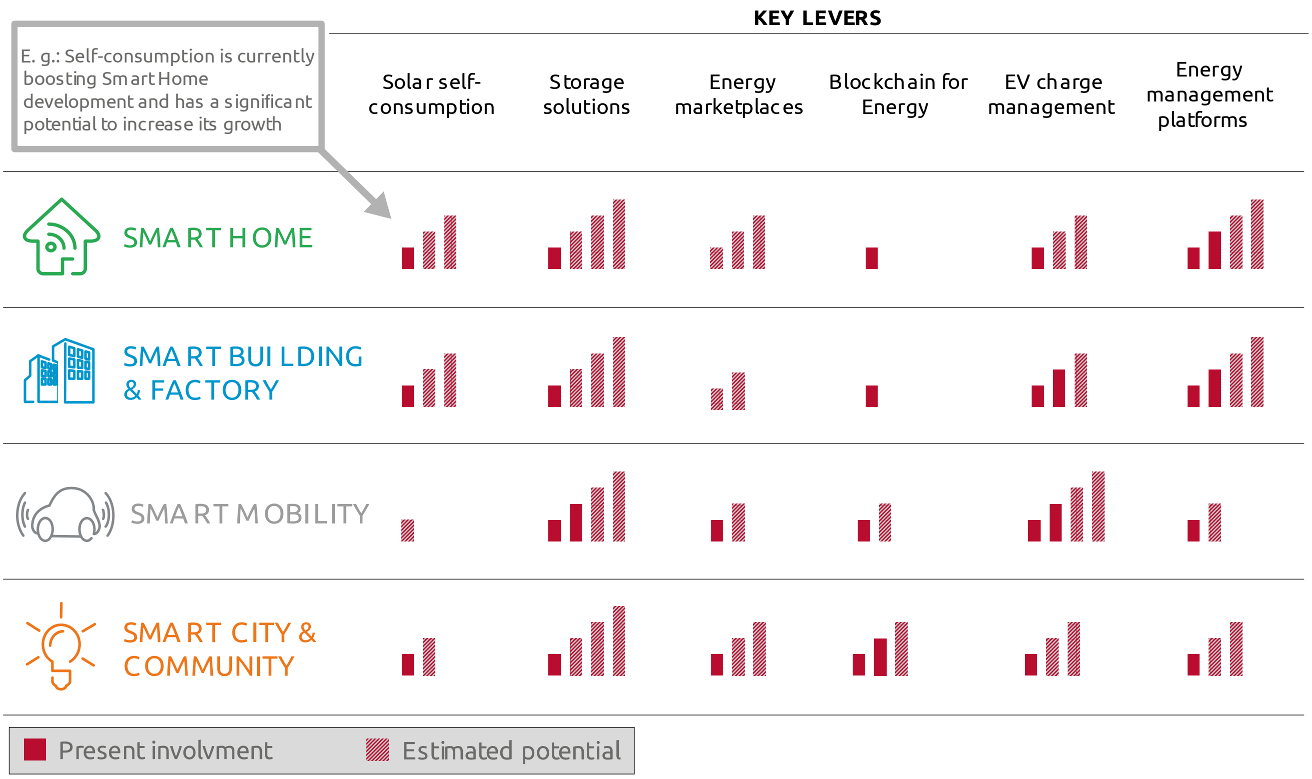
2 Blockchain: the blockchain is a distributed database technology that allows the processing and validation of all sorts of information transactions without a trusted central party, across a large number of participants (see topic box 5.4).

Figure 5.2 Selection of digital levers for the energy transition



Source: Capgemini Consulting Analysis

Figure 5.3 Contribution of key levers to the 4 Smart areas



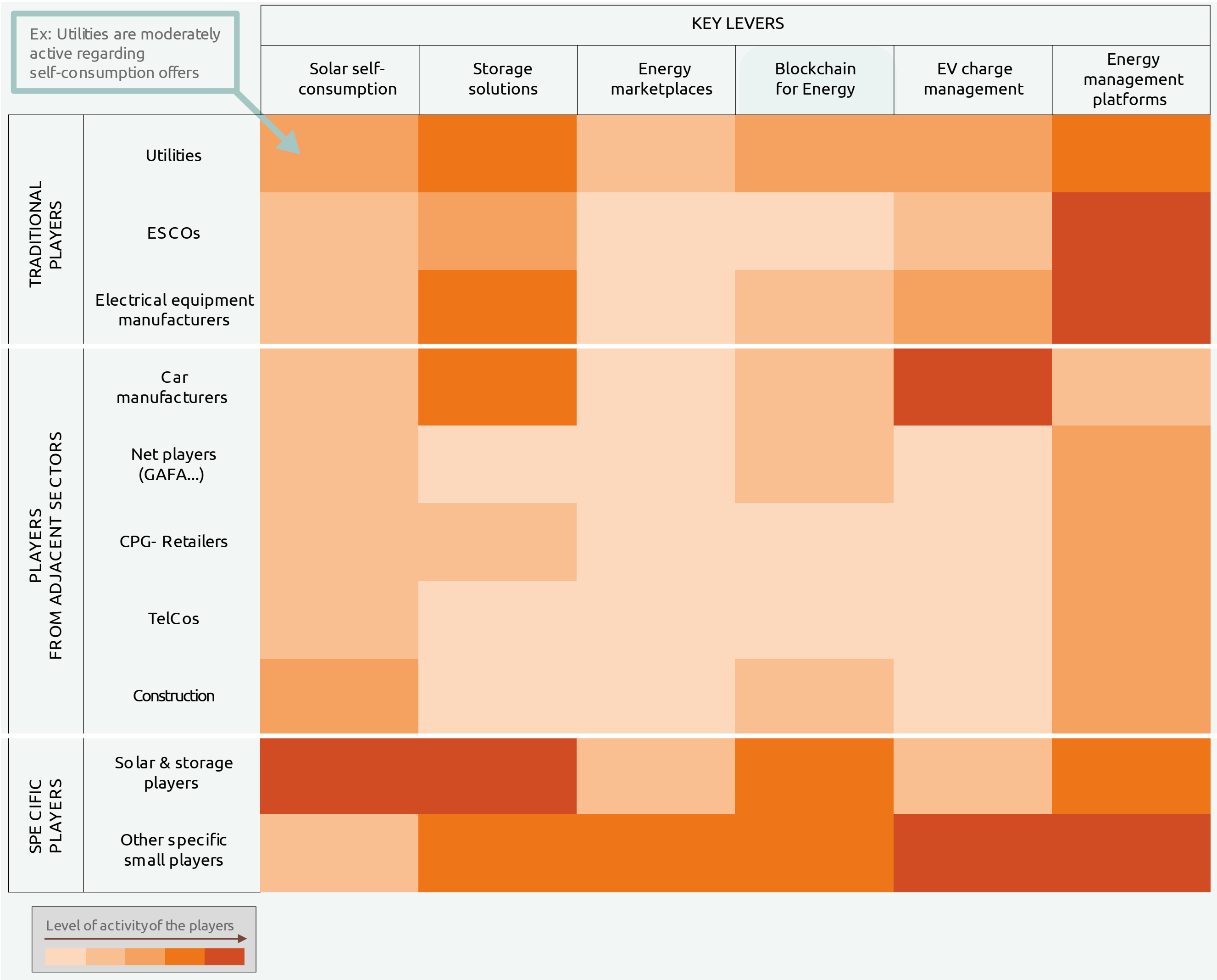
Source: Capgemini Consulting Analysis

Europe

marketplaces[3], electric vehicle (EV) charge management[4], and energy management platforms[5] (see figure 5.3).

- Active players in these areas are highly diverse and go beyond traditional Utilities, energy service companies (ESCOs), and electrical equipment providers. They include car manufacturers; Google, Apple, Facebook, Amazon (GAFA); telcos; construction companies; consumer product goods (CPG) retail companies; specific solar and storage players; and other small pure players (e.g. small new retailers, startups focusing on software solutions for energy performance, peer-to-peer platforms) (see figure 5.4).
  - Traditional Utilities are active in every key lever but in almost all fields, other types of player overshadow them.
  - In energy management platforms, many types of players have been developing offerings, led by traditional ESCOs and electrical equipment providers.
  - In several key levers (energy marketplaces, blockchain, storage), small pure players appear to be the most active.

Figure 5.4 Heatmap of types of players on key levers[6]



Source: Capgemini Consulting analysis

3 Energy marketplace: platform enabling the direct exchange and/or direct commercialization of energy between identified and selected producers and customers.

4 Both ways: grid-to-vehicle and vehicle-to-grid.

5 Energy management platform: software (or soft and hardware) solution to collect, analyze and value data linked to energy.

6 Level of activity based on initiatives, projects and offers developed and communicated by the particular type of player on the specific key lever.

– Car manufacturer activity has been growing since H1 2016, as they move into stationary applications (e.g. smart home and storage) in addition to their traditional mobility business.
- These players want to serve customers whose opinions about energy are changing and for whom energy could be a lifestyle choice in terms of choosing the source and method of delivery, for example, claiming: "I want to consume my energy, my way".

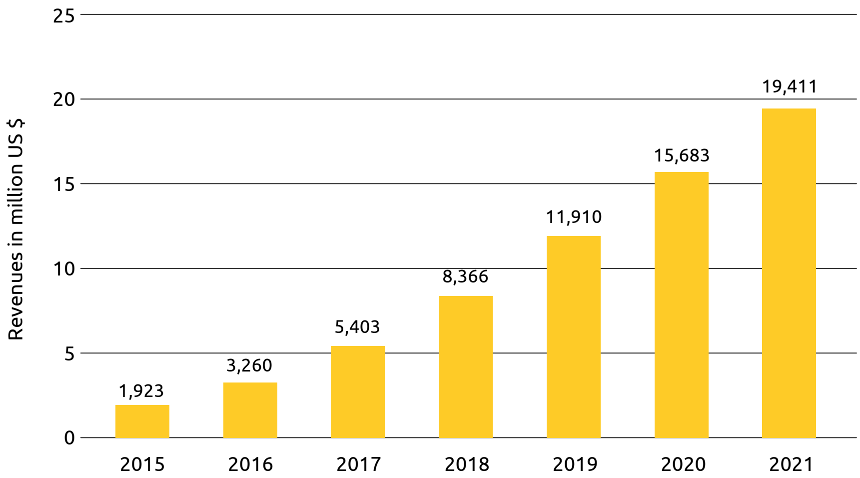
Smart homes

Dynamic perspectives on energy storage and self-consumption complete the traditional smart home model. Utilities are collaborating with other smart home players and ecosystems to build and push new offers.

A smart home is a house with digital, automated or remotely controlled components, enabling, among other things, energy management (as well as increasing home automation, and improving comfort and security). It encompasses communication, information, entertainment and audio-visual equipment, security, comfort, healthcare, energy management, and heating, ventilation and air conditioning (HVAC). Europe's smart home market is expected to grow from $5,403 million in 2017 to $19,411 million by 2021[7].

Regarding energy, the basic components of smart homes are monitoring and control devices, and home automation.

Figure 5.5 Revenue in the Smart Home Market in Europe in million US $[8]



Source : Statista: Smart Home in Europe October 2016

- **Equipment providers have been very active in this area during the last 5 years.** Many offers measure and visualize energy consumption, like Schneider Electric's Wiser Link, launched in 2014. Others also allow consumers to control their home energy devices, such as Schneider's Wiser Smart, launched in 2014, the Smart Home Controller, launched by Bosch in 2016, and Legrand's Céliane with Netatmo in 2017. Some offers combine energy management, comfort and security, such as ABB's free@home launched in 2016, and xComfort from Eaton.
- Many Utilities offer innovative energy management solutions:
  – Since the first products hit the market, such as Eneco Toon in the Netherlands or Centrica Hive in the UK, offers from established Utilities have proliferated. In 2015, SSE in the UK offered a boiler with tado°, a smart thermostat that allows consumers to control heating and hot water from their smartphone. In France, EDF launched its Sowee solution in October 2016.
  – In 2017, Casino subsidiary GreenYellow launched a single energy supply offer for residential customers, called Energie connectée. The system includes a meter connected to a sensor, which allows consumers to monitor their energy consumption.
  – Home battery storage has been a dynamic component of Europe's smart homes since 2015, allowing consumers to have much more control over their energy use.

- Equipment manufacturers (e.g. Samsung, Panasonic, LG, Sony) and storage companies (e.g. Sonnen, the leader in Germany) are the top sellers of battery storage solutions.
- Some Utilities, such as Eneco's CrowdNett, pay consumers to use their home energy storage to help balance the grid.

Europe

7 Statista: Smart Home in Europe, October 2016 https://www.statista.com/outlook/279/102/smart-home/europe#

8 Statista, idem

Topic Box 5.1: Self-consumption in France and international perspectives

Christine Le Bihan-Graf

Self-consumption, which can be defined as the ability of consumers to produce all or part of their electricity consumption, is expected to grow substantially in France but also in several other countries due to a favorable legal framework.

The development of self-consumption is also consolidated by technological advances and tends to increase in line with progress made in storage devices.

1. In France, self-consumption is expected to grow strongly thanks to a favorable legal and economic context

According to the Energy Regulatory Commission in 2017, there are 14,000 self-consumers, representing 0.04% of customers connected to the public electricity distribution grid[1]. This is likely to increase with lower production costs and the simultaneous rise in retail electricity prices.

- **Public authorities encourage development of this practice through an advantageous legal framework.**
  Within the enabling environment created by the Energy Transition Law of August 17, 2015, the Ordinance of July 27, 2016 on self-consumption gave legal status to individual and collective self-consumers. On this basis, the government has set up several direct or indirect support mechanisms:
  - Premiums and feed-in tariffs: Small-scale photovoltaic installations benefit from an investment premium and feed-in tariffs for the excess electricity[2]
    Development of large-scale facilities is supported by calls for tenders for the award of contracts providing premiums on energy consumed and energy injected into the grid. Compensation encourages self-consumption rather than injection into the grid.
  - Tax exemptions: Most self-consumption facilities are exempt from payment of the public service contribution (CSPE). Small-scale facilities are also exempt from payment of the final consumption tax on electricity (TCFE)[3] and are not subject to value-added tax for self-consumed energy.
  - Specific grid tariffs: Small-scale facilities benefit from an adapted tariff[4]. The regulator has therefore set up a specific management component for self-producers[5].
    The regulator has also said that wide-ranging consultation will be undertaken in order to define a tariff adapted to the development of self-consumption[6].
- **However, self-consumption causes significant disruption in the economic balance of the sector especially regarding financing the grid.**
  The reduction of energy withdrawn from the grid necessarily leads to a reduction in revenue for grid operators while their costs remain constant.
  But self-consumption does not allow total independence from the grid. In the absence of significant storage capacity, self-consumers are forced to alternate between self-production and grid dependence, and continue to benefit from services provided by the grid.
  Also, the tax advantages of self-consumption may unbalance the existing framework and result in a transfer of charges to other consumers.

2. Self-consumption is also growing internationally within significantly different legal frameworks

The International Energy Agency has carried out in-depth analysis in 20 countries where PV self-consumption is permitted. The study identified five main economic models of self-consumption[7]:

- **Self-consumption with constraints:** fees or taxes are applied to self-consumed electricity, and electricity injected into the grid is not remunerated. This is the case in Spain, where there is no payment for excess electricity below 100 kW injected into the grid and self-consumption facilities are charged a fee per kWh consumed (the so-called "sun tax").
- **Self-consumption with a feed-in tariff:** excess electricity injected into the grid is bought at a predefined tariff.
  This scheme was set up in Germany in some market segments and is being developed in France.

---

1 Energy Regulatory Commission, Eléments de réflexion, Les enjeux associés au développement de l'autoconsommation, July 25, 2017

2 Ministerial Order of May 9, 2017 (NOR: DEVR1712972A)

3 Articles L. 3333-2, V, 4° and L. 2333-3 of the General Local Authorities Code

4 Article L. 315-3 of the Energy Code

5 Energy Regulatory Commission, Deliberation of November 17, 2016 on the tariffs for using the public electricity grid in areas of high and low voltage ("TURPE 5")

6 Energy Regulatory Commission, Deliberation of 17 November 2016 on the tariffs for the use of public electricity grid in the areas of high voltage and low voltage, p. 3

7 International Energy Agency, Review and analysis of PV self-consumption policies, 2016

8 On September 12, 2017 the Energy Regulatory Commission organized a conference to initiate consultation on this subject.

- **Net-billing regulation:** self-consumers pay the difference between the electricity they inject into the grid and the electricity they withdraw from it, knowing that the two might have different values.

This is the case in Chile where excess electricity is valued at a lower rate than the retail electricity price.

- **Net-metering regulation:** consumer billing is based on periodic assessment of production and consumption at the site, with excess electricity remunerated at the retail rate.
  This is the most widespread model, especially in the USA where the majority of states have adopted it.
- **Self-consumption with premium:** self-consumers receive an additional payment for self-consumed electricity (generation tariff) and electricity injected into the grid is valued at a higher price than the retail rate, which is the case in the UK.

Since the development of self-consumption is still at an early stage, it is difficult to appreciate the benefits and disadvantages of each model, with their very different approaches. It can be argued that excessive remuneration of self-consumed energy, with no value attached to energy injected into the grid, could lead to increased consumption and unintended consequences. Support given to self-consumption must minimize these effects and encourage changes in behavior by self-consumers.

Faced with the expected expansion of self-consumption (particularly due to the competitiveness of solar energy), the French energy regulator is launching a major consultation regarding adaption of the existing model to allow controlled development of this practice[8].

- Car manufacturers have been very active in this area since 2016. Many have launched home energy storage solutions that can be used for self-consumption, peak load shaving, and time shifting. This is of particular interest in countries such as Germany where retail prices are high and variable:
  - Tesla launched Powerwall in 2015 followed by an upgraded and 30%-cheaper[9] version called Powerwall 2 in October 2016. Both solutions can be used for self-consumption, backup power supply in case of outage, and rate arbitrage;
  - At the end of 2015, Mercedes launched Energy Storage Home, followed in 2016 by a joint project between Nissan and Eaton, called xStorage. These solutions use recycled car batteries.

- In August 2017, Ikea became the first mass retailer to sell battery packs in its stores. These are made by Solarcentury, the UK's largest solar company[10].

Since 2016, another dynamic component of smart homes has been solar self-consumption.

Until recently, consumers installed solar photovoltaic (PV) panels on their rooftops and injected all PV-produced energy into the grid. Today, with self-consumption, part of that energy is directly consumed or stored in a battery for use later. Self-consumption is growing and could be a major disruption for traditional electricity retailers (see topic box 5.1). Favorable scenarios suggest that by 2030, up to 19% of European Union (EU) electricity could come directly from prosumers[11]. This development has been enabled by:

- Rising retail electricity prices for households (+31.3% between H2 2007 and H2 2016 for EU-28)[12], with falling feed-in tariffs;
- Lower solar system prices (from €5,000/kWp in 2006 to €1,300/kWp in 2016 (-74%) in Germany)[13];
- Cheaper and cheaper batteries, driven by the growing market for consumer electronics and the demand for EVs (see Chapter 2);
- More favorable financing conditions;
- Evolving regulatory frameworks, allowing individual and collective self-consumption in some countries, such as France.

The attractive environment for self-consumption has led many players, in particular Utilities and car manufacturers, to launch offers.

- Some Utilities provide basic self-consumption offers consisting of PV installation and energy management systems, such as EDP's Solar Energy Solution. Others extend these types of offers by including battery storage to maximize self-consumption, such as E.ON's Aura and EDF's Mon Soleil et Moi. Some Utilities go even further: Endesa's integral photovoltaic solution and ENGIE's My Power cover everything from installation, obtaining the necessary permits, providing advice to customers, and maintaining the entire system. All these offers were launched in 2016.
- Some car manufacturers are offering self-consumption

9 IHS Markit, 2016: Powerwall 2 is 30% cheaper than its predecessor (on a per kWh basis) and 50% cheaper than the international average of batteries launched during 2016. https://technology.ihs.com/585071/why-is-the-powerwall-20-giving-tesla-an-edge-on-competition

10 Investopedia, 2017: http://www.investopedia.com/news/ikea-launches-battery-storage-product-compete-tesla/

11 The potential of energy citizens in the European Union – September 2016 https://rescoop.eu/potential-european-prosumers

12 Eurostat, electricity prices for domestic consumers (consumption between 2.5-5 MWh), bi-annual data, update 08-06-2017

13 Renewable Energy Watch: Europe net-metering and self-consumption solar PV market outlook (2016-2025), 2016

packages that include PV installation and storage:
  - In 2017, Tesla launched Solar Roof, which includes "invisible" solar cells made from glass and installation of an integrated Powerwall 2 battery;
  - Daimler with RWE is offering a self-consumption package that includes home energy storage and PV installation.

- Other players taking advantage of the rise in self-consumption in the residential sector include construction companies building positive energy houses (e.g. Baufritz and DAVINCI HAUS in Germany, Maisons Pierre in France), or Google's Project Sunroof, which helps homeowners to map their potential solar production.

Smart buildings and factories

This growing market is attracting a wide range of players and benefiting from innovative solutions integrating energy assets and grid constraints

The smart building market is expected to grow, reaching $47 billion[14] by 2019 in Europe, the Middle East, and Africa (EMEA) (from $29 billion in 2014).

Regulatory frameworks are the key driver for this development[15], and the proposal to revise the EU Energy Efficiency Directive (EED), including a 30% energy efficiency target for 2030, will probably speed things up even more.

This vibrant market is notable for its variety of players: ESCOs, equipment manufacturers, Utilities and pure players.

Offers for smart buildings and factories fall into three main types of energy management platform:

- **Monitoring** (aggregation of data to provide real-time information on energy usage);
- **Control** (capacity to switch on or off, or to time-shift consumption assets such as HVAC or lighting);
- **Integration of other energy assets** (such as PV panels and using them with the grid). The number of energy assets that can be integrated is increasing due to the rise of self-consumption in the B2B market (see topic box 5.2).

Topic box 5.2: Snapshot of self-consumption development in Europe's B2B segment

In Europe, strategies for promoting photovoltaics in the B2B market vary according to country. Some, such as Turkey, Switzerland and the UK, mainly rely on feed-in tariffs while others, such as France, mainly use tenders, for both grid injection and self-consumption.

In France, the latest tenders (September 2016 and February 2017) for self-consumption resulted in 134 projects selected for a total of 40 MW. Almost 100% of this capacity uses photovoltaics as its generation technology.

The solar Power Purchase Agreement (PPA) business model is developing fast. This is a financial agreement where a developer/investor sells the generated energy to the customer at a fixed rate (usually lower than the current electricity price for the customer). The benefits of a PPA for the customer are no, or low, upfront capital costs; reduction of the environmental footprint; and long-term savings on energy costs.

Various kinds of developers/investors position themselves in the B2B photovoltaic market, such as solar-focused players (e.g. Lightsource, IBC SOLAR); CPG retailers (e.g. GreenYellow, subsidiary of Casino); utilities (e.g. RWE, Enel Green Power); ESCOs (e.g. Cofely); and construction companies (e.g. Armorgreen, subsidiary of Legendre). They usually integrate end-to-end solutions: from the first studies, through finance and construction, to operation and maintenance of the system.

14 Technavio, Global 2015-2019 Smart Building Market
15 IEA, Energy Efficiency Market Report, 2016

ESCOs, the traditional players in smart buildings, operate in all three areas. They focus particularly on monitoring and control offers, where they innovate using digital levers such as the Internet of Things (IoT):

- EDF subsidiary Dalkia (through "the desc: Dalkia Energy Savings Center")[16] and ENGIE subsidiary Cofely[17] both offer self-consumption enhanced with optimization services (to manage production, consumption and storage).

Other large players are also operating in this market, delivering similar offers and researching more innovative ideas, such as integrating EVs:

- **There are various monitoring and control offers:** in particular from equipment manufacturers (e.g. ABB, Siemens, Schneider, Bosch) often through IoT, but also from power retailers (e.g. GreenYellow, Centrica) and other sectors (e.g. Orange Business Services).
- **With energy assets integration, some players are going a little further than ESCOs:** Siemens is using its building automation system DESIGO in a research project integrating EVs into the energy management of the building[18]. The aim is to use EVs as temporary energy storage units (see smart mobility, below).

Most of the innovative offers (e.g. integrating weather forecasts, electricity prices, and grid constraints) have been launched by startups (see figure 5.6).

Figure 5.6: Selection of startup offers for smart buildings and factories

COMPANY	DATE	COUNTRY OF ORIGIN	OFFERS			
			Monitoring	Control	Integration of energy assets	Description
Sensing Labs	Industrialization launched in March 2016	France	√			Data visualization based on communicating sensors that can measure water, electricity and gas consumption[19]. These sensors even work with old meters (an optical captor measures the number of rotations of the meter). Some major ESCOs (Bouygues Energy Services, Dalkia and Vinci Energies) are currently testing this offer.
Actility	Raised €70m in 2017	France	√	√	√	IoT platform applied to many sectors. In particular, its ThingPark energy platform integrates every phase of demand response and load shifting programs, providing Utilities with real-time energy data to monitor their portfolio performance.
BeeBryte	Commercialization in 2017	France	√	√	√	Software that enables optimization of a building's electricity costs by consuming or storing energy when prices are low and using electricity stored or produced when prices are high[20].
Reactive Technologies	Founded in 2010	UK	√	√	√	For buildings and factories, this energy management tool optimizes consumption, production and storage. In addition, it uses the flexibility of energy assets for demand side response and thus generates new revenue for the business[21].
Origami Energy	Startup founded in 2015	UK	√	√	√	Optimizes self-consumption for commercial and industrial businesses with production and storage assets[22]. It matches a building's energy demand to the energy it produces.
KiWi Power	Founded in 2009	UK	√	√	√	The UK's leading demand response aggregator for the B2B market. Offers include energy intelligence and smart metering.
Hero Balancer	Founded in 2015	Netherlands	√	√	√	Optimizes local renewable heat production and storage assets to match a building's consumption (estimated in advance)[23].

16 Article from July 2017: https://www.dalkia.fr/fr/e-mag-efficacite-energetique/autoconsommation-une-opportunite-doptimisation-energetique
17 Cofely website offer: http://www.engie-cofely.fr/solutions-innovantes-engie-cofely/nouvelles-energies/photovoltaique/
18 Article from June 2015: https://www.siemens.com/innovation/en/home/pictures-of-the-future/infrastructure-and-finance/smart-cities-smart-buildings.html
19 Article from March 2016: http://objectif-languedoc-roussillon.latribune.fr/innovation/innovation-technologique/2016-03-16/objets-connectes-sensing-labs-lance-l-industrialisation-de-ses-capteurs.html
20 BeeBryte website offer: http://www.beebryte.com/
21 Reactive Technologies website offer: https://www.reactive-technologies.com/businesses/
22 Origami Energy website offer: https://www.origamienergy.com/renewables-balancing/
23 Hero Balancer website offer: https://www.herobalancer.nl/en/home/

Smart mobility

Among the various areas of smart mobility, electric vehicles are growing, creating opportunities for energy system balancing and giving birth to new business models focusing on mobility roaming

Smart mobility enables connections between smart homes and smart buildings inside a smart city, but it also allows connections between cities and wider geographical areas.

- Smart mobility relates mainly to new services and products for door-to-door mobility (optimization of trip duration or cost with all transportation modes available) and mobility-as-a-service (MaaS) (car sharing, carpooling, etc.). The main benefits are trip duration optimization, better energy consumption, and reduced emissions.
  Blue Solutions (part of the Bolloré group) launched an electric vehicle (EV) car-sharing platform in Paris, which has expanded within France (Lyon, 2013; Bordeaux, 2014), as well as to the USA (Indianapolis, 2016; Los Angeles, 2017), Singapore (2017), and Italy (2017).
  The Finnish company MaaS Global offers an alternative to car ownership by providing a single digital platform that enables the user to access and book a whole set of transport options (taxis, car rental, buses, etc.), optimized for the user's route.
- EVs are a crucial part of smart mobility for two key reasons: their low impact on the local environment, enabling key health issues in urban areas to be tackled, and their connection to the power grid.
  - According to IEA[24], in a post-COP21 scenario, EV stock should reach 120 million units by 2030.
  - The main obstacles to EV adoption (price, autonomy and load duration) are being addressed by long-term improvements (decreased battery costs, higher energy density of batteries, etc.) but car manufacturers are also developing new business models to trigger the market. For instance, Renault is leasing batteries to decrease the price of Zoe Europe[25]; Tesla is combining the vehicle with free use of a private fast-charge network.

Even though they may be considered a threat to the power balance, **EVs could be key contributors for improving the performance of smart homes, buildings and cities,** increasing the potential for distributed renewable energy sources (RES) and eventually helping to balance the grid. Several EV applications for energy system management are available, and they are becoming smarter:

- As a consuming appliance (load), **EV charging can be monitored and optimized.**
  - A major issue is to manage peak load in order to ensure that a home or building does not exceed its maximum power threshold. This is particularly important where there are parking lots with large numbers of EVs.
  - Charge management also means that EVs can be charged when power is greener or cheaper (for instance, in the case of peak and off-peak pricing times).
    Many companies are offering to install and manage charging points. The European leaders are New Motion (2009) and EV-Box (2010), acquired by ENGIE in 2017; both companies are based in the Netherlands and they offer charge management for homes, offices and public charging points.
    Startups keep appearing, such as Jedlix, which launched its smart charging app in 2016, connecting more than 1,000 charging stations.
  - These first applications are limiting, rather than improving, the impact of EVs on the charging infrastructure.
- The storage capacity of EVs can also be used to **optimize integration of RES** in self-consumption installations. For instance, SMATCH (developed by ENGIE in 2017) optimizes the use of EV charging points for B2B, and maximizes the use of RES while taking into account the total consumption of the building.
- EV batteries can also be used **as a source of power** (vehicle-to-grid, V2G). As with batteries in homes and other buildings, a connected EV battery can provide power to the user or to the grid. For example, it can store power from an intermittent RES. In these situations, EVs are key assets in smart homes and buildings. Other valuable applications for V2G include ancillary services such as, in particular, frequency regulation[26]. Some of these ideas are currently being developed:

---

24 Global EV Outlook, IEA, 2017: https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

25 Purchasing or leasing the ZOE battery is the choice of the customer in European countries, except France where Renault only offers leasing. This strategy is controversial and may prevent Renault from reaching a part of the market: many drivers attach importance to whole car ownership.

26 In electricity grid operation, the alternating current frequency must be held within tight tolerance bounds. Different methods are available for "frequency regulation" including electricity storage. (Source: Energy Storage Association)

- In 2016, Nissan and Enel launched the first-ever V2G trial in the UK, enabling owners to sell stored energy from their EV battery back to the grid via 100 V2G charging points.
- The two-year Parker Project, launched in Denmark in August 2016, is applying grid-balancing services to a fleet of EVs to demonstrate their potential to support the electricity grid. The project partners include car manufacturer Nissan; software companies NUVVE (which manages bidirectional energy flow) and Insero (energy and intelligent software solutions); Frederiksberg Forsyning (a multi-supply Utility), and the Danish Technical University (DTU) Electrical Engineering department.
- In May 2017, PSA, Direct Energie, Enel, NUVVE, Proxiserve and the DTU launched the two-year GridMotion project. The project aims to evaluate the savings that bidirectional charging can offer to EV users. The project fleet has 50 private vehicles (unidirectional smart charge) and 15 B2B vehicles (with V2G capacity).

Many private operators own public charging point networks and offer charging services. Some operators own thousands of stations, such as ChargePoint (USA-based startup with strong growth in Europe), New Motion, Sodetrel (EDF affiliate), and Vattenfall; others have very few stations (typically in the case of city networks). Thus, **roaming[27] is a key challenge** as it is impossible for EV users to register with every network.

- To address this, some mobility operators provide cards that give access to several networks and manage the billing on a monthly basis. PlugSurfing, a 2012 German app startup, covers 45,000 charging points in more than 15 European countries and has 20,000 users (at the end of 2016). In April 2017, a French pure player, ChargeMap, offered a pass that allows EV drivers to use 17 networks. Hubject, a startup based in Berlin, has developed a roaming platform for charge point operators and, unusually, services are generally offered as white-label products.
- At last, specific networks are also being built. For instance, the Open Fast Charging Alliance (2017) is creating an extensive and seamless network of cross-border fast charging, open to all EVs. Founded by five European fast-charge networks – Fastned, Sodetrel, Smatrics, Grønn Kontakt and GOtthard FASTcharge – the Alliance has more than 500 fast-charge stations already deployed across six countries.

Smart cities and communities

Numerous players are developing offers for citizens in smart cities, and peer-to-peer marketplaces appear particularly dynamic

No two smart cities are alike, and there are no agreements on the definition of what "smart" is, but many countries are starting major transformation of their territories (e.g. in 2017, more than 500 Chinese cities[28] started their smart-city transformation with IT companies, and 252 smart city projects were launched in 178[29] cities around the world: about 50% more than in 2013).

Broadly speaking, a smart city uses data, innovation and digital technology to make urban areas more sustainable and pleasant for residents. A smart city has six components: smart mobility, smart economy, smart governance, smart living (home, building, factory), smart energy and environment, and smart people.

In terms of energy consumption, cities that are powered by data could improve their energy efficiency by 30% within 20 years[30]. Already, the use of innovation and data in smart cities is bringing benefits:

Enhancing customer interaction with the energy system while reducing consumption, with offers such as:

- **Real-time energy consumption follow-up at home:** for example, the French Watt & Moi project in 2012 with Grand Lyon Habitat and Enedis;
- **Self-consumption and energy management services:** The City-zen project, launched in 2016 in Amsterdam by Alliander (smart grid) and Greenspread (energy exchange enabler), is piloting the virtual power plant (VPP) concept with a group of 50 households. The project will aggregate people's production and consumption of

27 Roaming is the ability for a network customer to use other networks' charging points without specific registration
28 Economic Information Daily, April 2017
29 https://cities-today.com/europe-leads-number-of-smart-city-projects-says-new-report/
30 According to Cisco, in https://www.postscapes.com/anatomy-of-a-smart-city/

solar energy and store the surplus locally using home batteries, which also makes it possible to trade energy on wholesale markets;
- **Paying electricity bills on mobile or at service stations:** The pan-African partnership agreement in January 2017 between Orange Money and Vivo Energy (the Shell licensee in Africa), allows Shell customers to pay for their fuel in any Shell service station operated by Vivo Energy, using Orange Money;
- **Smart public lighting:** Streetlights can be transformed into smart objects to reduce network consumption, allow real-time exploitation, offer services such as electricity or internet points (Bouygues Energies & Services was a pioneer with its Citybox intelligent public lighting network launched in 2012), or control lighting according to pedestrian traffic (such as Kara, the smart public lighting system from startup Kawantech, 2016).

Optimizing operations and reducing cost and waste, with, for example:
- **Smart metering and smart grid:** The Kalasatama area of Helsinki has its own medium voltage grid network, built in 2015, with continuous bidirectional supply. The network uses ABB's latest technology to provide real-time information on the flow of water and electricity in each apartment;
- **Predictive maintenance, automation and remote control of networks:** Smart Electric Lyon with, among others, EDF, Enedis, Schneider Electric, Orange, SFR, Panasonic and Philips;
- **Urban energy management systems** that leverage collected data: such as the VINCI Energies project CONNECTe-CITY, launched in 2016;
- **Leak detection:** In France's Yonne region, ENGIE is testing the use of a blockchain to connect a network of water meters and detect leaks, alert consumers, and trigger service calls;
- **Recycling:** In Amsterdam, AEB's waste-to-energy plant is converting 1,000 kg of waste into 900 kWh of electricity/urban heating;
- **Waste collection:** Suez Environnement in France and Enevo in Finland are using radio-frequency identification (RFID) to track waste generation for real-time analysis of the quantities of waste collected and to measure how much is diverted from landfill by recycling.

The smart revolution is transforming the business models of traditional players as well as creating openings for new entrants, with offers such as peer-to-peer (P2P) energy trading and microgrids.

The increasing interest in microgrids is based on two key customer requirements: (1) the desire to **consume locally** and function autonomously at a local scale, and (2) the wish to **choose the source of their energy,** such as renewables (see Chapter 4 regarding customer expectations). Pioneer microgrid projects have been launched all over the world, for instance at Borrego Springs (California, 2015), in Brooklyn (NY, 2016), and at Higashimatsushima (Japan, 2015). Most of them were made possible by **new business models using power marketplaces** allowing "prosumers" to sell energy (from their own domestic PV installation on their house roof, for example) directly to their neighbors. A few recent projects are well known and expanding in Europe, particularly in the Netherlands, such as Vandebron with 54 generators (9 solar, 45 wind) and more than 100,000 customers (in July 2017) and Powerpeers (376 generators in July 2017).

Other projects – such as ECOYO in Belgium, supported by ENGIE, which closed in 2017 after registering 46 B2C customers and 60 generators – have had to stop because of the high investment needed for customer acquisition and working capital, and the difficulty in attracting customers given the relatively high electricity price. Also, the growth potential in Belgium was estimated to be quite low.

Some **P2P marketplace models are using blockchain technology** (see topic box 5.3) to safely register data and information. Even though business models using blockchain technology for energy purposes have existed since 2016 (especially in the USA, e.g. TransActive Grid, Brooklyn Microgrid), they must still be tested in order to create sustainable value rather than being just a fashionable trend. Several innovative projects in Europe are promoting blockchain for energy purposes (see figure 5.7).

The potential to consume locally generated power is a clear component of these projects, and this principle is expanding to include larger geographical areas. Some suppliers, such as EkWateur in France, are offering to support RES projects all over the country by buying electricity produced by residents. And it's possible to imagine that this concept could expand beyond borders to become a Europe-wide phenomenon. Of course, it would involve regulation and international collaboration, but it could accelerate both RES development and Europe's digitalization.

Conclusion – looking forward

The examples in this chapter show that, since 2016, the **development of offers has accelerated in the four smart areas.** Moreover, the boundaries of these areas are becoming blurred: **players that have traditionally focused on one area are developing in others, while new entrants challenge the conventional stakeholders.** Solar and storage companies, as well as mobility players such as car manufacturers, are entering homes and buildings through energy storage and self-consumption offers. Small pure players are questioning the traditional retail business, either pushing new value propositions (e.g. efficiency-oriented offers, local-generation offers, guarantees of origin) or implementing different business models such as P2P energy markets.

Most of these new models are based on **smart utilization of the data** generated by multiple systems (see topic box 5.4). Beyond the pure data analytics issues, which are directly tackled by the variety of players and often constitute the heart of their value proposition, this also raises **cybersecurity challenges**, which will become central for those models that manage to scale up.

What can we expect next?
The initiatives around electricity mobility roaming raise the question of **roaming for stationary purposes.** For example, electricity is currently billed to a physical point of delivery (PoD) – which means that someone with two houses receives two separate bills. In the future, customers could receive just one bill that covered all the energy consumed in a given period – at home, in holiday rentals, for EV charging – irrespective of location.

Energy markets are now ready to deal with the shift in end-customer behavior and expectation: energy is gradually becoming a lifestyle component. Customers want to buy products that reflect their values and who they perceive themselves to be, especially if the process is quick and easy, and confers a gratifying sense of freedom and ownership. Regarding energy, this can be seen at three stages:

- Customers want to design their own energy mix, which could be generic or tailor-made, for their stationary and mobile uses, choosing from the grid (e.g. centralized or decentralized; wind, solar, nuclear, fossil fuel; local or not) and/or from their home (e.g. solar self-consumption, domestic battery storage);
- In their day-to-day life, customers are demonstrating an increased sense of control and ease: they

Europe

Figure 5.7: Blockchain for energy purposes – a selection of innovative projects

PLAYERS	COUNTRY	DATE	STATUS	PROJECT
32 European energy trading firms, together with the developer Ponton	Europe	Joined the initiative in May 2017	Proof of concept	The project aims to conduct peer-to-peer trading in the wholesale energy market using a blockchain-based application developed by Ponton, called **Enerchain**. In 2016, Enerchain was used to conduct the first European energy transaction via blockchain, in Amsterdam.
Shell, Statoil, Tepco, Engie, Centrica and other energy companies	Europe	Joined in May 2017	In development	The companies joined the **Energy Web Foundation**, a global non-profit organization focused on accelerating blockchain technology across the energy sector.
ISA Energy, ENGIE, Soltech, CNR, EKE, Fortum, ECRO, SIVECO, and other companies	Europe	Launched in 2016	In development	The **Smart Energy Aware Systems** (SEAS) ITEA 2 project aims to optimize energy consumption at European level, with real-time interactions for all market players in consumption and production energy systems, using automation, ICT systems, and blockchain.
Ofgem, EDF Energy R&D UK, Electron (blockchain provider), PassivSystems (energy technology), Repowering London (renewables developer), University College London, and others	UK	Launched in 2017	In development	**Ofgem's Innovation Link** initiative is an "energy regulatory sandbox" – a space in which innovators can test business propositions without incurring all the usual regulatory requirements.
EDF, PSA (car manufacturer), startups (Evolution Energy, KeeeX, Pack'n Drive), and others	France	Launched in December 2016	In development	**IRT SystemX**, the institute for technological research, has launched a new project focusing on blockchain for smart transactions.
TenneT (Dutch TSO), IBM, Hyperledger (an open source collaborative effort hosted by Linux to advance cross-industry blockchain technologies), and electricity market platforms (sonnen eServices in Germany and Vandebron in the Netherlands)	Germany and the Netherlands		In operation	The partnership proposes that users who own a battery make it available to TenneT without compromising its availability for their personal use. The objective is to **use EVs and household batteries as an available, ready-to-activate pool,** to ensure flexibility, balance and security of supply in national grids, and support the integration of more RES into the national electricity supply system. Blockchain technology is used to record each battery's contribution.
Bouygues Immobilier, Microsoft and two startups: Stratumn (blockchain) & Energisme (energy management)	France	2016	In operation	The **mini smart grid** project in Lyon allows P2P solar energy exchange at district scale, using blockchain technology to certify the energy is from a renewable source.

Topic Box 5.3: Blockchain for energy purposes

Blockchain and distributed ledger technology protocols introduce new information distribution infrastructures that are of interest in an increasingly decentralized energy world

A little primer to Blockchain

- Blockchain is a distributed database technology that allows the processing and validation of all sorts of information transactions without a trusted central party, across many participants.
- The term "blockchain" comes from the way transactions are validated with such protocols:
  - Transactions are bundled by packets, called blocks;
  - Blocks are submitted to the network for encryption and validation: stakeholders are computationally charged to review the transactions and ensure nothing fraudulent or malicious is accepted;
  - When validated, the new block is added to the list of previously validated transaction blocks, the blockchain;
  - The process is repeated for all new transactions submitted to the network.

- Such protocols ensure immutability, resilience and data authenticity without a trusted central party. In low-trust environments involving many agents, a blockchain offers the possibility to transact without relying on established authorities, thereby digitalizing and distributing trust among participants and securing the whole system, providing traceability, transparency and pseudonymity[1].
- Initially devised as the underlying protocol powering the digital Bitcoin currency, blockchain technology has evolved to suit other use cases that benefit from distributed systems, across all industries and capabilities: financial services disintermediation, luxury goods certification, supply chain traceability, incorruptible land registries, and, more to the point, energy management.

Utilities are testing blockchains for energy use cases

- The prosumer trend breaks down the legacy electricity value chain and forces it to evolve from a top-down configuration to a decentralized network architecture. With a growing number of energy-producing nodes on the network, balancing supply and demand becomes an opportunity at a smaller scale than nationwide grids, from regional, city scale down to micro-grids.
- Such a decentralized setting appears to be appropriate for leveraging the possibilities of a blockchain:
  - Increased distribution of energy production and consumption across a growing number of nodes;
  - Low level of trust between individual energy prosumers;
  - No need for thousands of transactions per second.

- Many processes may be improved or digitized with blockchains. Energy supply transactions come to mind first, but blockchains can also be used for metering, billing and clearing, as well as documentation of assets ownership, guarantees of origin, emissions allowances, and renewable energy certificates.
- As a result, several initiatives have been undertaken to identify the best use cases for blockchains in energy:

Bouygues Immobilier

The French conglomerate **Bouygues** is experimenting with blockchain infrastructure for **energy trading** in the city of Lyon[2]. Following in the footsteps of the Transactive grid initiative in Brooklyn[3], New York, Bouygues is testing the possibility of trading electricity at neighborhood level, directly between prosumers. This use case could prove interesting in the case of global network outages as it helps decouple some parts of the

1 Pseudonymity is the near-anonymous state in which a user has a consistent identifier that is not their real name: a pseudonym.
2 http://observatoire-blockchains.com/cas-concrets-usages-blockchain/bouygues-immobilier-ecoquartier-confluence-a-lyon
3 http://lo3energy.com/projects/

grid without interrupting power supply.

The German company **Innogy, subsidiary of RWE,** and the Ethereum[4]-based startup Slock.it have launched several initiatives to simplify the **charging of electric vehicles** using smart contracts[5,6], . At CES 2017, they introduced a digital wallet for cars leveraging distributed ledger[7] technology, allowing **electric cars to recharge** using their integrated eWallet to transact small payments[8] in equipped charging stations. They have also launched the Share&Charge mobile app. This enables private individuals to rent their home charging station in a peer-to-peer fashion, on-boarding over 1,000 charging stations to the blockchain.

Wien Energie[9] together with other international energy companies is participating in a pilot project conducted by BTL Group, a Canadian blockchain startup, to implement a pilot project for **gas trading** based on its existing Interbit trading platform. The goal of the three-month project is to test the blockchain for energy trading.

In the French Yonne department, **Engie** is trialing a blockchain infrastructure[10] on a network of connected water meters that can automatically call for assistance in case of a leak. Based on smart meters integrated in buildings, the company seeks to integrate IoT and blockchain to better react to water-linked issues such as leaks or other infrastructure malfunctions.

SolarCoin[11] is a blockchain-based reward program enabling the development of photovoltaic electricity. The solar power producer redeems solarcoins on its dedicated blockchain for each MWh produced. These digital assets can then be traded for conventional currencies, or used to buy services from other participants. The SolarCoin Foundation, which initiated this currency, aims to leverage the blockchain to reduce the levelized cost of electricity for solar installations, reducing the payback time of PV projects, thus helping the industry grow.

- Dedicated events are also being organized: the first global summit on blockchain technology in the energy sector was held in Vienna, Austria, on February 14-15, 2017[12]. It gathered experts from around the globe to present the latest innovations in decentralized energy services and the future of energy technologies.

Major energy blockchain challenges ahead

- Blockchain technology is still in its early stages and technological sustainability may still be out of reach;
- Scalability of blockchain infrastructure is not yet readily available, even for the most experienced players in the field;
- The largest blockchain experiment to date, the Bitcoin network, still faces complex and important operational drawbacks in terms of energy consumption and speed;
- Purely distributed systems with no central authority may be interesting only for very specific use cases with little or no overlap with the actual energy needs of end consumers;
- Hacking and cybersecurity risks remain significant as with any potentially ground-breaking digital technology;
- Business models remain to be proved.

4 Ethereum is an open-source, public, blockchain-based distributed computing platform.
5 https://blog.slock.it/partnering-with-rwe-to-explore-the-future-of-the-energy-sector-1cc89b9993e6
6 Smart contracts are computer protocols intended to facilitate, verify or enforce the negotiation or performance of a contract.
7 As in blockchain, a distributed ledger is a consensus of replicated, shared and synchronized digital data geographically spread across multiple sites, countries or institutions. There is no central administrator or centralized data storage.
8 https://bitcoinmagazine.com/articles/innogy-charges-new-electric-car-fleet-using-ethereum-blockchain/
9 https://www.wienenergie.at/eportal3/ep/contentView.do/pageTypeId/67831/programId/74495/contentTypeId/1001/channelId/-53365/contentId/1801137
10 http://www.engie.com/breves/blockchain-energie
11 https://solarcoin.org/en/front-page/
12 http://eventhorizon2017.com/

Topic Box 5.4: The Internet of Things is one of the key solutions addressing disruption in the Utilities sector

The Internet of Things (IoT) is expected to be a game changer in various domains of the Utilities value chain (generation, smart energy, energy services, etc.). A Capgemini Consulting study[1], on behalf of French energy agency ADEME, assessed the IoT footprint to be expected by 2020 and 2030 in smart energy applications in households, for charging electric vehicles (EVs), and for distribution networks. Looking only at the French market:

- The study predicts that 20% of the 35 million households will be equipped with smart applications in 2020, and 50% in 2030.
- It expects 350 million objects will be connected in 2030, more than doubling the volume in 2020 (150 million), split into:
  - 35 million smart meters;
  - 280 million objects for smart homes;
  - 33 million objects for smart charging;
  - 1 million objects within the distribution grid.

IoT is a system of "things" or objects that can be connected to each other. This includes obvious devices, such as connected cars or smart meters, and also animals with microchips, or humans with heart monitor implants, for example.

- In its simplest arrangement, the system consists of the two lower layers of IoT architecture, that is, the physical layer (the object itself) and the communication or network layer. These layers enable the acquisition of data through sensors, and the execution of action through actuators.
- These layers can be augmented by analytics solutions and apps (to analyze data and decide on actions) and/or assignment (control/command of the objects).

Smart objects in the IoT can support **numerous use cases** in all four identified domains (cf. Chapter 5): smart homes, smart buildings and factories, smart mobility, and smart cities and communities. Even though IoT is clearly a hot topic today in the energy and utilities sectors, these use cases are mostly at an early stage of maturity (development, test or pilot), with few industrialized products or services. Examples include:

- **Renewables integration and supervision**
  - IoT company ParStream developed performance optimization and predictive maintenance IoT-based solutions for wind turbine company Envision Energy, which together are helping to deliver a 15% improvement in productivity[2]. [Smart Factory / Plant]

- **Generation asset management**, e.g. critical asset management in nuclear reactors, used to shorten the duration of maintenance operations.
- **Microgrids** (See topic box X.Y "The electricity DSO facing the energy transition paradigm shift")
  - Electricity supply company Southern California Edison has been involved since 2015 in an initiative called Microgrid Communication and Control Testbed, aiming to prove the viability of IoT in microgrids[3]. [Smart City & Community]

- **Energy management** for generation assets, storage, consumption stationary assets and electric vehicles [Smart Home, Smart Building, Smart Mobility, Smart City & Community]
- **Energy efficiency** to optimize consumption [Smart Home, Smart Building]
- **Demand response,** e.g. management of connected objects at the end-customer's premises to reduce or shift electricity consumption, in order to help balance the grid.
  - In 2016, US-based Rainforest Automation launched an IoT connected gateway providing demand response services, compatible with many Utilities in the USA, Canada and Australia[4]. [Smart Home]

- **Smart energy and additional services**
  - In 2017, Ericsson was chosen by real estate firm Landmark Dividend to provide its Zero Site communications platform across the USA, using street lighting poles as the platform for connectivity services[5]. [Smart City]

These use cases are only partially addressed, if at all, by existing solutions (SCADA[6], Advanced-DMS[7], OMS[8], etc.).

1 http://www.ademe.fr/sites/default/files/assets/documents/evaluation-consommation-electrique-couche-tic-smart-grid-rapport-final.pdf
2 https://www.iiconsortium.org/case-studies/ParStream_Envision_Energy_Case_Study.pdf
3 https://www.iotone.com/usecase/microgrid/u63
4 https://rainforestautomation.com/utilities/
5 https://enterpriseiotinsights.com/20170519/internet-of-things/infrastructure-investment-firm-taps-ericsson-iot-microgrid
6 SCADA: Supervisory control and data acquisition
7 DMS: Distribution management system
8 OMS: Outage management system
9 DERMS : Distributed energy resources management system

IoT has several characteristics that make it uniquely suitable for these use cases:

- **Scalable:** it can manage a huge number of devices (magnitude of 100,000s to millions) compared to existing systems (magnitude of 1,000s or 10,000s);
- **Open:** IoT is necessarily open to multiple types of objects addressing both B2B and B2C through multiple telecommunication protocols and layers;
- **Simple:** solutions can be implemented at much lower cost than existing systems, although security will be a key issue;
- **Modular:** it is able to deal more naturally with distributed systems, based on distributed architecture (split between end-user apps, objects, gateways and cloud).

Several hurdles need to be overcome in order for IoT to unleash its full potential.

- **Ability to identify use cases at the intersection of multiple domains** (asset management, energy efficiency, supervision services, etc.), **players and sectors** (DSOs, energy retailers, mobility, telcos, local authorities and public bodies, etc.), which will entail:
  - Working collaboratively, through partnerships and ecosystems. Today players tend to build complete solutions without exploiting the potential of their components;
  - Finding suitable sales channels and business models that will reward all partners.
- **Availability of "augmented" solutions:** based on analytics and/or artificial intelligence (functional models, e.g. energy consumption profiles, grid behavior, real-time calculation of demand response, etc.) and assignment of actions (arbitrage between energy self-consumption and re-selling, microgrid reconfiguration depending on renewables availability, DERMS[9] for high penetration of renewables, etc.), allowing value to be added to the objects' raw data.

This could be accelerated if:

- **Standards** in terms of features/functionalities/protocols were created for each market sector. This would lower costs, accelerate deployment, and secure investment;
- **Robust commercial open IoT platforms existed**, based in the cloud, that (IoT) business services providers could rely on;
- **Thing to Thing (T2T) communication** between smart objects was developed. In such a system, everyday objects and infrastructure would be able to interact without the need for a central system to coordinate them or make decisions.

IoT Data Process (5 As)

Acquisition	Aggregation	Analysis	Assignment	Action
of generation, storage, consumption, asset and data	to make data suitable for analysis	to create insight about usage and how to optimise it	to ensure someone/something is allocated to solving issues	to solve the issue

Source: Capgemini Consulting, WEMO2017

remotely manage their domestic equipment with a single swipe (e.g. lighting, heating, washing, security, solar panels, EV charging) and benefit from predictive technology to support their everyday decisions;

- Customers share the way they live, and how energy is a part of that, with their physical or virtual communities, which creates value (rather than energy only being a commodity).

The main market development trigger is finding services that customers are willing to pay for. The market leaders of tomorrow will be the ones who really empower their customers, using the combination of energy and digital to allow customers to live in the way that they choose.

Financials

Against a background of increased competitiveness, regulatory constraints, and low energy prices, Utilities are starting to benefit from their efforts to adapt to a new framework

The major European Utilities have faced difficulties over the last five years. In 2016, the overall downward trend of their financial performance (shown in income statements and balance sheets) has slowed but individual variations can be seen in our sample group.

This effect was made possible because players had already reacted to the essential, wide-ranging sector transformation by restructuring their asset portfolios to reduce exposure to risk and price volatility (divestments in conventional power and investments in regulated sectors), increasing customer and services activities (following the U2ES – Utilities to Energy Services – trend), and striving to achieve better financial discipline (including decreasing debt levels and reducing operational and structural costs).

By the end of 2016 and the beginning of 2017, the stabilization or slight recovery of wholesale prices had also alleviated some of the pressure felt by Utilities, enabling a more optimistic outlook.

Figure 6.1: Main trends observed on financial indicators

	Overall 2015 - 2016 qualitative evolution[1]	Comments
Revenues [€]	↘	Erosion of revenues continued in 2016
EBITDA [€]	↘	EBITDA levels were down in 2016
EBITDA [as % of revenue]	→	EBITDA margins show signs of stabilization
Net debt reduction	↗	Debt levels are clearly decreasing
Leverage ratio	↘	Net debt improvement does not compensate for EBITDA decrease
Dividends [€]	↘	Most companies reduced their dividends in 2016
Stock prices [€]	↘	Stock prices showed a major underperformance vs. EURO STOXX 50 in 2016
S&P credit rating & outlook	→	S&P ratings and outlooks are mostly stable
Generation CO_2 intensity	↗	CO_2 intensity is improving (i.e. decreasing in gCO_2/kWh) in our sample

[1] *In our Utilities sample group*
Source: Capgemini Consulting analysis - WEMO2017

Topic Box 6.1 E.ON – Uniper: benefits of the separation still to come

2016 saw the official separation of Uniper from German Utility E.ON

Following the strategic orientation decided by its board of management at the end of 2014, E.ON SE began in 2015 to separate its activities between conventional energy sources and decarbonated ones. These two businesses require markedly different strategies. The official separation was established on January 1, 2016, with the following division (after some deliberation about the attribution of the nuclear power segment):

E.ON	Uniper
• Renewables • Energy networks • Customer services • Nuclear power (operated by PreussenElektra)	• Conventional generation: hydropower, gas, coal • Exploration • Gas & electricity trading

On June 8, the shareholders approved by 99.68% the creation of Uniper as a separate company and its IPO (initial public offering) occurred three months later (on September 12). E.ON still owns 46.65% of Uniper but is supposed to sell this stake at the mid-term (not before 2018).

The operation had a significant financial impact on E.ON, which registered a net loss of €16 billion for 2016: worse than the €6.4 billion recorded for 2015 and a far cry from the €0.6 to €1 billion expected net income[1]. E.ON explains this loss as mainly down to discontinued operations as well as the provisions for the participation in the national nuclear waste management program[2]. E.ON's chairman and CEO Johannes Teyssen declared that "2016 has been a transition year" and is confident that E.ON will reap the rewards of this strategy in the coming years.

At the same time, Uniper had to deal with a net loss of €3.2 billion, mainly due to some depreciation of its gas and electricity generation assets. Despite this, the company highlights improved EBITDA and operating cash flow.

After taking a hit at Uniper's trading debut, E.ON's stock price on September 1, 2017 was trading at around H1 2016 levels. Uniper stock soared from a €10 offering to more than €20 on September 1, 2017, supported by M&A speculation, the rise in commodity prices and assets disposal.

The consensus from analyst estimates for E.ON indicates a slightly growing EBITDA and adjusted net income in the coming three years, outperforming the market. The refund of the nuclear fuel tax (€2.8 billion) plays a major role in this forecast[3].

Uniper has outperformed analyst expectations in 2016 and H1 2017 (e.g. with a low debt level). Even though current estimates for EBITDA and net income show a contraction for three years to come[4], the underlying industrial performance is judged promising (e.g. investment plan if leverage ratio targets are exceeded).

The profound transformations undertaken by E.ON/Uniper seem to be paying off. Will this trend be confirmed in the future? And will the "new" E.ON manage to quickly regain a top-tier player position with strong competitive advantage coming from its transformation?

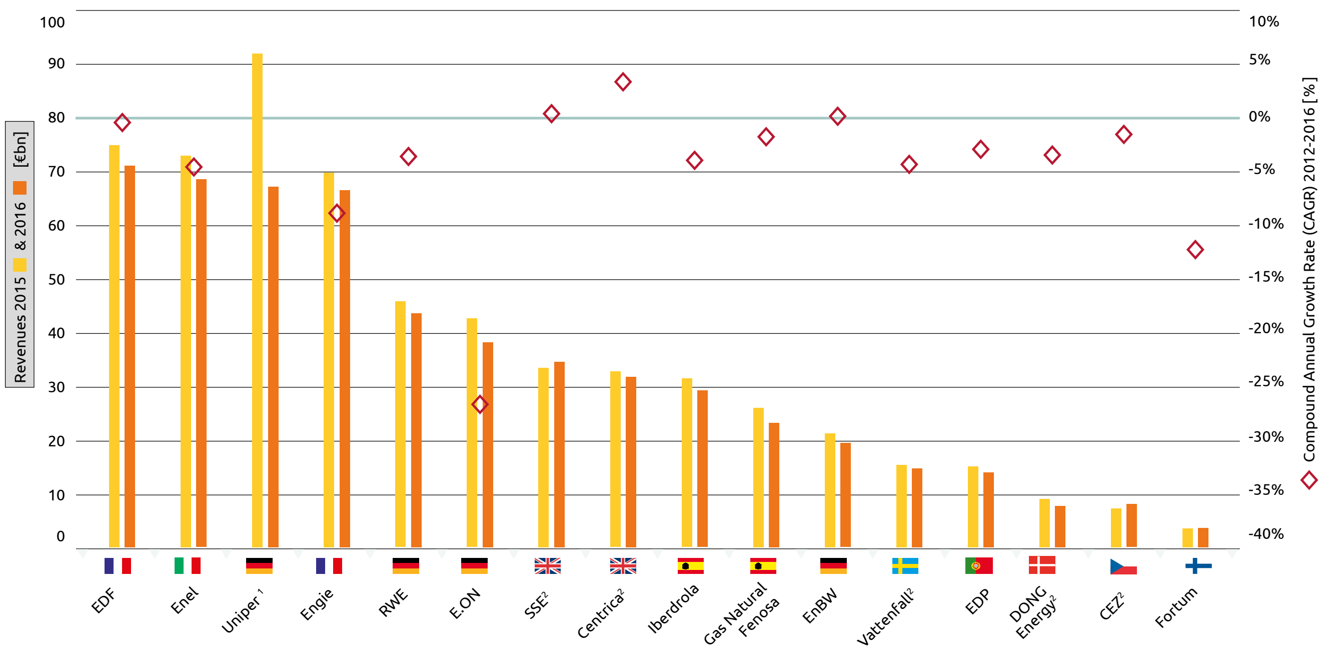
1 E.ON Capital Market Story, April 26, 2016

2 A German law, passed in December 2016, will push major German Utilities (E.ON, EnBW, RWE) as well as Vattenfall to provision €23.6 billion in a state-run fund to support nuclear waste storage and disposal and waive their responsibility

3 Source: https://www.eon.com/en/investor-relations/analysts-estimates.html as of September 1, 2017

4 Source: https://ir.uniper.energy/websites/uniper/English/1150/analyst-consensus-estimates.html as of September 1, 2017

Figure 6.2: 2015 & 2016 revenues in € billion and CAGR 2012-2016



Sources: Thomson Reuters EIKON data ("Total Revenue"), Capgemini Consulting analysis

[1] *No CAGR calculated for Uniper for which only 2 years of data have been considered*

[2] *SSE, Centrica, Vattenfall, DONG Energy and CEZ revenues were calculated using fixed exchange rates taken at the end of their reporting period*

Revenues

The downward trend continues

Figure 6.2 shows the revenues of 16 of the largest European Utilities for 2015 and 2016, as well as the 2012-2016 compound annual growth rate (CAGR).

A distinct group of four companies, each with revenue over €65 billion, accounts for more than half the total revenue in our sample. Besides EDF, ENGIE and Enel, who held their positions, newcomer Uniper as a fully distinctive company (see topic box 6.1) took a larger share of revenue than E.ON after the separation, placing it in the top four. At the same time, E.ON's remaining activities put it in sixth place. The particularly low 2012-2016 CAGR for E.ON is a direct result of this spin-off and the associated change of scope, with a drop of 62% in revenue between 2014 and 2015.

The downward trend observed in recent years continued in 2016 compared to 2015 for all companies with the exception of SSE, CEZ and Fortum. Common explanations for this decrease are lower gas and electricity prices than in 2015 – these prices having only started to recover at the end of 2016 – sometimes combined with a drop in volumes sold, as well as unfavorable exchange rates in some cases. The Brexit announcement had a negative impact for non-British companies with businesses in the UK, such as EDF (13% of its revenue is from the UK) and ENGIE, due to loss of market share and unstable foreign exchange rates. French companies also had to deal with the end of some regulated tariffs in the French market (the so-called yellow and green tariffs) and increased competition, which mainly affected EDF. Uniper, which shows the greatest decrease in revenue between 2015 and 2016 (-27%), was hit by the combined effects of the drop in gas and electricity prices and – to a lesser extent – a reduction of the volumes of electricity sold after some business operations disposals.

These negative events are nevertheless in keeping with the general trend observed over the past five years. During that period, only Centrica showed a positive CAGR (3%), mainly thanks to its external growth between 2012 and 2014 (e.g. Neas Energy). Other best-in-class players are hovering around a zero CAGR (EDF, SSE, EnBW) whereas most Utilities experienced negative growth like, for instance, ENGIE whose revenue fell from €92 billion in 2012 to €66.6 billion in 2016 (due to portfolio reduction and price decreases).

EBITDA

In a market that remains highly competitive, EBITDA is decreasing but margins have stabilized

Figure 6.3 shows normalized EBITDA margins for the companies in our sample for the period 2012-2016 (2015-2016 for Uniper).

The downward trend of EBITDA margins in the last five years slowed in 2016 and seems to have stabilized at around 16% for our sample, demonstrating how Utilities have adapted to tough market conditions. While most companies form a cluster around a margin of 25% (+/-5%), a group of three major German companies has noticeably low margins (5-10%).

The transformation has been achieved using various strategies and levers. Projected capital expenditures for 2017-2019 reflect the first two levers, with planned investment shared between networks (48%) and renewables (36%).

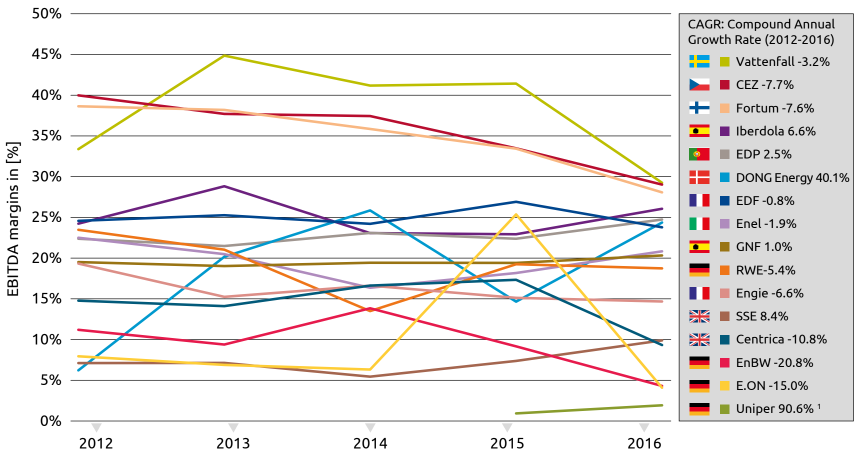
- Investment in regulated network activities is a major lever to compensate for the decline in volume and prices and for exposure to riskier commodity-linked activities. Investment in networks is also supporting integration of renewables and development of smart grids. Networks are expected to take a bigger share of Utilities' business mixes. The average EBITDA share from regulated energy distribution now exceeds 40%, with RWE (Innogy), Gas Natural Fenosa (GNF), and Iberdrola leading the way.
- Investment in renewables is also a major transformation driver: Iberdrola, EDP, Enel, EDF and ENGIE show the strongest renewables portfolio in 2016 in terms of capacity installed.
- Improvement of internal operating methods, through digital levers and internal restructuring, is aimed at increasing efficiency and thus EBITDA margins. Most major Utilities are implementing wide-ranging cost-cutting plans, including a €1.4 billion cut for EnBW (2012-2020) and €1.2 billion each for ENGIE (2016-2018) and E.ON (2016-2018).

In a context of low wholesale electricity prices, Fortum and CEZ, even though they operate in two very different markets, have seen their EBITDA margins stabilize at the upper end of the good performers cluster (20-30%).

- DONG Energy is still the exception, managing a 10-point margin increase thanks to one-off payments from renegotiated contracts, higher construction activity, and the divestment of 50% of two offshore wind farms (in line with its wind farm development strategy). Given the infrequent nature of these events, will DONG Energy be able to sustain these levels of growth in the coming years?
- At the other end of the spectrum, Uniper's significant loss in revenue for the global commodities business line (90% of overall revenue) was offset by a significant release of provisions for favorable long-term gas supply contracts with Gazprom.
- EnBW is diversifying its sources of revenue (grids and renewables) to limit the effects of declining wholesale energy prices, but is still negatively affected by the law on reorganizing responsibility for nuclear waste management that was passed in Germany in April 2016.
- E.ON and Vattenfall margins dropped significantly after reaching highs in 2015 (see topic box 6.1). Low prices and new Swedish nuclear regulations contributed to the 70% decrease in Vattenfall's power generation EBITDA which itself represents more than 40% of the company's activity and consequently the significant EBITDA margin decrease.

In 2017, German Utilities scored a major victory with the constitutional

Figure 6.3: EBITDA margins and associated CAGR (2012-2016)



Sources: Thomson Reuters EIKON data ("Normalized EBITDA"), Capgemini Consulting analysis
[1] *For Uniper, the CAGR corresponds to the 2015 to 2016 evolution*

court's decision that the nuclear fuel tax imposed from 2011 to 2016 was illegal, entitling them to a refund of more than €6 billion.

Debt

Most companies reduced their net debts, seeking better financial health for the transition, but leverage ratios are still affected by decreasing EBITDA

2016 was a transitional year with many divestments from conventional energy towards more diversified and regulated activities. Those major divestments contributed to significantly reduce European Utilities' net debt (-25% or more for 7 companies in our sample, to which we could add ENGIE with the impact of its €15bn divestment program expected to be visible by 2018). Only five of the 16 companies also decreased their leverage ratios but this is mainly due to offsetting effects linked to important EBITDA variations. Reducing debt and improving performance are the key aims for Utilities during this transition phase. Several of them (EDF, ENGIE, Uniper etc.) are indicating target leverage ratios of 2.5x to 3.0x or below (to achieve a comfortable investment-debt grading) by 2020.

Figure 6.4: Net debt and EBITDA in €million and leverage ratios for 2015 and 2016

	2016 Net Debt [€m] (2015-2016 evolution)	2016 EBITDA [€m] (2015-2016 evolution)	Leverage ratio 2016	Leverage ratio 2015
Fortum	35 (-102%)[1]	1,018 (-12%)	0.0x	-1.8x
DONG Energy	1,457 (-47%)	1,882 (+43%)	0.8x	2.1x
RWE	7,008 (-32%)	8,179 (-7%)	0.9x	1.2x
Uniper	1,853 (-60%)	1,831 (+39%)	1.3x	4.7x
Vattenfall	6,444 (-21%)	4,246 (-31%)	1.5x	1.3x
Centrica	5,504 (-20%)	2,991 (-48%)	1.8x	1.2x
EnBW	1,990 (-28%)	857 (-56%)	2.3x	1.4x
EDF	43,011 (+2%)	16,926 (-16%)	2.5x	2.1x
SSE	7,840 (-3%)	3,412 (+35%)	2.3x	3.2x
CEZ	5,279 (+5%)	2,171 (-15%)	2.4x	2.0x
Engie	31,289 (-7%)	9,805 (-8%)	3.2x	3.2x
Enel	58,071 (-2%)	14,302 (+8%)	4.1x	4.5x
GNF	20,303 (-1%)	4,714 (-7%)	4.3x	4.1x
Iberdrola	32,316 (+5%)	7,603 (+6%)	4.3x	4.3x
E.ON	8,848 (-33%)	1,606 (-85%)	5.5x	1.2x
EDP	21,299 (+0%)	3,608 (+4%)	5.9x	6.1x
		Average leverage ratios	3.0x	2.7x

Sources: Thomson Reuters EIKON data ("Normalized EBITDA" & "Net Debt Incl. Pref. Stock & Min.Interest STND"), Capgemini Consulting analysis

[1] *2015-2016 Net Debt evolution is listed as -102% for Fortum, as in 2015 the net debt was negative at -€2,126 million*

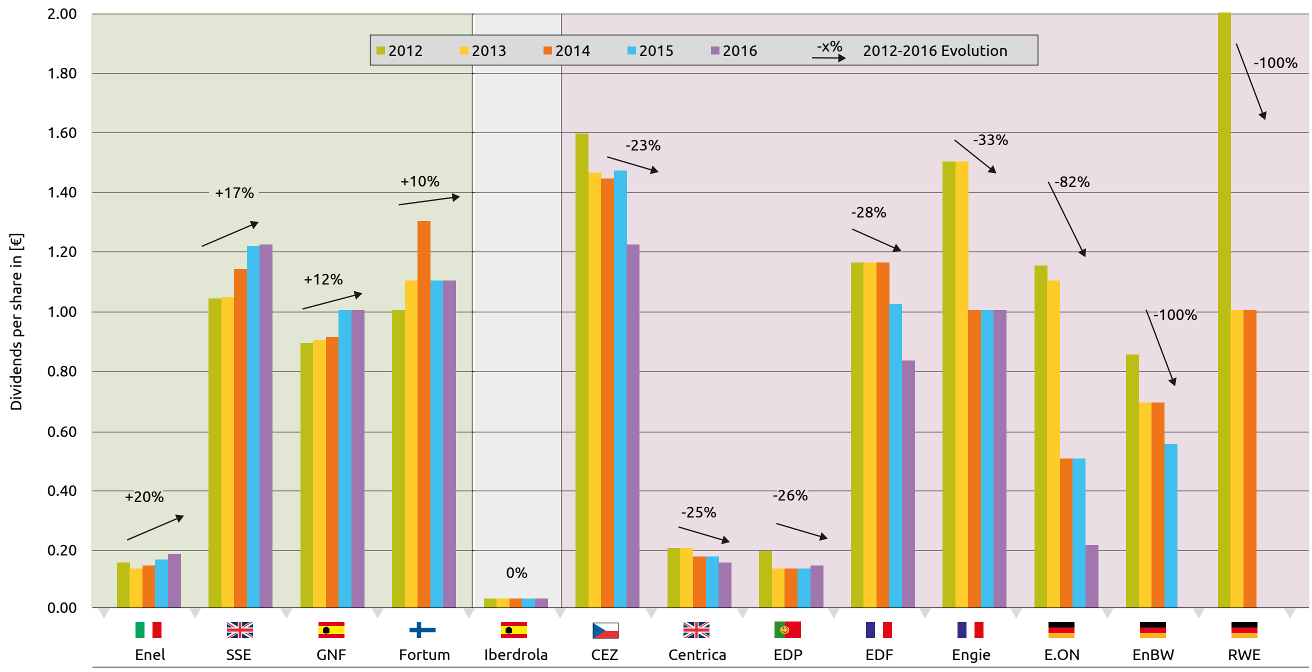
The most notable effect that the divestments and investments mix had on Utilities' financial situation was regarding net debt.

- Although EDF's debt increased by 2% following €11.8 billion net investments and €6.7 billion disposals signed or closed, its bad performance in 2016, due to market conditions and lower activity, affected its ratio. However, its program of assets disposal and €4 billion capital raised in March 2017 should enable debt reduction from 2017.
- SSE also managed to stabilize its debt levels and decrease its leverage ratio, notably by managing the disposal of 16.7% of Scotia Gas Networks to wholly owned subsidiaries of the Abu Dhabi Investment Authority on October 26, 2016 for £615.1 million.
- DONG Energy's excellent 2016 performance is evidenced by a 47% debt reduction and 42% EBITDA increase attributable to positive free cash flow from operating activities, and divestments exceeding investments. The same trend is seen with Uniper, which cut its net debt threefold and increased its global EBITDA despite a lower EBITDA from its power generation business units.
- Fortum, which had a large cash inflow in 2015 thanks to the divestment from its Swedish electricity distribution business, acquired Ekokem Corporation - a recycling and waste management company - and Grupa DUON - a Polish electricity and natural gas provider - for €695 million.

German Utilities managed to significantly reduce their debts despite the German nuclear phase-out, thanks to important divestments and restructuring programs: RWE transferred most of its capital market debt to its new subsidiary Innogy, and Uniper reduced its costs, divested massively (e.g. sale of PEGI shares), and had a high operating cash flow. These two companies capitalized on the net debt reduction to significantly reduce their leverage ratios and aim to continue their fiscal policy to diversify their assets and revenue sources.

E.ON's debt reduction, however, could not offset its 2016 bad performance and it is thus now suffering from a major leverage ratio increase to 5.5x. The company aims to reduce it to 4x over the medium term.

Figure 6.5: Dividends per share in € and 2012-2016 evolution



Sources: Thomson Reuters EIKON data ("Dividend per Share DPS"), Capgemini Consulting analysis

Dividends

Dividends are increasingly hard to sustain

In 2016, all companies in our sample delivered stable or lower dividends per share compared to 2015, except EDP and Enel.

German companies in particular appear to have followed this sharp trend. Indeed, as with RWE in 2015 (for common shares), EnBW had to announce that it would not pay any dividend in 2016 because of a retained loss of €63.5 million for the financial year. Although E.ON managed to maintain its dividend in 2015 despite huge losses, it had to reduce it in 2016 to cope with a decreasing adjusted net income.

However, these two companies, along with RWE, appear confident in their ability to distribute more dividends in 2017: the RWE and E.ON management boards have already announced their intention to distribute, respectively, €0.50 and €0.30 per share.

The two French companies EDF and ENGIE are also following a declining trend.

- EDF further lowered its dividend to €0.86 per share, following France's state shareholder policy, which finally agreed to consider the financial difficulties of the group, after having kept the dividends at a high level despite a critical financial situation for several years.
- ENGIE had managed to pay a stable dividend of €1.0 per share since 2014 but has already announced a reduction to €0.70 per share for 2017 and 2018. The company justifies the decision with the transformation it is currently undergoing.

At the left-hand side of figure 6.5 (positive trends), two distinct strategies can be seen for SSE and Enel.

- SSE gives high importance to shareholder remuneration and has managed to continuously increase the dividend per share since 1999, aligning its progress with inflation shown in the UK's retail price index (RPI)[1].
- Enel has been able to distribute rising dividends since 2013 – after a long period of reducing them – following the growth of its ordinary net income.

1 The RPI is a measure of inflation published monthly by the Office for National Statistics in the UK: it assesses the change in the cost of a representative sample of goods and services.

Stock performance

Significant underperformance compared to EURO STOXX 50: Utilities have not benefited from the overall economic upturn

For the second consecutive year, stock prices for almost all Utilities fell in 2017 (-8.5% on average in July 2017 vs. July 2016) against a background marked by high uncertainty (regulatory changes, competition from new players) and investors' lack of confidence.

In contrast, the EURO STOXX 50 partly recovered from its 17.5% drop in 2016 with a 20.1% increase in 2017, outperforming the three best players in our sample (RWE, Fortum, Enel) by roughly 12 percentage points, suggesting that its performance was supported by sectors other than energy. Enel probably benefitted from its strong exposure to international markets.

However, while only one company in our sample performed positively in 2016, there were three in the first half of 2017. RWE shares are rising again after a 25.5% decrease in 2016, suggesting that investors were reassured by its transformation and debt reduction plans.

Strong disparities between Utilities reflect their difficulties coping with the changing environment:

- UK-based Utilities struggled with low electricity prices, potential regulatory changes, and fierce competition. SSE, the only company whose shares rose in 2016, suffered a setback in 2017. It was hit by strong competition and severe customer losses in Q2 2017, shortly followed by Ofgem announcements in favor of tougher price controls effective from 2021.
- In France, large integrated Utilities suffered from several factors: low prices, ongoing deregulation of the French power and gas markets, low availability of nuclear power plants, and uncertainty regarding future energy policies associated with the presidential election. In addition:
  - EDF stock suffered from major investment in the Grand Carénage program, suspicion of cost overrun and delays in Hinkley Point C (confirmed early July), safety checks of reactor vessels, and the dilution effect induced by the €4 billion capital increase in March 2017;
  - ENGIE's stock plummeted again in 2017 but the market seems to be responding positively to stabilization in commodity prices, high asset disposals, and the company's strong position in energy services, with a slight stock price increase since Q2 2017.
- German Utilities have been affected to a lesser extent:
  - E.ON's shares fell after posting a record annual loss in Q4 2016, as well as after the rise in capital intended to fund nuclear waste storage and decommissioning provisions. But shares rose again in Q2 2017 after the German high court judged the nuclear fuel tax illegal.
  - RWE's performance has differed from market trends in other German groups, partly due to its reorganization and high-performing subsidiary Innogy.

Figure 6.6: Utilities' stock performance (July 2017)[1]

	Share price year-to-year ratio (2017/2016)	Share price ratio (2017/2012)	Share price / EURO STOXX 50 ratio (2017/2016)	Share price / EURO STOXX 50 ratio (2017/2012)
EDF	-29.1%	-49.8%	-41.0%	-66.9%
Engie	-25.0%	-45.8%	-37.6%	-64.3%
EDP	-17.4%	7.5%	-31.2%	-29.2%
SSE	-14.6%	6.2%	-28.9%	-30.2%
E.ON	-11.6%	-58.9%	-26.5%	-73.0%
Centrica	-8.3%	-28.0%	-23.6%	-52.6%
GNF	-8.2%	30.1%	-23.6%	-14.4%
Vattenfall	-8.2%	-15.3%	-23.6%	-44.3%
Iberdrola	-5.7%	57.5%	-21.5%	3.7%
EnBW	-4.3%	-51.1%	-20.3%	-67.8%
CEZ	-1.2%	-51.7%	-17.8%	-68.2%
RWE	4.9%	-61.5%	-12.7%	-74.7%
Enel	5.0%	24.3%	-12.6%	-18.2%
Fortum	5.3%	-15.6%	-12.3%	-44.5%
EURO STOXX 50	**20.1%**	**52.0%**	**0.0%**	**0.0%**

Sources: Thomson Reuters EIKON data (stock prices and index values from July 1, 2012, 2016, 2017), Capgemini Consulting analysis

[1] *The analysis does not include Uniper, as its stocks started trading on September 12, 2016*

S&P ratings

The outlook for integrated Utilities has stabilized

Although Utilities have faced downward S&P ratings over the past seven years, particularly between 2011 and 2012, the stabilization experienced in 2016 seems to be confirmed in 2017.

This trend illustrates the following important steps taken by companies to adapt to the challenging environment described at the start and shows improved market confidence in the choices made by Utilities.

As in 2016, the few changes observed have been downward but there have been some positive signs.

- As explained earlier Topic box 6.1, German Utilities have been damaged by some "off-balance sheet" liabilities such as regulatory and political changes in the nuclear sector. Yet, diversification of activities and investments in renewable energies is helping these companies maintain relatively stable outlooks.
- Enel's rating was downgraded in 2017, but S&P simultaneously raised its outlook to positive, hailing its EBITDA growth and debt decline. According to S&P, the company is starting to reap the benefits of an investment strategy in regulated networks and corporate structure simplification.

Figure 6.7: Standard & Poor's credit ratings

	31/12/2012	31/12/2013	31/12/2014	31/12/2015	31/12/2016	31/12/2017	2016-2017 Evolution	Outlook
EDF	A+	A+	A+	A+	A-	A-	→	From negative to stable
Engie	A	A	A	A	A-	A-	→	Negative
SSE	A-	A-	A-	A-	A-	A-	→	Negative
EnBW	A-	A-	A-	A-	A-	A-	→	From stable to negative
CEZ	A-	A-	A-	A-	A-	A-	→	Stable
Fortum	A-	A-	A-	BBB+	BBB+	BBB+	→	Stable
Centrica	A-	A-	A-	BBB+	BBB+	BBB+	→	From stable to negative
Vattenfall	A-	A-	A-	BBB+	BBB+	BBB+	→	From negative to stable
DONG Energy	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	→	Stable
Iberdrola	BBB	BBB	BBB	BBB	BBB+	BBB+	→	From positive to stable
E.ON	A-	A-	A-	BBB+	BBB+	BBB	↘	From negative to stable
Enel	BBB+	BBB	BBB	BBB	BBB+	BBB	↘	From stable to positive
Gas Natural Fenosa	BBB	BBB	BBB	BBB	BBB	BBB	→	Stable
RWE	BBB+	BBB+	BBB+	BBB	BBB-	BBB-	→	From negative to stable
Uniper	No data				BBB-	BBB-	→	From stable to positive
EDP	BB+	BB+	BB+	BB+	BB+	BB+	→	Positive

Sources: Companies' websites, S&P long-term issuer rating data, Capgemini Consulting analysis

- EDF was downgraded twice, in May and September 2016, from A+ to A-. This was mainly due to concerns about its ability to cope with major investments despite an already stretched balance sheet.
- Finally, S&P upgraded Vattenfall's outlook to stable, explaining this decision by the sale of lignite assets in September 2016, increased wind capacity under different supporting schemes, and stable cash flow from electricity distribution and district heating.

This stabilization shows an improved market confidence in the choices made by Utilities

Europe

A rise in the cost of CO_2 across Europe might jeopardize the profitability of conventional power generation assets

CO_2 emissions intensity ratio

Utilities are paying increasing attention to CO_2 emissions

The CO_2 intensity ratio is going to be a key performance indicator for Utilities. It indicates the amount of CO_2 (g) emitted per unit of energy generated (kWh), and an increase in CO_2 emission costs is potentially a financial risk for Utilities.

Figures provided by major Utilities over the past two years highlight several trends:

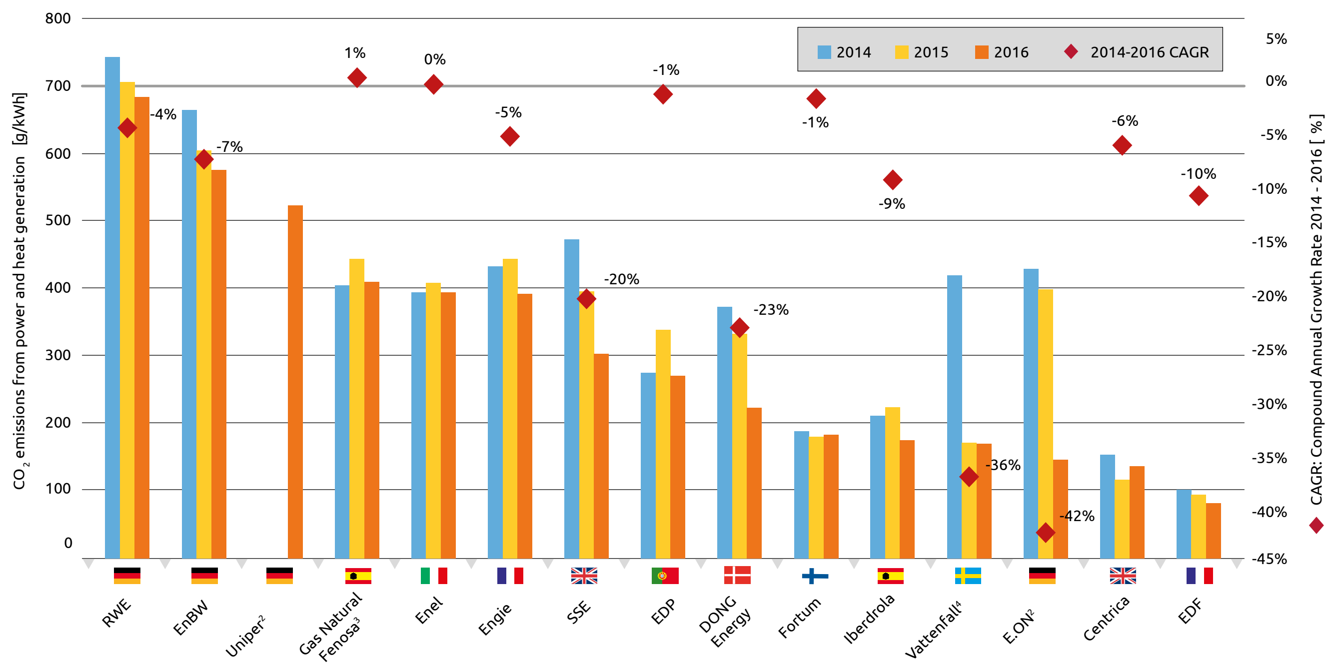
- When emission allowances were low, the 2014-2015 decrease in overall CO_2 emissions was low, except for Vattenfall. A more substantial decrease was observed between 2015 and 2016.
- Major CO_2 emitters such as RWE or EnBW generate more than 400 gCO_2/kWh, mainly because their respective energy mixes are driven by 60% coal and 45% lignite. On the other hand, extensive nuclear and hydro assets are helping best-in-class players such as EDF to boast strikingly low intensity (82 gCO_2/kWh).
- Four Utilities have significantly reduced their CO_2 intensity over the past two years. Thanks to major gas, coal or lignite divestments, SSE, DONG Energy, and Vattenfall have reduced their emissions by, respectively, 20%, 23% and 36% per year over the period 2015-2017. DONG Energy has set itself an emissions target for 2023 of 30 gCO_2/kWh by getting rid of coal and massively scaling up its offshore wind sector.

It should be noted that E.ON's CO_2 emissions decrease in 2016 must be treated with caution as it is mainly due to withdrawal of conventional power generation (coal, lignite) for the benefit of newly created Uniper; 2017 indicators will thus be necessary to draw a sound conclusion.

The overall downward trend is likely to remain strong in the foreseeable future:

- First, some Utilities have announced aggressive objectives for the reduction of CO_2 emissions.
- Second, through its "Clean Energy for all Europeans" package, the European Commission has set out design principles for existing national capacity mechanisms: power plants constructed after the entry into force of the proposed regulation may only participate in capacity mechanisms if they emit less than 550 gCO_2/kWh. For pre-existing power plants, the emissions limit will be applied five years later.
- Third, voices throughout the world are increasingly demanding a rise in the cost of CO_2; for instance, the French regulator (CRE) is recommending an increase from €6/tCO_2 to €30/tCO_2 to reduce CO_2 emissions by 10%. This might jeopardize the profitability of conventional power generation assets across Europe.

Figure 6.8: CO_2 emissions from power and heat generation[1]



Sources: companies' 2015 and 2016 annual reports, Capgemini Consulting analysis

[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] *2016 indicators calculated from CO_2 emission and generation reported in the annual report as companies no longer report on CO_2 intensity*

[3] *Gas Natural Fenosa has excluded its nuclear sector from its average CO_2 emissions calculation. As nuclear represents 10% of its power generation mix, the total average CO_2 emission figures might be slightly lower*

[4] *Vattenfall has reported its figures excluding lignite operations starting from 2015 despite divestments in early 2016*

Europe

Conclusion

The restructuring of Utilities, often through divestment of conventional power assets, was triggered by the drop in competitiveness and profitability of these segments in the European market. This shift has fueled massive investments in other revenue streams, mainly centered on renewable energy sources – sometimes incentivized by local governments. It remains to be seen whether Utilities will start to recover in 2017 and whether they can demonstrate better resilience to potential challenges in the future.

A CO_2 reduction program at EU or worldwide level will push this transition phase even further but it represents a major risk for traditionally large emitters such as RWE and EnBW who are slowly recovering and are not yet in a position to make profound changes to their business models.

Southeast Asia

Southeast Asia

Energy Transition in Southeast Asia

Editorial by Gaurav Modi

Southeast Asia (SEA) is the third-fastest growing region in the world, based on real gross domestic product (GDP) growth. SEA's high economic growth comes at a cost and its rapidly increasing energy demand has driven up its energy security risks. Additionally, in the backdrop of rapid industrialization and population surge, the growing economies are increasingly becoming vulnerable to climate change.

SEA is eager to pave a path towards a clean and renewable energy landscape. However, burgeoning energy demand in the region, primarily driven by industrial and transportation sectors, is surpassing the generation of sustainable energy and proving detrimental to the progress. Additionally, the economic and political support in favor of traditional sources of energy are impeding the growth of sustainable energy in many countries in the region. Despite the existing challenges, regional governments have been stepping up efforts to grow their renewable energy capabilities, streamlining their policies to increase energy efficiency and have also set targets for clean energy, by ratifying the Paris Agreement.

Comparatively developed economies like Hong Kong and Singapore aim to slash emissions intensity by 26%-36%, under the 2030 action plan, with focus on promoting energy efficiency initiatives through carbon audits. The most appropriate and available large-scale replacement technology for Hong Kong is natural gas-fired electricity generation. Singapore plans to introduce a carbon tax on the emission of greenhouse gases from 2019, in a move to maintain a high-quality living environment and do its part in fighting climate change.

Malaysia intends to reduce its greenhouse gas (GHG) emissions intensity of GDP by 45% by 2030, while Philippines intends to undertake an even robust GHG emissions reduction target of about 70% by the same time. Since the Ninth Malaysia Plan (2006-2010), Malaysia has started initiatives to increase the share of non-fossil fuel energy, while the Philippines is making significant strides toward a more inclusive growth aimed at further reducing poverty and creating more opportunities for shared prosperity.

Vietnam has made an unconditional commitment of 8% reduction in GHG emissions by 2030 relative to their business-as-usual projection, in which emission intensity per unit of GDP will be reduced by 20% compared to the 2010 levels.

Taiwan's renewable energy target will focus on the development of photovoltaics and offshore wind power, with 3GW of offshore wind capacity expected to be installed by 2025.

Policy makers in SEA are revisiting their 'energy mix' amid growing focus on clean energy and climate change. SEA continues to be dependent on fossil fuel, coal, natural gas and oil to meet most of its energy demand, but simultaneously, renewable energy is also gaining traction with support from the regional government and local authorities. Renewable energy infrastructure development initiatives such as new technology testing, investment in new capacities and public tenders and auctions are also gaining traction to keep pace with these policy changes.

Energy infrastructure is one of the main factors for energy development in SEA, primarily because of its direct impact to the energy connectivity and energy market integration. At present, both the availability and the affordability of fuel supply are being prioritized. Efforts to use energy resources effectively are being hampered by the uneven distribution of resources and the different levels/rates of investment and economic development among the countries.

The energy markets in this region are largely controlled by monopolies and are at the cusp of transformation. The concept of Distributed Energy Resources (DER) will come to play a major role in these regions. For instance, DER development is gaining traction in Malaysia and Singapore with ongoing testing and integration projects. Micro Grid development dynamics and distribution are playing a pivotal role in this development. In Malaysia, for instance, both Petronas and Tenaga Nasional Berhad are concentrating extensive spend on smart meter programs which is expected to be in the US$80-100 million range.

The traditional single buyer model is likely to undergo a change and move towards either a deregulated market or offer better services in the existing models. These key energy players are likely to be open to considering moving away from large monolithic systems and consider modular, distributed topology, configurable and flexible billing systems.

Historically, the pattern of development of electricity systems across SEA has had a distinctly national focus. Recently, the perspective has shifted towards integrating the power grids supplied by a variety of resources including coal, natural gas, hydropower and other renewables to meet various demand profiles. There are increased signs of regional collaboration which is very similar to more mature markets like the US and Europe. Some cross border collaborations have already happened due to the need for energy security and address the challenges of individual countries. The Singapore-Malaysia interconnection, for instance, has connected Singapore and Malaysia aimed at emergency security and peak demand support. Investment in regasification capacities is growing to cope with the increased dependency on imported natural gas. Philippines is pitching to become SEA's LNG hub, given its geographical advantage in the region

In a bid to improve operational efficiency and sustainability, countries are opening up their energy markets to competition ~ countries across the region such Singapore, Malaysia, Philippines and Taiwan have opted for market deregulation. Singapore and Philippines have undergone FRC (Full Retail Contestability) as part of the deregulation while Hong Kong is considering market competition as one of the key aspects in its Scheme of Control Agreement 2018 Review.

Malaysia is phasing out the subsidies provided via Subsidy Rationalization Programme and has instead paved way for the introduction of Independent Power Producers in the country's energy supply mechanism, by encouraging schemes like Incentive Based regulation to drive both competition and innovation in the market.

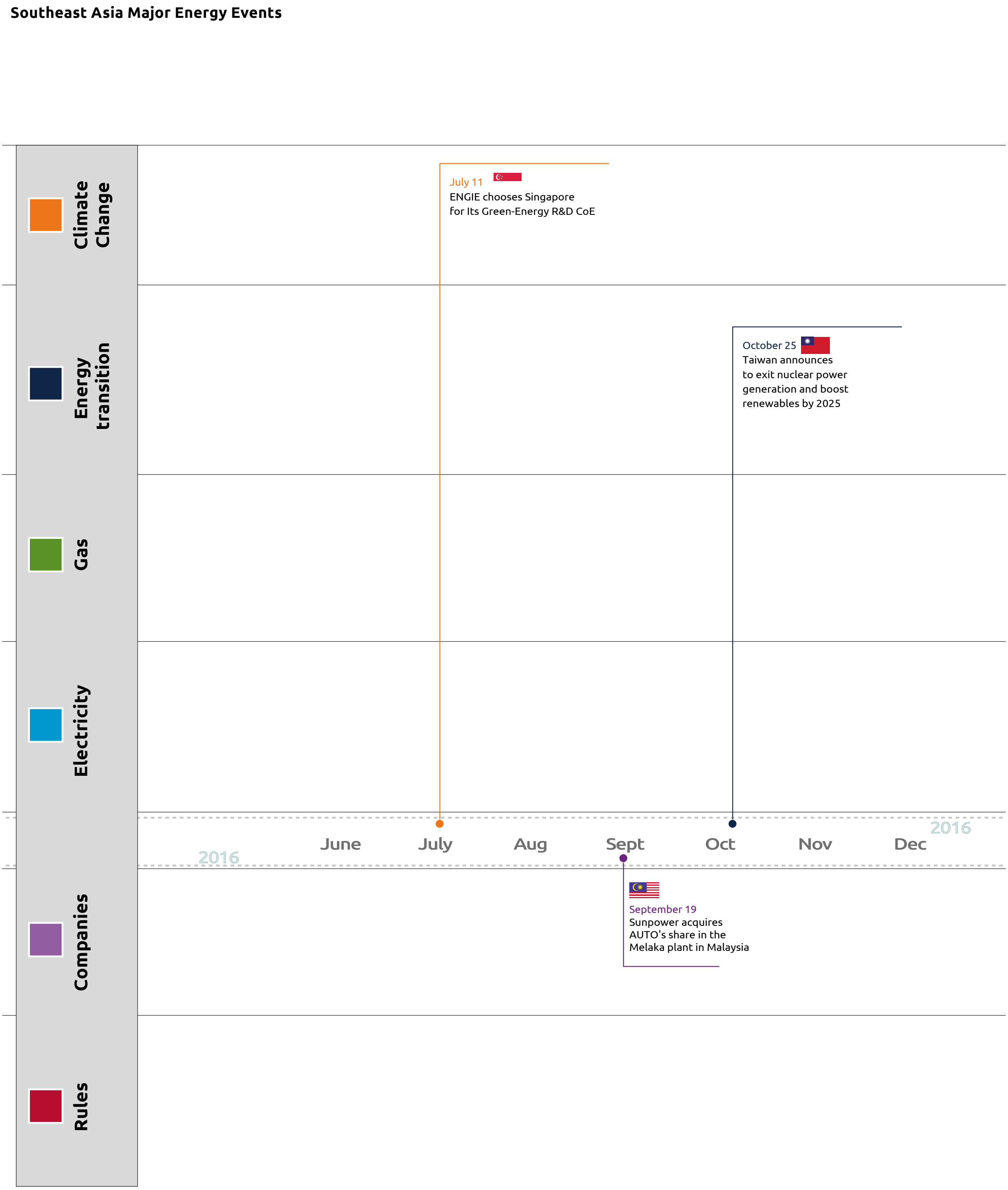
In Philippines, the government is promoting private sector investment in the energy space ~ Philippines's Energy Regulatory Commission facilitated the privatization of the National Power Corporation which proved to be successful and beneficial for urban consumers.

Given the surge predicted in energy demand, it is imperative that innovative ways to generate power in a socially, economically, and environmentally sustainable manner are uncovered. A combination of the current challenges in each country combined with the rapid economic growth, SEA's electricity market presents a tremendous growth potential across the value chain. Some of the key areas include asset optimization and management, predictive asset management, grid optimization, cyber security, IT / OT convergence, better customer channels, AMI rollout, data monetization, IoT and cloud, among others. The key to success in these future scenarios will be a strong partnership with the likes of SAP, Microsoft and IBM as well as building a hybrid capacity model locally as well as supported from India. The adoption of Cloud is expected to remain very high on these markets that will help bring all these various systems to together securely, at scale and at an affordable cost.

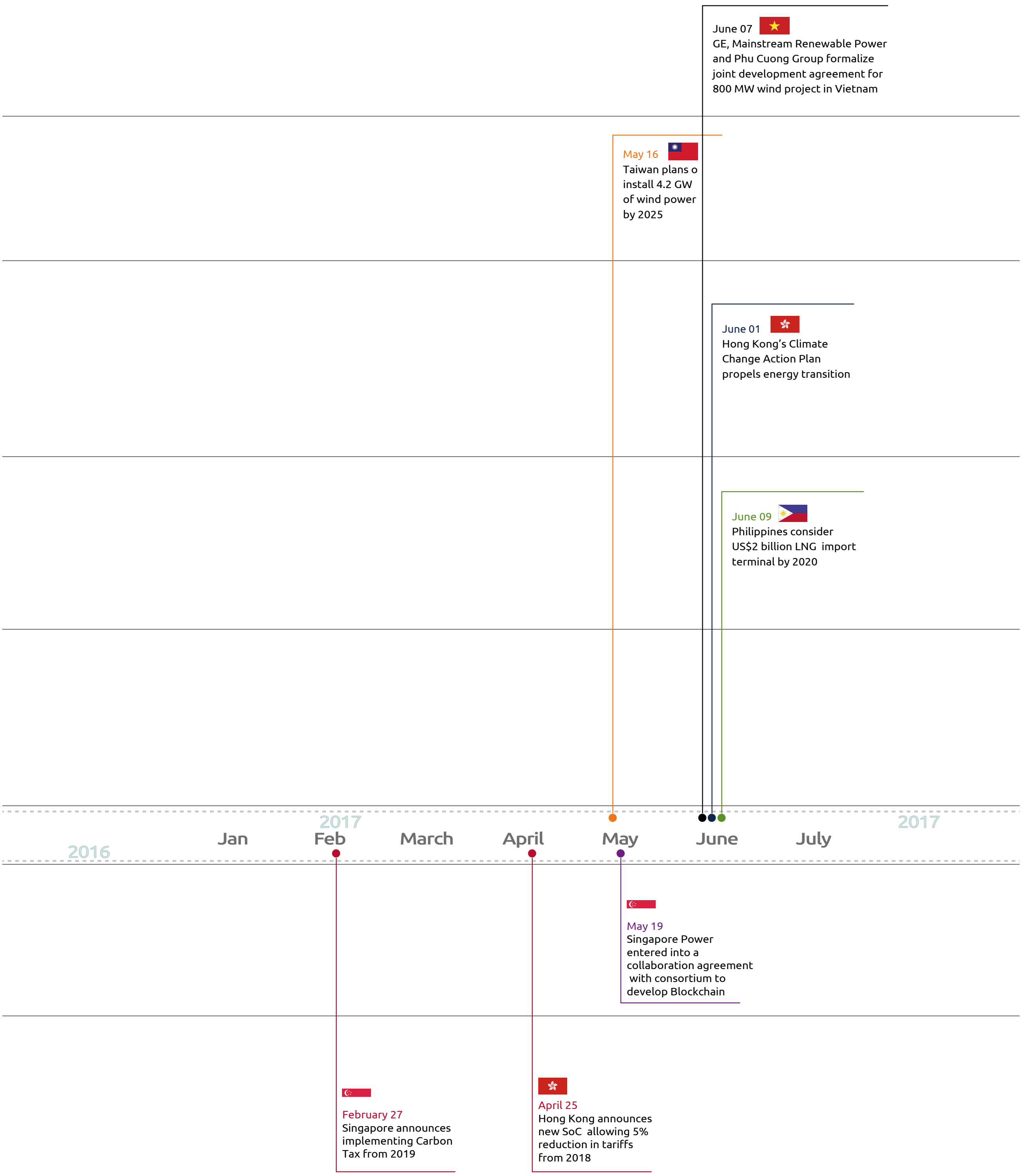
Gaurav Modi

Chief Executive Officer
Capgemini Southeast Asia & Hong Kong

Southeast Asia Major Energy Events



Source: Various industry sources - Capgemini analysis, WEMO2017


June 07
GE, Mainstream Renewable Power and Phu Cuong Group formalize joint development agreement for 800 MW wind project in Vietnam
May 16
Taiwan plans o install 4.2 GW of wind power by 2025
June 01
Hong Kong's Climate Change Action Plan propels energy transition
June 09
Philippines consider US$2 billion LNG import terminal by 2020
2016
Jan
2017
Feb
March
April
May
June
July
2017
May 19
Singapore Power entered into a collaboration agreement with consortium to develop Blockchain
February 27
Singapore announces implementing Carbon Tax from 2019
April 25
Hong Kong announces new SoC allowing 5% reduction in tariffs from 2018

Introduction

Region - Southeast Asia (SEA)

In this Observatory, SEA refers to a region covering the following six countries only:

1. Hong Kong
2. Singapore
3. Malaysia
4. Philippines
5. Vietnam
6. Taiwan

Figure: SEA region within the scope of this Observatory

Country facts[1] [2]:

Country	Population (in millions)	GDP per capita (US$)	GDP (US$)	Primary energy consumption (Mtoe)	Gas consumption (Mtoe)	Electricity generation (TWh)	Electrification rate (%)
Hong Kong	7.4 (2016) World share: 0.10%	43,544.0	321.0	28.6 (2016) *World share: 0.22%*	3.0 (2016) *World share: 0.09%*	38.2 (2016) *World share: 0.15%*	100.0% (2014)
Singapore	5.6 (2016) World share: 0.08%	52,920.0	297.0	84.1 (2016) *World share: 0.63%*	11.3 (2016) *World share: 0.35%*	51.6 (2016) *World share: 0.21%*	100.0% (2014)
Malaysia	31.7 (2016) World share: 0.41%	9,420.0	298.0	99.5 (2016) *World share: 0.75%*	38.7 (2016) *World share: 1.21%*	156.8 (2016) *World share: 0.63%*	99.0% (2015)
Philippines	104.3 (2016) World share: 1.38%	2,926.0	305.0	42.1 (2016) *World share: 0.32%*	3.4 (2016) *World share: 0.11%*	89.9 (2016) *World share: 0.36%*	88.0% (2015)
Vietnam	92.6 (2016) World share: 1.27%	2,111.0	196.0	64.8 (2016) *World share: 0.49%*	9.6 (2016) *World share: 0.30%*	175.7 (2016) *World share: 0.71%*	98.0% (2015)
Taïwan	23.5 (2016) World share: 0.31%	22,585.0	532.0	112.1 (2016) *World share: 0.84%*	17.2 (2016) *World share: 0.54%*	264.1 (2016) *World share: 1.06%*	NA

Country introductions:

1. Hong Kong

- Officially the Hong Kong Special Administrative Region of the People's Republic of China (Hong Kong SAR), it is an autonomous territory south of mainland China and east of Macao in East Asia
- A major capitalist service economy characterized by low taxation and free trade
- The greatest potential for reducing sizable quantities of carbon emissions is through reducing coal usage for local electricity generation and maximizing energy efficiency, especially in buildings

2. Singapore

- As a low-lying island state with no natural resources, Singapore has to accommodate not only housing and commercial centers, but also power plants, reservoirs, air/seaports and industries within city boundaries
- Singapore's small size means it has limited access to renewable energy sources, so the main thrust of its climate mitigation policy is energy efficiency
- Singapore made early policy choices to reduce its greenhouse gas (GHG) emissions by switching from oil and coal to natural gas, greatly reducing its dependence on fossil fuels

1 http://www.bp.com/statisticalreview ; http://www.worldometers.info/

2 https://www.eia.gov/conference/2016/pdf/presentations/gandolphe.pdf

3. Malaysia

- Malaysia is a federal constitutional monarchy, separated by the South China Sea into two similarly sized regions, Peninsular Malaysia and East Malaysia
- It continues to allocate financial resources for the implementation of climate change mitigation programs through both public and private sector initiatives, along with national priorities such as poverty eradication, and improving quality of life
- It has introduced initiatives to increase the share of non-fossil fuel energy and plans to further develop green technology for sustainability and resilience are covered in the Eleventh Malaysia Plan (2016-2020)

4. Philippines

- The Philippines, an archipelagic country with a population of more than 100 million, is highly vulnerable to the impacts of climate change and natural hazards
- It was ranked fifth in the long-term Climate Risk Index (CRI) for the period 1994 to 2014 in the Germanwatch Global CRI[3]
- The challenge is to pursue economic development while simultaneously increasing the resilience of vulnerable sectors and natural ecosystems to climate change

5. Vietnam

- Vietnam is extremely vulnerable to climate change impacts given its extensive coastline and river deltas, and highlands that have poor water retention capacity and are susceptible to severe erosion
- The country transitioned from a centrally planned economy to a market-oriented system with unprecedented success
- A key challenge is to manage its rapid economic development in a sustainable manner and to prevent adverse impacts of environmental degradation and climate change

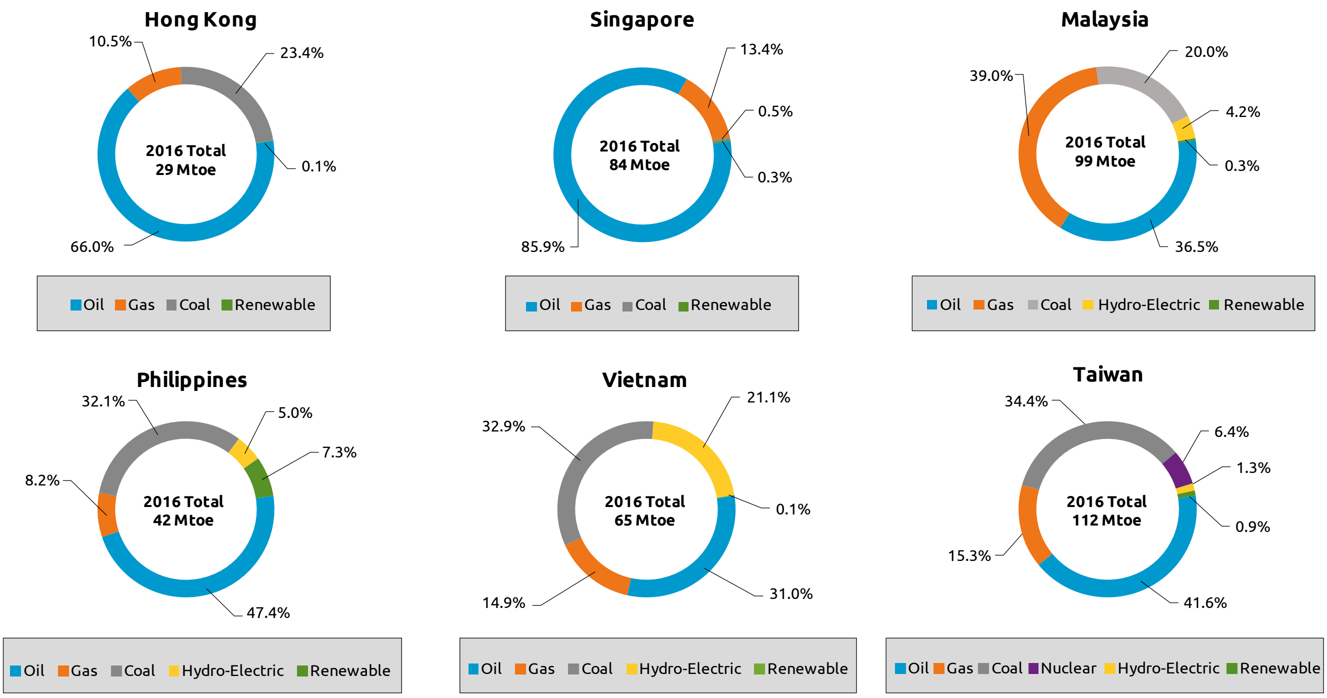
6. Taiwan

- Taiwan is located at the border of East and Southeast Asia, between the Taiwan Strait and Philippine Sea
- The economy depends upon international trade; energy demand has increased rapidly over the past 20 years due to rapid economic growth
- As an island with an independent electricity grid and no gas pipelines, it relies heavily on imported energy, which represents more than 98% of its energy demand[4]

3 http://www4.unfccc.int/Submissions/INDC/Published%20Documents/Philippines/1/Philippines%20-%20Final%20INDC%20submission.pdf

4 http://enews.epa.gov.tw/enews/enews_ftp/104/1117/174044/Submission%20by%20Republic%20of%20China%20(Taiwan)Intended%20Nationally%20Determined%20Contribution.pdf

Figure : Primary sources of energy consumption (2016)[5]



Scope of the Observatory

This Observatory focuses on the current and future state of the utilities sector, specifically electricity and gas, with an emphasis on the renewables market in the Southeast Asia (SEA) region.

5 http://www.bp.com/statisticalreview

Climate Challenges & Regulatory Policies

Southeast Asia (SEA) intends to shift to a clean energy system, but high energy demand and cost pressures are proving detrimental to progress

Despite ambitious clean energy targets, the region's fight against climate change could be an uphill one, going by some turbulent trends over the past decade ~ energy demand in the region has frequently outpaced growth in sustainable energy

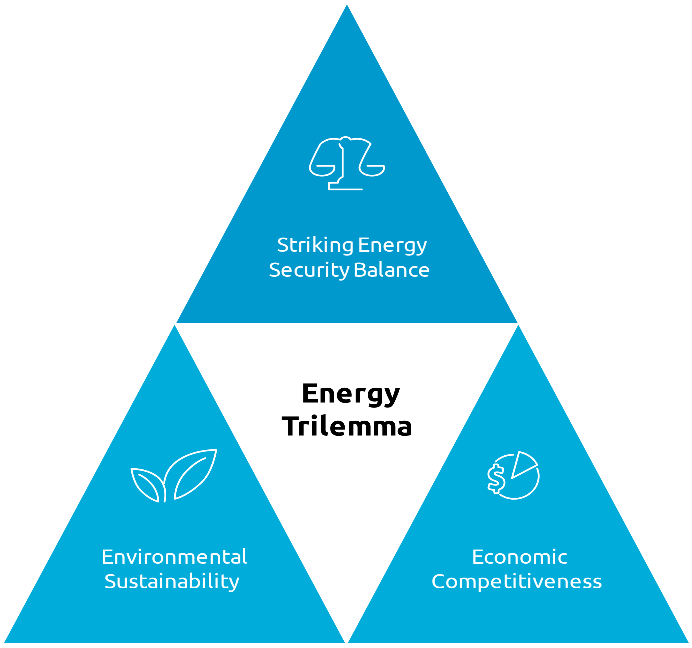
Strong economic growth and poor regional coordination have been cited by experts as underlying causes for the persistently low share of renewables in the region's energy mix

However, boosting regional coordination and technical expertise ~ SEA governments have been stepping up efforts to grow their renewable energy capabilities over the past few years

Evolution of primary energy consumption and overcoming the "energy trilemma"

Regional governments have been making efforts to overcome what is being described as the 'energy trilemma'[6].

Figure 1.1: Energy Trilemma facing SEA for Sustainable Growth[7]



6 http://bradmanrecruitment.com/powering-ahead-solving-southeast-asias-energy-challenges/

7 http://bradmanrecruitment.com/powering-ahead-solving-southeast-asias-energy-challenges/

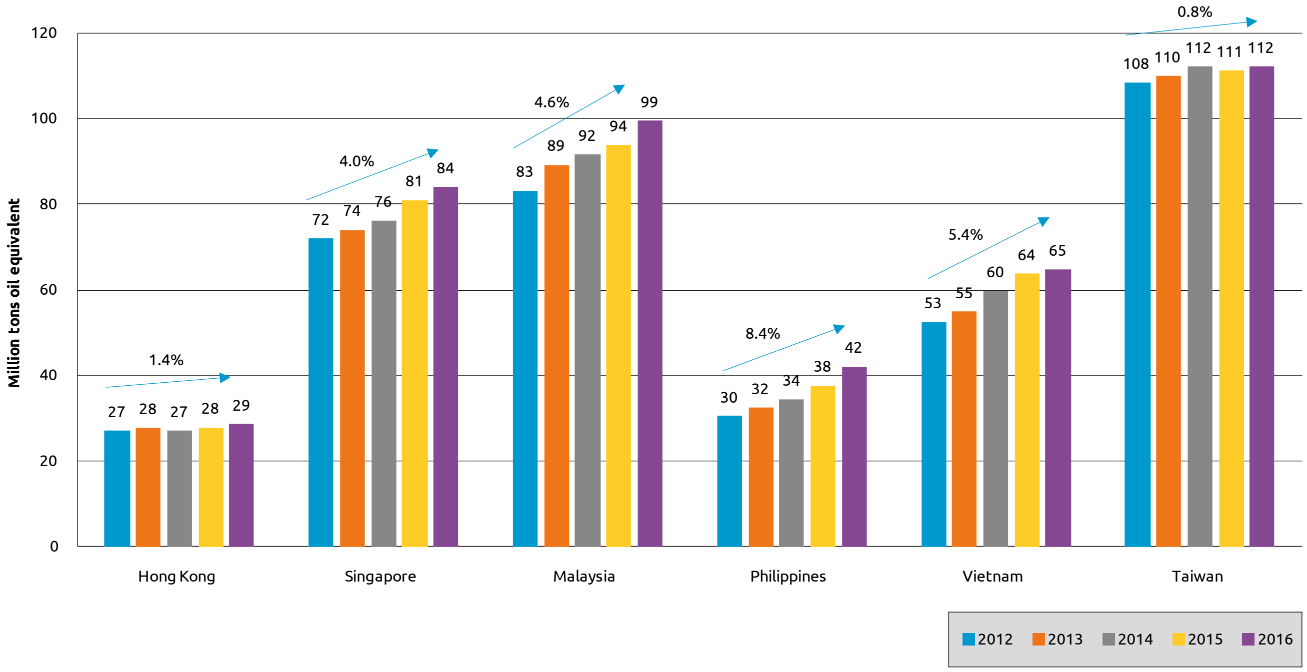
SEA's use of coal has increased amid the abundance, relative affordability and the need to provide energy.

With the energy demand set to jump by more than 80% between 2015 and 2040, as projected by the International Energy Agency, SEA governments face the daunting task of producing enough sustainable energy to meet the burgeoning demand for electricity.[8]

Challenges remain as pragmatic energy polices in many countries have been constrained by social and political pressures

- Heavy subsidies supporting traditional energy sources have created an unequal playing field for sustainable energy development
- Traditional energy suppliers have strong economic and political influence over the status quo

Figure 1.2: Primary Energy Consumption (million tons oil equivalent)[9]



- SEA's primary energy demand is dependent on fossil fuels; driven by industry-related sector followed by transport-related consumers
- Energy consumption is being driven by increasing income levels, boosting energy demand in spite of several energy efficiency measures being adopted
- In 2016, when comparing on an year-on-year basis, the total primary energy consumption of SEA grew by ~4%, where Philippines is leading the consumption growth having shown ~11% growth in primary energy demand, followed by Malaysia at ~5%

8 http://bradmanrecruitment.com/powering-ahead-solving-southeast-asias-energy-challenges/

9 https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf

What the future holds for primary energy consumption

As per APEC the primary energy supply for the SEA region is expected to reach 630 Mtoe by 2040.[10] The underlying positive theme would be rising energy efficiency, resulting in decoupling of energy consumption from economic growth

- **Hong Kong** endeavors to develop sustainably and fully supports APEC's Honolulu Declaration in 2011, seeking to reduce 45% of energy intensity by 2035
  - To step up energy efficiency and conservation, various policies have been implemented, such as the Mandatory Energy Efficiency Labelling Scheme, Energy Efficiency Registration Scheme for Buildings, Building Energy Efficiency Ordinance as well as the Scheme on Fresh Water Cooling Towers
- **Singapore** is also fully committed to APEC's objective[11]
- **Malaysia's** energy consumption is expected to grow at an annual rate of 4.8% for the period 2000 to 2030
  - Energy for transport is projected to be the fastest growing sector during the next 25 years, expanding at an annual rate of 5.3%
  - Malaysia's final energy requirements are expected to triple by the year 2030 from current consumption levels

- Consumption of coal for electricity production is expected to increase for most countries
  - When compared to natural gas, coal is cheap and readily available in countries such as **Malaysia**
  - Following the Fukushima disaster, countries have become wary of adding to nuclear capacity which is expected to increase the use of coal as a fuel for developing economies especially with cheap availability
  - Coal is still the dominant fuel for **Philippines'** baseload requirement
  - **Vietnam's** decision to stay away from nuclear power is expected to increase the dependence on coal for the nation
  - **Taiwan** has reaffirmed a '20%-by-2025 Renewable Energy Target' ~ Taiwan plans to phase out nuclear power plants and have an energy mix containing 50% natural gas, 30% coal and 20% renewable energy by 2025, along with improvement of the power distribution system[12]

10 http://aperc.ieej.or.jp/file/2016/5/10/APEC_Outlook6th_VolumeI.pdf
11 http://aperc.ieej.or.jp/file/2017/6/30/APEC+Overview+2016.pdf
12 http://www.offshorewind.biz/2017/02/15/taiwan-reaffirms-20-by-2025-renewable-energy-target/

With rapid industrialization and population surge, the growing SEA economies are increasingly becoming vulnerable to climate change. According to the Asian Development Bank it is estimated that if left unaddressed, climate change in the region would account to cost ~6.7% of the combined annual GDP by 2100.

Figure 1.3.a : Emissions Evolution (million tons CO_2)[13]

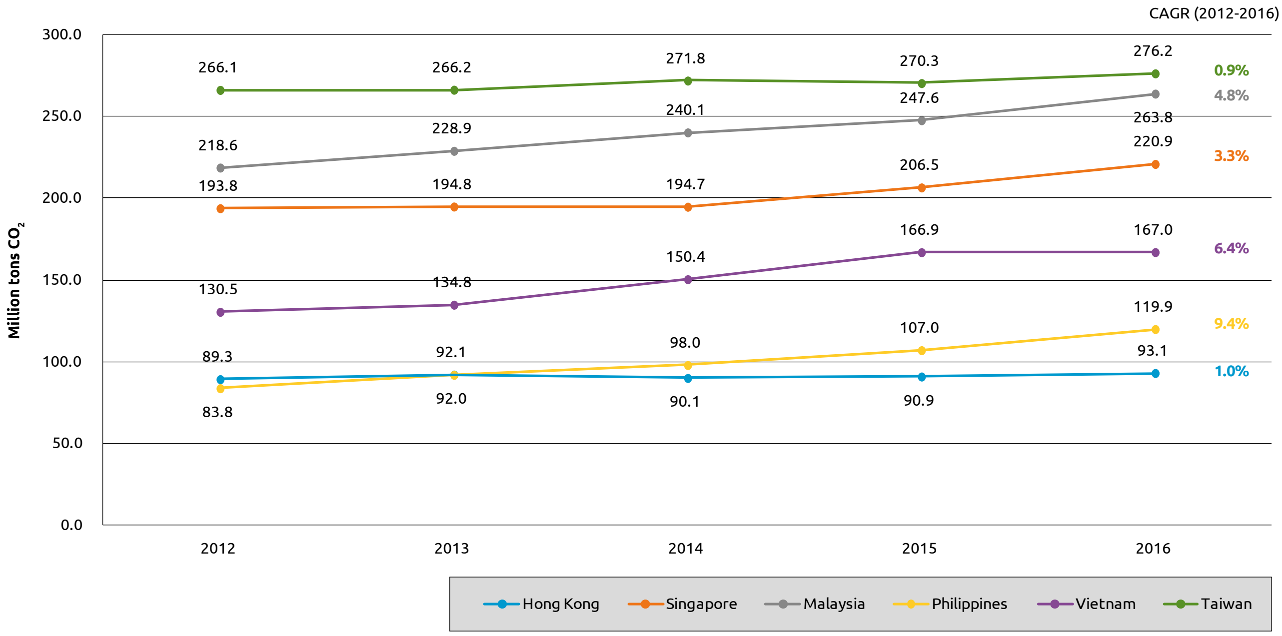
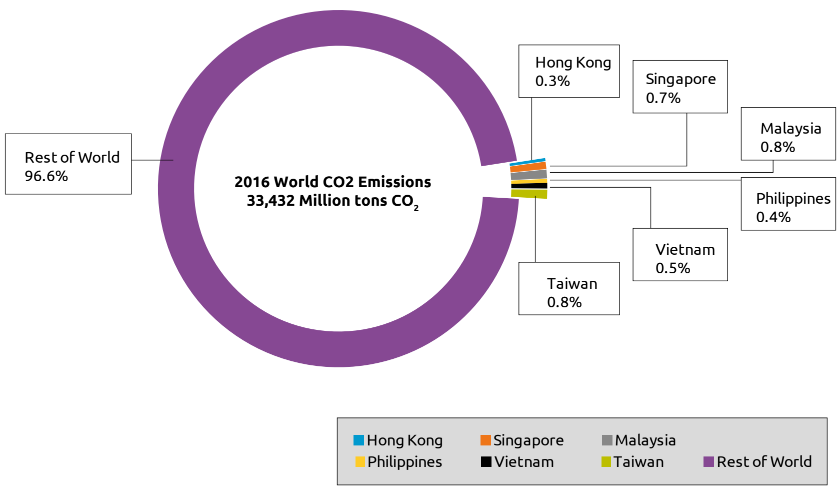


Figure 1.3.b : Share in 2016 World Emissions[14]



13 https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf
14 https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf

Total CO_2 emission in the region reached a level of over 1,100 MT CO_2e in 2016. Most of the countries in SEA are expected to reduce or stabilize their carbon dioxide emission in the future. However, growing economies like Vietnam, which plan to reduce dependency on nuclear energy, will most likely experience a larger dependence on coal, resulting in growth in their carbon emission.

- Power generation is the largest GHG emitter in **Hong Kong**, accounting for ~70% of overall emissions, far outweighing the second largest emitting source, i.e. the transport sector, despite the decision in 1997 not to build new coal-fired electricity generating plants
  - Despite its declining share, coal has remained the most dominant fuel in meeting growing local power demand and has accounted for about half the fuel mix of the power generated and imported since 2005
  - Evidently, power generation holds the key to managing GHG emissions for Hong Kong

- Currently, **Singapore, Malaysia and Taiwan** are among the highest contributors to CO_2 emission in SEA
  - The most significant GHG emitted in **Singapor**e is CO_2, primarily produced by the burning of fossil fuels to generate energy used by the industry, buildings, household and transport sectors
    • The majority of the direct emissions from the industrial sector are from the combustion of primary fuels by the refining and petrochemical sector
    • Emissions from the commercial and residential sectors are driven by the use of Liquefied Petroleum Gas (LPG) and Gas Works Gas[15], mainly for cooking and hot water systems

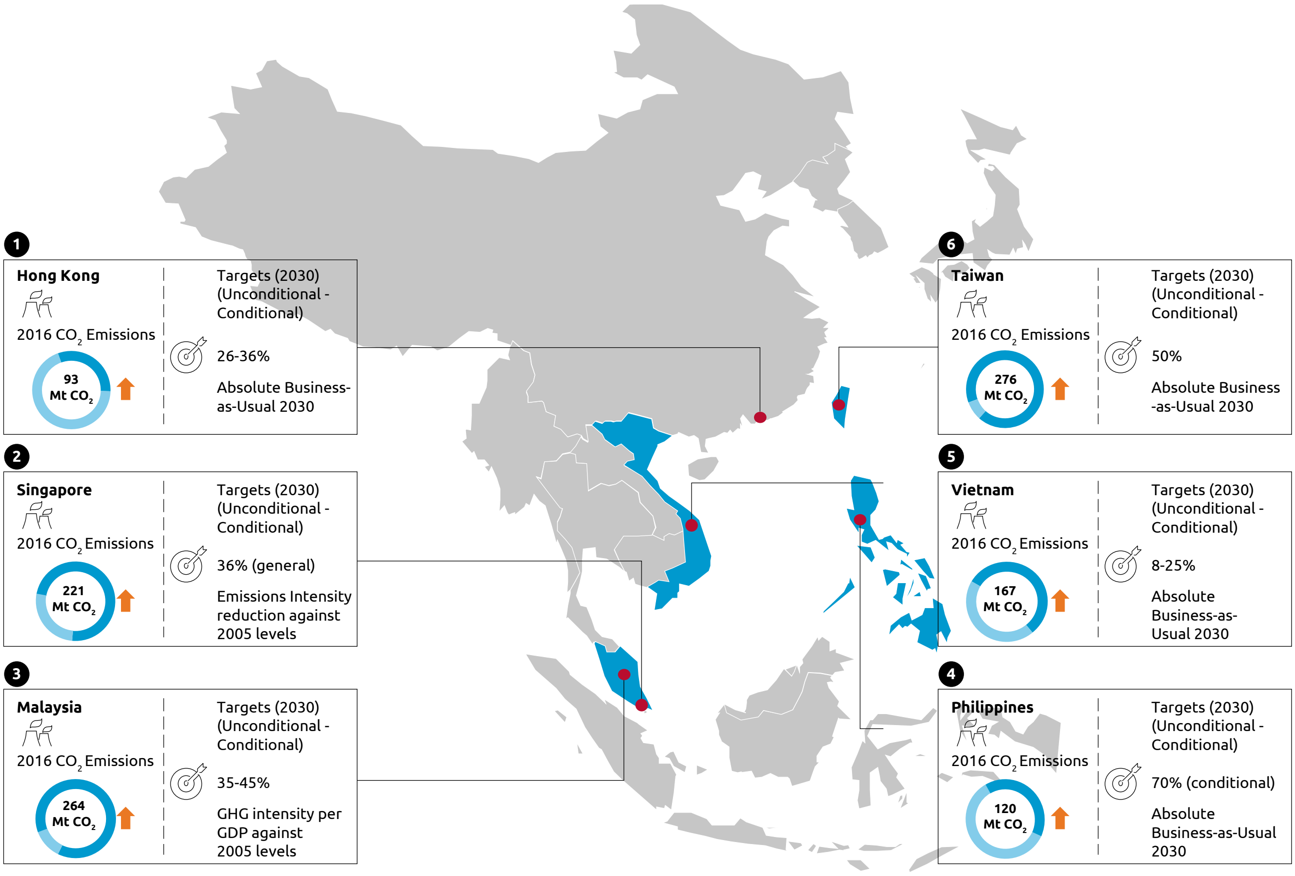
  - Power generation and transportation are the main contributors to CO_2 emissions in **Malaysia**
    • Utilization of old technologies, inefficient power usage and business reluctance to adopt environment friendly technologies have been driving CO_2 emission up, increasing the greenhouse effect and rise in sea water and flooding

- **Philippines' and Vietnam's** emissions are dominated by the energy sector, with electricity and heat production driving this increase, followed by agriculture, industrial processes (IP), and waste
- Over the past 2 decades, primary energy sources in **Taiwan** reclined mainly in coal, petroleum and natural gas, with coal representing the majority share
  - Currently, Taiwan is being listed among the top 20 emitting countries

15 Gas Works Gas is primarily hydrogen gas generated through steam reforming of natural gas

Overview and analysis of the energy-related CO_2 reduction targets and mitigation plans of SEA

Figure 1.4.a : NDC Targets[16]



Capgemini Analysis, WEMO 2017

Hong Kong aims to slash carbon emissions with 2030 action plan ~ while the government hopes to reduce total emissions by 26-36%, critics say the plans lack conviction.

- Annual carbon emissions could be slashed from around six tonnes per person to between 3.3 and 3.8 tonnes by 2030, according to the government's latest climate change action plan
- The target, which will translate to a reduction of 65-70% in carbon emissions per GDP from 2005, will use a cleaner, less coal-intensive fuel mix and more energy efficient buildings and transport
- Measures to incentivize private investment in renewables could be introduced in the post-2018 regulatory framework with power companies, which is being negotiated
  – Government departments are looking at installing floating photovoltaic systems on reservoirs, with two expected to be completed at Shek Pik and Plover Cove in 2017, and on slopes, such as at the old Anderson Quarry
- However, the Environment Bureau has stressed that the city does not have favorable conditions for large-scale commercial use and as such, did not set any concrete targets for 2030

16 Capgemini Analysis, WEMO 2017

Singapore intends to reduce its Emissions Intensity by 36% from 2005 levels by 2030, and stabilize emissions with the aim of peaking around 2030.

- Being heavily dependent on fossil fuels, and given its severe limitations on using alternative energy, Singapore had made early policy choices to reduce its GHG footprint by switching from fuel oil to natural gas, the cleanest form of fossil fuel, for electricity generation, even though it meant higher cost
- Today, over 90% of electricity is generated from natural gas
- Singapore prices energy at market cost, without any subsidy, to reflect resource scarcity and promote judicious usage

Malaysia intends to reduce its greenhouse gas (GHG) emissions intensity of GDP by 45% by 2030 relative to the emissions intensity of GDP in 2005.

- This consist of 35% on an unconditional basis and a further 10% is condition upon receipt of climate finance, technology transfer and capacity building from developed countries
- The country continues to allocate financial resources for the implementation of climate change mitigation programs through both public and private sector initiatives
- Since the Ninth Malaysia Plan (2006-2010), Malaysia has started initiatives to increase the share of use of non-fossil fuel energy

Philippines intends to undertake GHG (CO_2e) emissions reduction of about 70% by 2030 relative to its BAU scenario of 2000-2030.

- Reduction of CO_2e emissions will come from energy, transport, waste, forestry and industry sectors
- The mitigation contribution is conditioned on the extent of financial resources, including technology development & transfer, and capacity building, that will be made available to the Philippines
- While the Philippines is making significant strides toward a more inclusive growth aimed at further reducing poverty and creating more opportunities for shared prosperity, the challenge is to pursue economic development while simultaneously having to deal with the impacts of climate change and natural hazards

Vietnam has made an unconditional commitment of 8% reduction in GHG emissions by 2030 relative to their BAU projection, in which emission intensity per unit of GDP will be reduced by 20% compared to the 2010 levels.

- This commitment could reach a 25% GHG emission reduction by 2030, conditional on international support through bilateral and multilateral cooperation, as well as through the implementation of new mechanisms under the Global Climate Agreement, in which emission intensity per unit of GDP will be reduced by 30% compared to 2010 levels
- The NDC cites the National Green Growth Strategy for the Period 2011–2020 with a vision to 2050, which puts forward targets for GHG reduction, energy consumption and energy efficiency, and conditional commitments for 2020, 2030 and 2050

Taiwan intends to implement an economy-wide target, through domestic abatement effort to reduce GHG emissions (214 MtCO_2e) by 50% from the business-as-usual level (428 MtCO_2e) by 2030.

- Taiwan government promulgated the Greenhouse Gases Reduction and Management Act on July 1, 2015, to serve as the legal basis for climate change response
- Being the first law in Taiwan to empower the government to formulate related regulations and share the common but differentiated responsibility with the global society, the Act not only has a clear emission reduction target of 50% 2005 level by 2050 but also implements carbon reduction through a five-year control cycle

Figure 1.4.b : NDC Policies[17]

	Key targets and quantified policies to achieve target	Main policies related to energy cited in the NDC
Hong Kong	• Reduce carbon intensity by 65-70% by 2030 • Phase electricity generation to gas from coal by 2030 • Introduce Renewable in a more systematic manner • Establish feed-in tariff and renewables certificate systems	• Hong Kong 2030+, Energy Saving Plan, Carbon Labelling Scheme for Construction Products, Energy Audit Code, Mandatory Energy Efficiency Labelling Scheme, 4T Framework (Timeline, Transparency, Targets, Together), Hong Kong Biodiversity Strategy and Action Plan 2016-2021
Singapore	• Renewables to reach 8% of peak electricity demand by 2030 • Achieve Green Building target of 80% by 2030 • Length of rail network to be doubled by 2030 • Vehicle and road taxes ongoing; CO_2 based as of 2013	• Energy Conservation Act, Grant for Energy Efficient Technologies (GREET), Energy Efficiency Improvement Assistance Scheme (EASe), Building Control Act, Mandatory Energy Labelling Scheme (MELS)
Malaysia	• Bio-diesel blending targets • Removal of energy subsidies • Renewables to reach 11% of electricity generation by 2030 • Investments in rapid transit and natural gas vehicles	• National Biofuel Policy 2006, National Renewable Energy Policy and Action Plan, Eleventh Malaysia Plan 2016–2020, National Renewable Energy Policy and Action Plan, National Biofuel Policy 2006
Philippines	• 10% energy savings across all economic sectors by 2030 • 30% of all public utility vehicles on alternative fuels by 2030 • Natural gas as a major alternative fuel for public transport • Additional CNG refilling stations and LNG hub terminals	• National Climate Change Action Plan 2011–2028, National Renewable Energy Program, Renewable Energy Act of 2008, Philippine Energy Plan, National Environmentally Sustainable Transport Strategy 2010–2020, National Energy Efficiency and Conservation Program
Vietnam	• Annual energy consumption decreases at 2.5-3% of GDP • Industrial production facilities to use cleaner technologies • 80% of buses and taxis using CNG and LPG by 2050	• Energy Conservation Act, Grant for Energy Efficient Technologies (GREET), Energy Efficiency Improvement Assistance Scheme (EASe), Building Control Act, Mandatory Energy Labelling Scheme (MELS)
Taiwan	• Introduce advanced energy conservation measures • Integrated utilization of energy in industrial zones • Development of green public transportation system • Encourage energy-saving designs of new buildings	• Greenhouse Gases Reduction and Management Act 2015, National Climate Change Action Guideline, Greenhouse Gas Reduction Action Plan, Emission Control Implementation Program, Energy Management Act, Renewable Energy Development Act, Minimum Energy Performance Standards

The most appropriate and available large-scale replacement technology for Hong Kong is natural gas-fired electricity generation.

- By around 2020, natural gas is expected to generate about half of electricity while coal will drop to about 25%[18]
- This will help achieve the target of 50% to 60% reduction in carbon intensity using 2005 as the base, equivalent to about 20% of absolute carbon emissions reduction
- Power companies need to ensure they can secure adequate supplies of natural gas and have the infrastructure needed in the coming decade to handle larger quantities of natural gas
- New gas plants need to be as energy efficient as possible
- Based on currently mature and commercially available technologies, Hong Kong has about 3-4% of realizable renewable energy potential arising from wind, solar and waste-to-energy (WTE) that can be exploited between now and 2030[19]
- Besides, Hong Kong is also promoting energy efficiency in buildings through carbon audits in order to reduce GHG emissions

Southeast Asia

17 Capgemini Analysis, WEMO 2017

18 http://www.enb.gov.hk/sites/default/files/pdf/ClimateActionPlanEng.pdf

19 https://www.climateready.gov.hk/files/report/en/4.pdf

by 65%-70% by 2030 with 2005 as a base
- As buildings account for about 90% of the electricity consumption in Hong Kong, it has become on the potential areas for improving energy efficiencies to reach the carbon targets for the country

Singapore plans to introduce a carbon tax on the emission of greenhouse gases from 2019, in a move to maintain a high-quality living environment and do its part in fighting climate change.[20]

- The carbon tax will likely cost between $10 and $20 per tonne of emissions, which is in the range of similar carbon tax rates around the world[21]
  - The carbon tax will generally be applied to power stations and other large direct emitters of GHG, not electricity users
  - The carbon tax will «create a price signal to incentivize industries to reduce their emissions
  - Current diesel taxes, which are a lump sum Special Tax levied on diesel cars and taxis, will be restructured to a volume-based duty
  - A new Vehicular Emissions Scheme (VES) will replace the Carbon Emissions-Based Vehicle Scheme (CEVS), which was implemented in 2013 with the aim of encouraging use of vehicles with low carbon emissions
  - The Early Turnover Scheme, which was introduced in 2013 to encourage early replacement of older and more polluting commercial diesel vehicles will be extended to July 31, 2019 for vehicle owners who turn over their existing Euro II and III commercial diesel vehicles for Euro VI vehicles
- Besides, Singapore has set a target of ramping up improvement in energy efficiency in the manufacturing sector by 1 to 2 per cent a year from 2020 to 2030, along with tightening energy monitoring and reporting requirements for large industrial players
- Besides curbing emissions, Singapore's climate action plan will also set out ways for the country to deal with climate change in six areas, including coastal protection, managing the water supply and improving food supply resilience[22]

Under the Green Technology Master Plan 2017-2030, Malaysia aims to slash CO_2 emissions from the present 8 Mt per capita to 6 Mt per capita in 2030.

- The 13-year plan targets 25% renewable energy in the country's power generation mix, boost energy efficiency from less than 2% to 15%, treated wastewater recycling to 35% from less than 1%, 15% freshwater extraction rates from the present 2%, and 50% green manufacturing small and medium enterprises from just 10% now[23]
- Other definite and behavioral initiatives include cost-balancing management for green application, tariff rates amendments and continuous engagement between various stakeholders
- However, balancing mitigation and adaptation actions is necessary for Malaysia to start the transition towards a climate-resilient development and low carbon economy[24]

In 2010, the Philippines Climate Change Commission (CCC) formulated the 2010-2022 National Framework Strategy on Climate Change which identified a long-term mitigation objective of facilitating the transition towards low GHG emissions for sustainable development.

- The CCC developed the National Climate Change Action Plan in 2011 which outlines the agenda for adaptation and mitigation from 2011-2028 in seven strategic priority areas
- One of the seven thematic areas in this action plan is sustainable energy
- The action plan outlines supply-side short, medium, and long-term actions, such as the development of the National Renewable Energy Program (NREP), seeking to

20 https://www.mfa.gov.sg/content/mfa/media_centre/singapore_headlines/2017/201702/headlines_20170221_2.html
21 http://www.straitstimes.com/singapore/environment/singapore-budget-2017-6-things-to-know-about-the-new-carbon-tax-tweaked
22 http://www.straitstimes.com/singapore/environment/boosting-energy-efficiency-to-curb-carbon-emissions
23 https://themalaysianreserve.com/2017/06/21/malaysia-slash-another-25-co2-emission-2030/
24 http://magazine.scientificmalaysian.com/issue-13-2017/tackling-climate-change-malaysias-emission-reduction-target/

increase renewable energy-based capacity by 2030
- The Philippine Energy Plan 2012–2030 states that, for the planning period 2012 to 2030, a total of 7,779 MW capacity is estimated to be generated from the indicative power projects, 47.29% (3,679 MW) of which would be from coal
- There is greater need to up the supply of renewable energy resources and to avoid the building new coal-fired power plants

Vietnam plans to keep applying various methods to reach the goal of greenhouse gas reduction and encourage the development of green industries.

- Vietnam has set a target to achieve 25% renewables in its energy mix by 2030 and 45% by 2050
- In May 2017, Vietnam confirmed a feed-in tariff for utility scale solar projects
  - The country's Trade and Industry Ministry is studying long-term policies that could support solar projects
- According to the Ministry of Finance, Vietnam needs to address relations between promoting growth and coping with climate change in each period and mitigate its negative impacts and enhance adaptation to climate change to bolster sustainable development
- Coordination between ministries, departments and localities is lacking[25]
  - In 2017, all ten relevant ministries and 63 localities have promulgated action plans to cope with climate change and sea level rises
  - Nevertheless, only a few ministries and departments study the impacts of climate change on socio-economic development plans
  - Mobilization of financial resources from individuals and businesses remains limited
- The Ministry of Planning and Investment has proposed the arrangement of public investment in 2016-2020 to focus on preventing saltwater intrusion, coastal erosions and droughts
- Vietnam is stepping up coordination in implementing mechanisms and policies to deal with environmental changes and increase awareness-raising campaigns

Taiwan's renewable energy target will focus on the development of photovoltaics and offshore wind power, with 3GW of offshore wind capacity expected to be installed by 2025[26]

- Reaching the renewable energy target will focus on the development of photovoltaics and offshore wind power, with 3GW of offshore wind capacity expected to be installed by 2025
  - Offshore wind development in Taiwan is projected to drive investments worth ~US$15.1 billion
  - The country saw the first phase of its Formosa 1 offshore wind farm, comprising two turbines, being completed last year
  - The entire project consists of 32 turbines, and the second phase is planned to be constructed in 2018/2019
  - In January 2017, DONG Energy and Macquarie Capital signed agreements to acquire a combined 85% ownership interest in the Formosa 1 project from Swancor Renewable
  - DONG Energy also plans to develop four offshore wind farms in the Changhua area, with the potential construction expected to start in 2021-2024
  - The area could see more wind turbines at sea after Taipower and Changhua

25 http://english.vietnamnet.vn/fms/environment/180814/more-efforts-needed-to-cope-with-climate-change-in-vietnam.html
26 http://www.offshorewind.biz/2017/02/15/taiwan-reaffirms-20-by-2025-renewable-energy-target/

Topic Box 1: Evolution of climate change policies and their impact on markets

Hong Kong[27]

Hong Kong had not taken any major initiatives historically for climate change. However growing concerns for environment has led them to announce climate change action plan to be implemented to achieve climate change targets.

- In 2008, the government announced that it will enhance energy efficiency, use clean fuels, rely less on fossil fuels, and promote a low carbon economy ~ an economy based on low energy consumption and low pollution
- Following this, a series of initiatives were rolled out to support the purpose of this policy goal
- In 2007, an inter-department working group was created to tackle climate change

Singapore[28]

Singapore has tried to maintain a low carbon profile by increasing dependence on gas as a fuel and moving away from coal based electricity generation

- Current Policy
  - Replacing oil and coal with natural gas which is seen with Natural Gas having a share of 96% in the energy mix in 2015
  - Currently expanding LNG and solar capabilities
- 2020 Pledge
  - Reduce emissions by 7-11% below BAU emissions unilaterally and the event of a legally binding international agreement, by 16% below BAU
- Climate Strategies are based on three areas
  - Increasing energy and carbon efficiency
  - Reducing carbon emissions in power generation
  - Development of low-carbon technology

Malaysia[29]

Malaysia has the potential for developing multiple types of renewable sources of energy and the government has started taking initiatives over the last few years to develop renewable energy and promote green infrastructure in the country.

- Steps taken in Malaysia after 2009 to tackle climate change include
  - Established Ministry of Energy, Green Technology and Water
  - National policy statement for green technology was founded
  - Malaysian Green Technology Corporation was established as an agency to implement the ministry's agenda for green technology
  - In 2009 Malaysia Green Building Confederation was established to support promotion of sustainable build environment
  - Launching green township framework
  - Legislation to promote renewable energy
- Impact of Policy
  - Diversification of energy mix
  - Increased energy efficiency

Philippines[30]

- **Philippine Agenda 21:** In 1996, Philippines developed a five point agenda in response to United Nations' Conference on Environment and Development in 1992.
  - The Philippine Council for Sustainable Development was created to manage and track the fulfillment of the commitments of the Philippines to the UNCED
- **Philippine Clean Air Act of 1997:** In 1999 the government introduced a law to monitor the set standards for greenhouse gas emissions.
- **Executive Order No. 320, s. 2004:** In 2004, as per the order given by then president Department of Environment and Natural Resources was designated as National Authority for Clean Development Mechanisms
- **Presidential Task Force on Climate Change:** A task force created aimed at Presidential Task Force on Climate Change and ensuring compliance of air emission standards
- **Climate Change Act of 2009:** In 2009 a law was introduced aimed at climate change adaptation into government policy and establish a framework strategy
- **People's Survival Fund (2012):** An amendment to the climate change act providing long term financing to projects address the problem of climate change
- **Executive Order No. 174, s. 2014:** As per the order Philippine Greenhouse Gas inventory management and reporting system was institutionalize

Vietnam[31]

Vietnam has come up with its own plan to maximize utilization of renewable energy resources and reduce carbon emission while modernizing the industry.

- National Action Plan to Respond to Climate Change, 2012
  - The plan aims to address:
    - Effective utilization of resources
    - Reduce GHG emission
    - Respond to climate change
    - Improve quality through green employment, sustainable lifestyles, green infrastructure/ building and restored natural capital

Taiwan[32]

High pace of industrialization has led to a rapid rise in carbon emitting sources in the country and thus the country has started to focus on improving energy efficiency and setting its own targets to combat climate change.

- **Greenhouse Gas Reduction and Management Act:** This bill consist of National Climate Change Framework and a GHG Reduction Implementation program
- **Sustainable Energy Policy Framework:** Passed in 2008 this framework was aimed at increasing energy efficiency more than 2% for 8 years and actively develop renewable potential in the country
- **Renewable Energy Development Bill, 2009:** A bill allowing the government to raise incentives for the development of renewable energy
- **Energy Management Law, 2009:** This law sets down guidelines for energy products and vehicles meet efficiency standards

County Government signed a Memorandum of Understanding (MOU) in December 2016, aiming to develop a series of renewable energy projects, including 1,010MW of offshore wind

- As part of the new energy plans, the state-owned Taipower, together with the private sector, could invest ~US$84.1 billion in energy infrastructure
- In photovoltaics and offshore wind, domestic and foreign investors are estimated to pour ~US$47.5 billion.

SEA's manufacturing, industry and services sectors are growing, increasing demand for electricity. The result has been an increase in pollution from the power sector. Regional governments have set targets for clean energy. Collaboration with customers, utilities and government is critical to design effective policies that encourage investment. SEA has a real opportunity to build a productive clean energy economy that delivers affordable and reliable power.

27 http://www.epd.gov.hk/epd/english/climate_change/files/Climate_Change_Booklet_E.pdf

28 http://climateactiontracker.org/countries/singapore.html

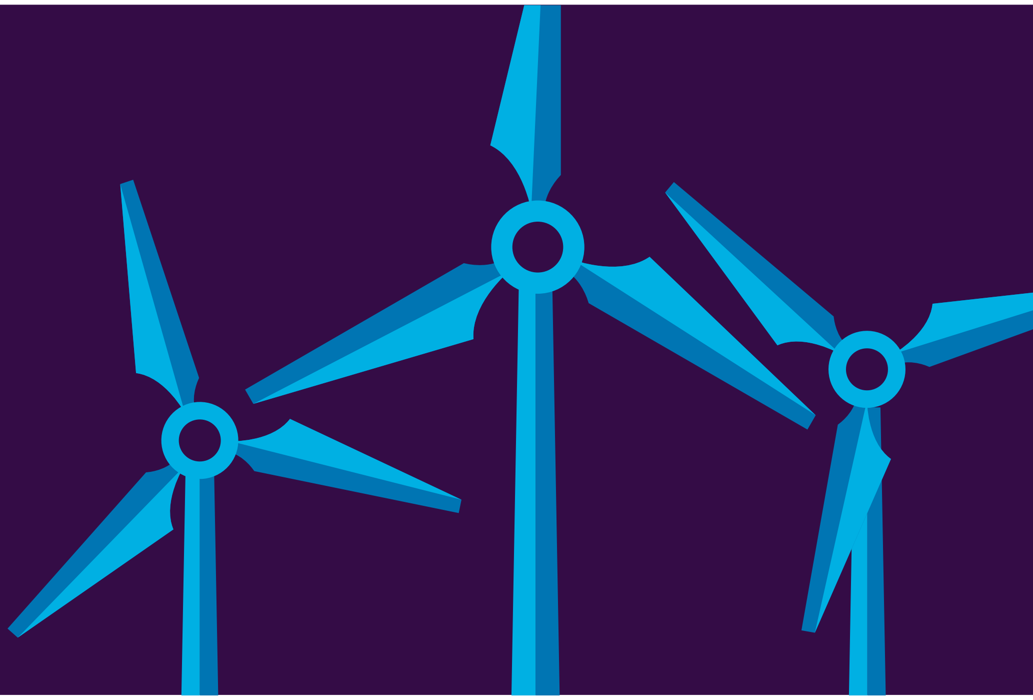
29 http://www.ukm.my/lestari/wp-content/uploads/2013/04/Policy-Framework-for-Green-Econ_Hezri_Apr2013.pdf

30 http://www.rappler.com/move-ph/issues/disasters/111307-climate-change-disaster-management-policies-philippines

31 http://www.unescap.org/sites/default/files/Session%202%20-%201.%20IMHEN%201.pdf

32 http://enews.epa.gov.tw/enews/enews_ftp/104/1117/174044/Submission%20by%20Republic%20of%20China%20(Taiwan)Intended%20Nationally%20Determined%20Contribution.pdf

Energy Transition



Soaring energy demand and mounting interest in sustainability across SEA region is driving policy makers to review their energy mix.

Clean energy and climate has become one of the key agendas for SEA countries, resulting in a rising focus on transition to low carbon energy sources.

With increasing commercial viability of renewable energy and energy efficient technology, more investment is expected in developing renewable energy in the SEA region.[33]

Governments are continuing to make new policies or enhance existing ones, which are acting as catalysts for investment in the region's renewable energy space.[34]

Average primary energy consumption CAGR for the period 2010-2016 was 4.1%, which exceeded the electricity generation growth (3.8%) for the same period in SEA region.[35]

SEA remains reliant on fossil fuels to meet growing energy demand.

- The fast growing SEA nations[36] collectively outpaced world GDP growth[37] (3.1%) in 2016 with an average GDP growth of 3.75%
- This growth is largely fueled by fossil fuels, which comprise more than 90% of average primary energy consumption[38]

Top 30 countries in the world with the highest coal power pipeline expansion plans include Malaysia, Philippines, Vietnam and Taiwan from SEA region[39]

- To reconcile the energy needed for economic growth with environmental sustainability, SEA nations need to meet growing energy demand while reducing CO_2 emissions
- The continued predominance of fossil fuels in the region's electricity mix calls for generation portfolios with lower carbon intensities

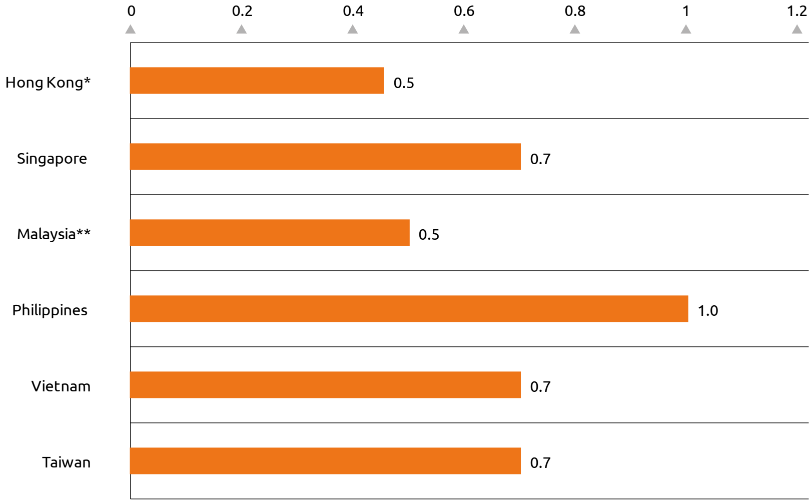
33 http://world.350.org/philippines/southeast-asian-movements-demand-for-coal-free-asean/
34 http://www.brinknews.com/asia/the-southeast-asian-clean-energy-opportunity-navigating-the-risks/
35 http://www.bp.com/statisticalreview
36 Average GDP growth of Hong Kong, Singapore, Malaysia ,Philippines ,Vietnam, Taiwan in 2016
37 http://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD
38 http://www.bp.com/statisticalreview
39 http://endcoal.org/wp-content/uploads/2017/03/BoomBust2017-English-Final.pdf

- **Singapore's** burgeoning clean energy industry is poised for growth, with the government helping locally based clean energy companies pursue regional opportunities
  - In addition, the Government will continue building capabilities in research and development, new renewable energy and energy management technology, and financing for the sector[41]

- **Malaysian** Investment Development Authority (MIDA) approved a total of 111 renewable energy projects in 2016, that include solar power projects, biogas projects, hydro and biomass projects
- **Philippines** remains an active renewable energy market, with a 5GW pipeline of wind, solar geothermal, biomass and small hydro projects under development
  - However, in 2016 solar made up almost all of the US$1 billion capacity investment, as developers rushed to take advantage of a feed-in tariff before it ran out of quota

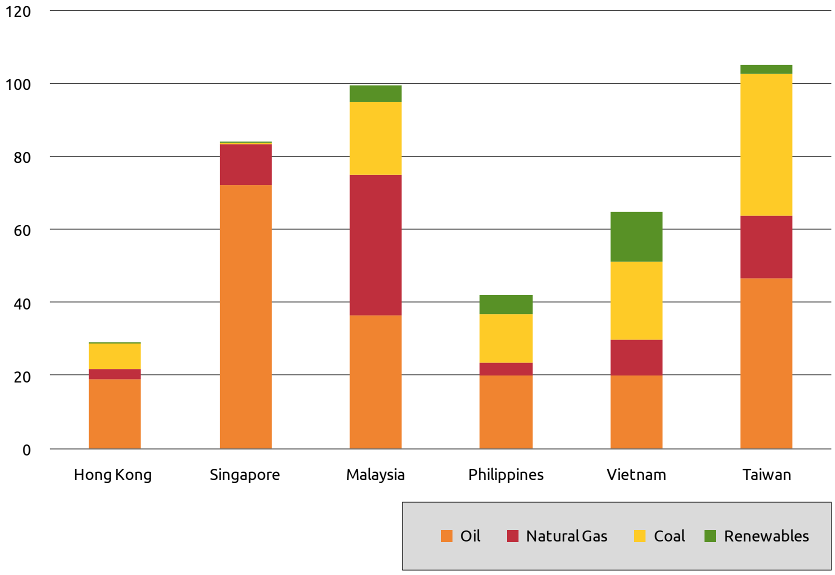
Despite rising shares of renewable electricity, including considerable shares of hydropower in some economies, coal, natural gas and oil account for most of the region's electricity generation.

Figure 2.1 : Renewable energy investment in SEA (US$ billion), 2016[40]



Note:
*Hong Kong has designed US$12 million power companies' Eco Building Fund for energy saving between 2014-18. Spend also includes possible investment from IPO for China Everbright Greentech, one of biggest alternative energy IPO in Hong Kong in 2017.
**Investment for Malaysia indicates total renewable energy and energy efficiency projects approved by Malaysian investment development authority (MIDA) in 2016.

Figure 2.2: Primary Energy: Consumption by fuel in 2016[42]



Note: Renewables includes hydro, wind, geothermal, solar, biomass and waste; Primary Energy consumption does not include energy generated through Nuclear Energy

40 http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf (Bloomberg New Energy Finance)
41 http://www.straitstimes.com/business/companies-markets/bright-future-for-solar-energy-sector
42 http://www.bp.com/statisticalreview

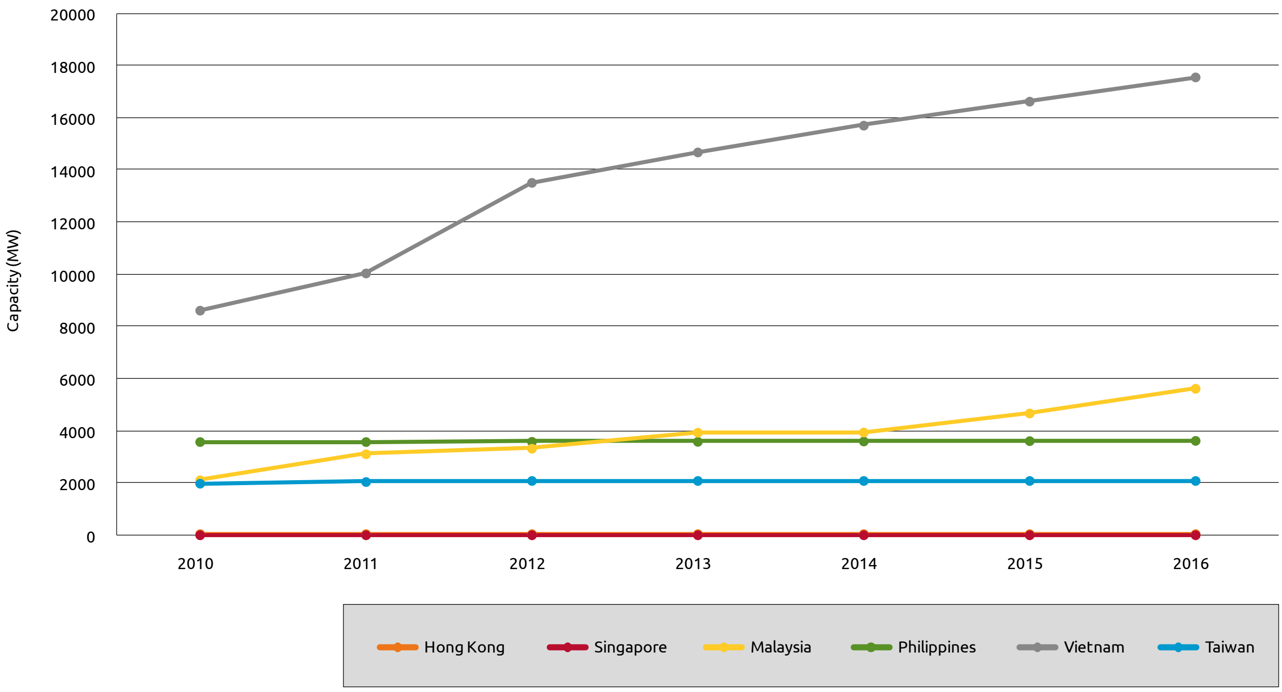
Hong Kong and Singapore are almost completely dependent on fossil fuels for energy, with less than 1% contribution by renewables.

- In 2016, consumption of renewables in **Malaysia (4.6%) , Philippines (12.3%) , Vietnam (21.2%) and Taiwan** (2.4%) increased marginally over the previous year
- However, hydroelectricity consumption in **Vietnam** grew significantly by 6% at 13.7 Mtoe, year-on-year in 2016

Evolution of Renewable Energy in SEA

Modest growth observed in Hong Kong for hydro power based projects. Hydroelectricity is expected to play a significant role in power generation in Malaysia.

Figure 2.3: Hydroelectricity capacity evolution (MW), 2010-2016[43]



- **Hong Kong does not have rivers with sufficient flow for large-scale hydroelectric generation**[44]
  - However, with projects such as hydropower plant at Tuen Mun Water Treatment, developed in-house, Water Supplies Department (WSD) was able to design an innovative method to harvest the residual energy from the water pressure to generate electricity
  - The plant generates 3 million kWh of electricity annually for use by the treatment plant Works (WTW), after its completion in March 2017[45]

43 http://tsp-data-portal.org/Breakdown-of-Energy-Consumption-Statistics#tspQvChart

44 http://re.emsd.gov.hk/english/other/hydroelectric/hyd_tech.html#

45 https://www.climateready.gov.hk/files/report/en/4.pdf

– A new hydroelectricity plant was announced in 2016 and more hydroelectricity options are being explored as part of country's total water management strategy[46]

- In **Singapore**, hydroelectric power cannot be harnessed, as it does not have a river system with fast flowing water throughout the year[47]
- **Hydropower is poised to play crucial role in meeting Malaysia's energy and climate goals with a total installed hydropower capacity of 6,094 MW (2016)[48]**
  – The share of hydropower in the country's electricity generation is around 11%, with less than 20% of the technically feasible generation potential utilized to date

– There is significant expansion already in the planning stages or under development

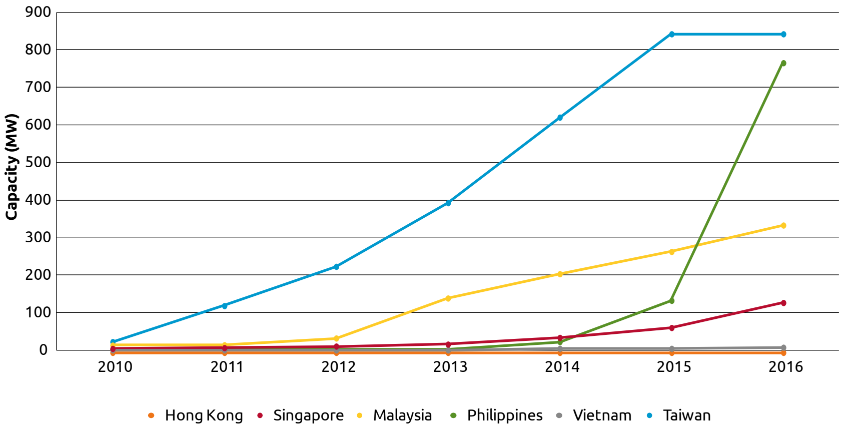
- **Philippines**' total installed capacity for 2016 was 21 GW, of which hydro power comprises of over 3 GW or 16.9% of total capacity[49]

- In October 2016, the total installed capacity of **hydropower** plants in Vietnam was 17 GW, around 44% of the total installed capacity of 39 GW
- The **Vietnamese** government aims to increase the share of capacity from coal-fired thermal plants (32.8% in October 2016) to 42.7% in 2020 and 49.3% in 2025[51]
  – The main reason behind this emphasis on coal-fired plants is that utilization of the river system in Vietnam for hydropower is already close to its maximum level

In February 2017, it was reported that The Philippines National Irrigation Administration (NIA), is working with the Philippine National Oil Company Renewables Corp. to create a new unit to study the potential of developing small hydropower projects in over 300 irrigation facilities across the country[50]

Strong growth seen in Solar PV systems installations in last two years in Singapore, Malaysia and Philippines

Figure 2.4: Solar power capacity evolution (MW), 2010-2016[52]

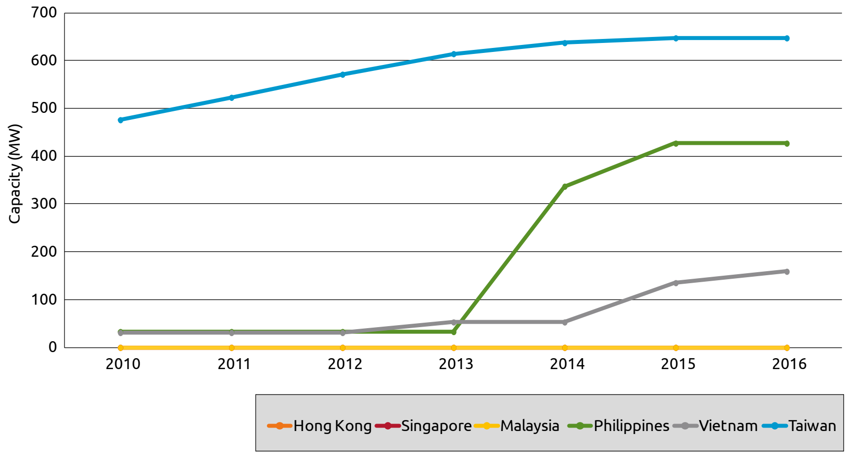


46 https://www.thesourcemagazine.org/hong-kong-pursues-renewable-water-sources/
47 https://www.nccs.gov.sg/climate-change-and-singapore/national-circumstances/singapores-approach-alternative-energy
48 https://www.hydropower.org/country-profiles/malaysia
49 https://www.doe.gov.ph/electric-power/2016-philippine-power-situation-report
50 http://www.hydroworld.com/articles/2017/02/philippines-creating-unit-to-study-small-hydropower-development-at-irrigation-sites.html
51 https://vcbs.com.vn/vn/Communication/GetReport?reportId=4793
52 http://tsp-data-portal.org/Breakdown-of-Energy-Consumption-Statistics#tspQvChart

- Solar energy accounts for a minuscule proportion of the electricity supply in **Hong Kong**
  - The government is committed to installing solar photovoltaic arrays on public buildings, however, these will continue to make only a minor contribution to the country's power needs[53]
- **In Singapore**, the installed capacity of grid-connected solar PV systems increased from 59.7 MW in 2015 to 129.8 MW by the end of 1Q 2017[54]
  - The total capacity was divided as non-residential private sector installations (59.6 MW), town councils & grassroots units (58.1 MW), residential installations (6.1 MW) and installations by public service agencies (6 MW)
- **Malaysia** installed 31.78 MW of solar PV in 2016, bringing its cumulative installed solar capacity to 294.85 MW[55]
  - In March 2017, the Energy Commission of Malaysia (EC) issued a Request for Proposal document to auction up to 460 MW of large-scale solar capacity in second competitive bidding program
- According to data released by the Department of Energy, **Philippines** installed 903 MW of solar power plants in 2016[56]
  - The country approved 755 renewable projects with a potential capacity of 16,948.98 MW of which projects totaling 4,521.74 MW were installed in 2016
- Solar PV is taking off in **Vietnam** with many international and domestic investors showing intention to develop projects in the central and south of the country
  - There are more than 30 projects with capacities ranging from 20-300MW being developed at different stages[57]
- The **Taiwan** government is targeting 1.52 GW of PV capacity additions through the middle of 2018, with cumulative installations to hit 20 GW by 2025[58]; Taiwan's total installed solar capacity is 1 GW in 2017(January)[59]
  - The unprecedented build-out will be based on the government's determination to expand PV capacity as the country reduces its reliance on nuclear generation

Wind power projects are burgeoning in Philippines. However, limited potential was assessed for wind energy in Malaysia.

Figure 2.5: Wind power capacity evolution (MW), 2010-2016[60]



53 http://asian-power.com/power-utility/news/hong-kongs-natural-gas-fired-power-generation-set-double-over-next-10-years
54 http://asian-power.com/project/news/singapores-installed-solar-capacity-reaches-1298mw
55 https://www.pv-tech.org/news/malaysia-installed-32mw-solar-under-fits-in-2016
56 http://solenergy.com.ph/philippines-installs-over-900-mw-of-pv-solar-power-capacity-in-2016/
57 https://www.pv-tech.org/news/vietnam-has-30-large-scale-solar-projects-under-development-but-fit-needed
58 https://www.bloomberg.com/news/articles/2016-09-08/taiwan-plans-solar-power-boost-in-push-to-become-free-of-nuclear
59 https://static1.squarespace.com/static/56bdd721d210b88e65b154ee/t/586f9ba5ebbd1acfb0af22b9/1483709367629/2017-001_GlobalSolarCouncil-Spreads-WebVer.pdf
60 http://tsp-data-portal.org/Breakdown-of-Energy-Consumption-Statistics#tspQvChart

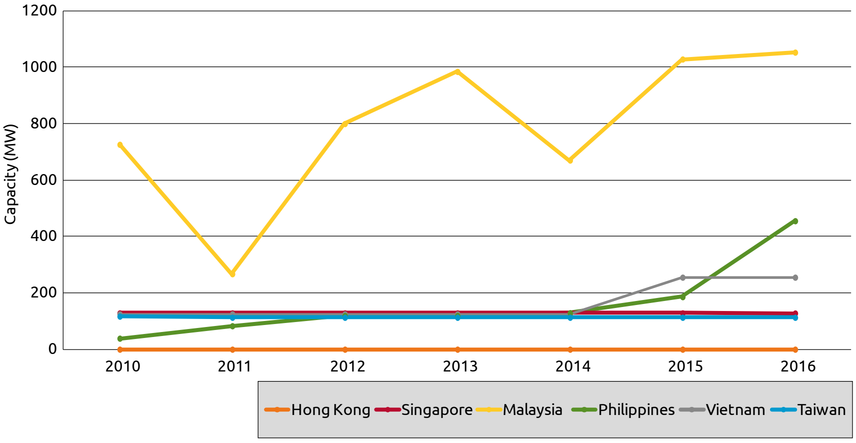
- **Hong Kong** has a number of small wind projects, which together produce less than 1MW, the largest of which is an 800 kW wind turbine on Lamma Island operated by HK Electric Company[61]
- Commercial wind turbines operate at wind speeds of around above 4.5m/s but the average wind speed in **Singapore** is only about 2m/s[62]; hence wind potential is currently in assessment stage
- The Meteorological Department has been recording wind data in **Malaysia** and concluded that that some locations have good potential for wind power generation
  - 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[63]
- Wind power is slowly taking off in the **Philippines**; with wind energy comprising only a fraction (1.99%) of the country's installed capacity of 21,423 MW in 2016[64]
- **Vietnam** currently has four wind farms with a combined capacity of just 160 MW, implying that there is much more potential for wind power in the country's energy mix
  - According to World Bank, 8.6% of Vietnam's mainland area has great potential, favorable for the installation of large-scale turbines[65]
- Government incentives and technical support programs are expediting the development of offshore wind farms in **Taiwan**
  - In 2017,Taiwan's first offshore wind farm off the coast of Miaoli County has generated 6.5MW , since the launch of commercial operations in April 2017, with capacity expected to grow to 120 MW by 2019[66]

In May 2017, **GE Renewable Energy, Mainstream Renewable Power and local Vietnamese partner the Phu Cuong Group** have formalized an agreement to develop, build and operate the 800 MW Phu Cuong Wind Farm in the Soc Trang province of Vietnam. The US$2 billion Joint Development Agreement was one of five agreements announced to support the development of Vietnam's energy and aviation sectors during the visit of Vietnamese Prime Minister Nguyen Xuan Phuc to the United States[67]

61 https://www.climateready.gov.hk/files/report/en/4.pdf
62 https://www.nccs.gov.sg/climate-change-and-singapore/national-circumstances/singapores-approach-alternative-energy
63 https://www.nst.com.my/news/government-public-policy/2017/06/252994/kudat-set-become-sabahs-renewable-energy-dynamo
64 https://www.doe.gov.ph/electric-power/2016-philippine-power-situation-report
65 http://english.vietnamnet.vn/fms/science-it/172864/vietnam-wants-to-develop-high-tech-wind-power-plants.html
66 http://focustaiwan.tw/news/aeco/201708060010.aspx
67 https://www.renewableenergymagazine.com/wind/ge-to-develop-800-mw-wind-project-20170605

Huge investments are expected in Biomass sector in Malaysia between 2017 and 2018

Figure 2.6: Bioenergy evolution (MW), 2010-2016[68]



Source: http://tsp-data-portal.org/Breakdown-of-Energy-Consumption-Statistics#tspQvChart

- **Hong Kong's** first waste-to-energy plant (T·PARK) was fully commissioned in April 2016[69]
  - It reduces the volume of dewatered sewage sludge by 90% and the heat generated by the incineration process is used to provide electricity to meet on-site operational needs
  - The surplus electricity is exported to the power grid for meeting the needs of up to 4,000 homes at maximum design throughput

Foreign investors have also started to notice the Philippines' potential for biomass power. Scottish firm **MacKay Green Energy Inc. (MGE)** is investing US$100 million in a biomass power plant and plantation for feedstock in Mindanao

- In 2015, The National Environment Agency (NEA) signed an agreement on Monday (Oct 26) with a consortium(Hyflux and Mitsubishi Heavy Industries) to develop **Singapore's** sixth waste-to-energy plant[70]
  - Slated to be Singapore's largest, the plant will have the capacity to incinerate 3,600 tonnes of waste and generate 120 MW of electricity per day
- **Malaysia** is expected to attract US$0.73 billion investments in biomass projects between 2017 and 2018[71]
  - In H1 2016, MIDA approved 12 biomass projects worth US$ 35 million
  - In 2015, MIDA approved 40 biomass projects worth US$169 million, more than triple the investment value for 40 projects recorded in the previous year
- The **Philippines** is pushing ahead with its biomass production and has a total of 18 biomass plants (as on April 2016)
- **Vietnam Energy Association** (VEA) recently reported that Vietnam has huge potential to generate energy from biomass and waste; this could amount to up to 1 billion kWh in 2020 and 6 billion kWh in 2050 from waste[72]

68 http://tsp-data-portal.org/Breakdown-of-Energy-Consumption-Statistics#tspQvChart
69 http://www.enb.gov.hk/sites/default/files/pdf/ClimateActionPlanEng.pdf
70 http://www.channelnewsasia.com/news/singapore/nea-inks-deal-for-largest-waste-to-energy-plant-in-singapore-8228788
71 https://themalaysianreserve.com/2017/04/03/biomass-sector-expects-huge-investments/
72 https://www.renewableenergymagazine.com/panorama/vietnam-has-huge-potential-from-biomass-and-20170320

Regulation Evolution of Renewable Energy in SEA region

In recent years, decision makers in most SEA countries have, through policy implementation, fostered deployment of renewable energy technologies in a more concerted manner. Countries in the region have put considerable effort into setting renewable energy targets and are introducing supportive policy frameworks to attract private sector investment. Nearly all SEA countries have adopted medium- and long-term targets for renewable energy.

Figure 2.7: Regulation evolution for renewables development (2006-2016)[73]

	2006	2007	2008	2009	2010
Hong Kong	• Wind Measurement Programme to gather wind data	• A revised ".Technical Guidelines on Grid Connection of Renewable Energy Power Systems (2007 Edition) available to public		• Set target for government buildings – to reduce 5% energy consumption within 5 years using 2007-08 as the base year	
Singapore		• Clean Energy Research Programme (CERP) • Energy Innovation programme office (EIPO) Singapore • Solar Pilot/Test-bedding programmes	• Solar Energy Reasearch Institute of Singapore (SERIS)		
Malaysia			• Malaysian Biofuel Industry Act 2007		• Renewable Energy Policy and Action Plan • Green Technology Financing Scheme (GTFS)
Philippines		• Biofuels Act	• Renewable Energy Act	• Accreditation guidelines for renewable energy equipment suppliers • Guidelines for issuing renewable energy service & operating contracts • Rules and Regulations for Implementing the Renewable Energy Act	• Feed-in Tariff Rules • Steering Committee on Establishment of a Renewable Energy Market
Vietnam	• National Power Development Plan 2011-2030 (RES targets and wind feed-in tariff)				
Taiwan			• "Framework of Sustainable Energy Policy"	• "Renewable Energy Development Act" Amendment of "Energy Management Law"	• Approval of the "National Master Plan on Energy Conservation and Emission Reduction" • Establishment of the "Committee on Energy Conservation and Emission Reduction"

73 Capgemini Analysis, WEMO 2017

	2011	2012	2013	2014	2015	2016
Hong Kong	• Adopted APEC's Energy Intensity Target – to reduce energy intensity by 45% by 2035 (base 2005)	• Adopted recommendations from the SDC – including to save energy and reduce carbon emissions from buildings, as well as to create a voluntary charter scheme		• New Air Quality Objectives (AQOs) for adoption in 2014 (proposed) • The Government issued Guidelines on Design and Construction Requirements for Energy Effi ciency of Residential Buildings (PNAP APP-156)	• Adopted new target for government buildings to reduce 5% electricity consumption between 2015-20 using 2013-14 as base. • Environment Bureau in collaboration with Development Bureau and Transport & Housing Bureau published the first of-its-kind Energy Saving Plan for Hong Kong's Built Environment 2015~2025+	
Singapore	• Energy National innovation Challenge (NIC) Singapore • Experimental Power Grid Center • Floating PV Pilot	• Energy Innovation Research Programme (EIRP)				
Malaysia	• Renewable Energy Act establishing feed-in tariff (FIT) system					
Philippines	• Mandatory use of biofuel blend • Utilization of Locally Produced Bioethanol in the Production of E-Gasoline Consistent With the Biofuels Act Of 2006 • Ensuring the adequacy and readiness of the National Transmission System to accommodate new generating capacities from Renewable Energy (RE) Technologies • Resolution for Electricity Generation Rates and Subsidies for Off-Grid Areas	• Feed-In Tariff for Electricity Generated from Biomass, Ocean, Run-of-River Hydropower, Solar and Wind Energy Resources	• Rules Enabling Net Metering Program for Renewable Energy	• Accelerating Household Electrification through Regulated Solar Home Systems • Implementation of the Household Electrification Programme		
Vietnam			• Accelerated depreciation tas relief for renewable energy projects	• Decision on support mechanisms for the development of waste-to-energy power projects in Vietnam (feed-in tariff) • Decision on support mechanisms for the development of biomass power project in Vietnam (biomass feed-in tariff)		• Vietnam Renewable Energy Development Strategy 2016-2030 with outlook until 2050 (REDS) National Power Development Plan 7 (PDPD7 – revised)
Taiwan	• New Energy Policy announced: to "Steadily Reduce Nuclear Dependency, Gradually Move Towards a Nuclear-free Homeland, and Create a Low-carbon Green Energy Environment"					

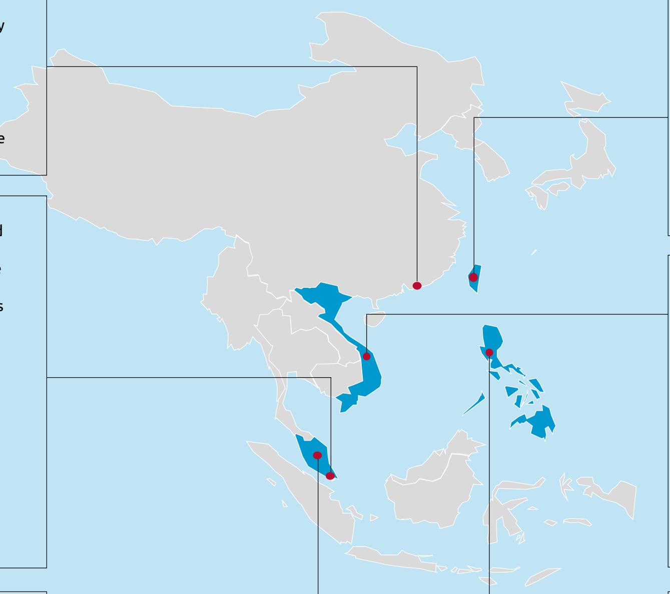
Topic Box 2: Impact of policy change on renewable energy infrastructure development

Figure 2.8: Impact of policy change on renewable energy infrastructure development[74]

Hong Kong
- In 2017, US consultancy Black & Veatch to carry out a feasibility study on floating solar panels on 17 water reservoirs
- In 2016,Hong Kong largest solar farm (1,100 KW) opens at the Siu Ho Wan Sewage Treatment Works of the Drainage Services Department

Singapore
- First large-scale, offshore power grid system, Renewable Energy Integration Demonstrator-Singapore or Reids, to combine renewable power from the sun, wind and sea, as well as diesel, storage and power-to-gas technologies
- World's largest floating solar PV testbed launched in Singapore in 2016
- Housing & Development Board (HDB) launched Singapore's largest ever public-led solar leasing tender, which will see 40 MW installed by 2017 under a nationwide initiative called the SolarNova program

Malaysia
- Total of 111 projects in renewable energy with total investments of US$ 0.5 billion approved
- 19 projects in energy efficiency with total investments of US$ 58.2 million were approved
  - The Energy Commission is conducting a second competitive bidding process for companies to build large scale solar (LSS) photovoltaic (PV) plants in Peninsular Malaysia and Sabah/ Labuan.



Taiwan
- Ministry of Economic Affairs (MOEA) to invest US$22.7billion as part of the nation's eight year plan to boost wind generated electricity to 4,200 megawatts (MW) by 2025
- US$33 billion to be invested by 2024 to increase electricity generated from solar panels to 20 GW
- Assessing pumped storage as part of eco-policy

Vietnam
- Hydro projects under construction: 193 projects (5.66 GW) are under construction and 245 (3 GW) are going through investment phases
- Solar projects under construction include: Thanh Hoa (160MW), by BS Heidelberg Solar, Hau Giang (40MW) by JinkoSolar
- Wind Power (2017 approved): Phu Cuong (800MW), Dam Nai (40MW)
  - Wind (34MW) –Solar (64MW) combined project: Fujiwara Binh Dinh project

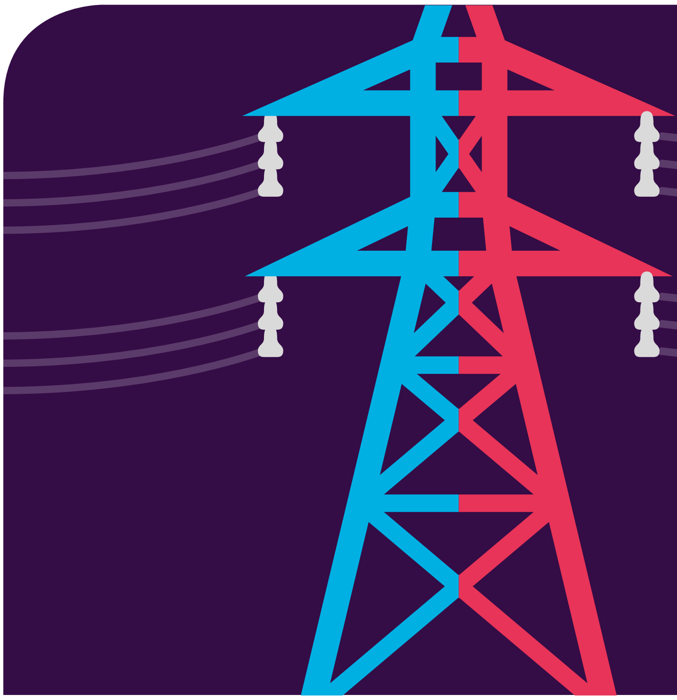
Philippines
- Solar Philippines begun work on the 150 megawatts (MW) solar photovoltaic (PV) project in Concepcion, Tarlac –largest to date
- Ongoing Hydro projects include the 8.5-MW Maris Main (South) Canal Hydroelectric Power in Isabela
  - Marbel #1 Mini Hydropower Project in South Cotabato and Butao Irrigation Drop Mini Hydropower Project in Pangasinan were approved
- Foreign investments in Biomass (locations : Negros Occidental, Mindanao)

New technology testing (Floating solar PV): Development of large scale floating solar farms could help **Hong Kong** reduce water loss, suppress algae growth and generate power from renewable resources. The introduction of the floating test bed is in line with **Singapore's** SolarNova Programme, launched in 2014 to raise solar generation capacity to 350 megawatt peak by 2020.

Public tenders & auctions: **Singapore** has launched the country's largest solar project to date, which will involve the installation of solar panels at eight government sites and 900 public-housing blocks across the island by 2017. The **Energy Commission of Malaysia** announced the second competitive bidding process to select developers/developer consortia to participate in the bidding process for the development of the large scale solar photovoltaic plants. The capacity of plants to be tendered will be from 1 to 30MW, which is expected to be commissioned in 2019-2020.

Investment in new capacities: Renewable projects approved in **Malaysia**, include hydro, solar and biomass projects. The International Finance Corp. (IFC), with support from the Government of Canada and Clean Technology Fund, announced in August 2016, a US$161 million investment in three Biomass power plants in Negros Occidental in **Philippines**. Around 193 Hydro projects are under construction in **Vietnam** while **Taiwan** government is planning to invest US$33 billion in solar panel by 2024.

74 Capgemini Analysis, WEMO 2017



Infrastructures and Adequacy of Supply

Energy infrastructure is one of the main factors for energy development in SEA, primarily because of its direct impact to the energy connectivity and energy market integration.

At present, both the availability and the affordability of fuel supply are being prioritized over environmental sustainability; hence fossil fuels, particularly coal- and gas-fired turbines, dominate the fuel mix. Efforts to use energy resources effectively are hampered by the uneven distribution of these resources and different levels/rates of investment and economic development among SEA countries.

Historically, the pattern of development of electricity systems across SEA has had a distinctly national focus.

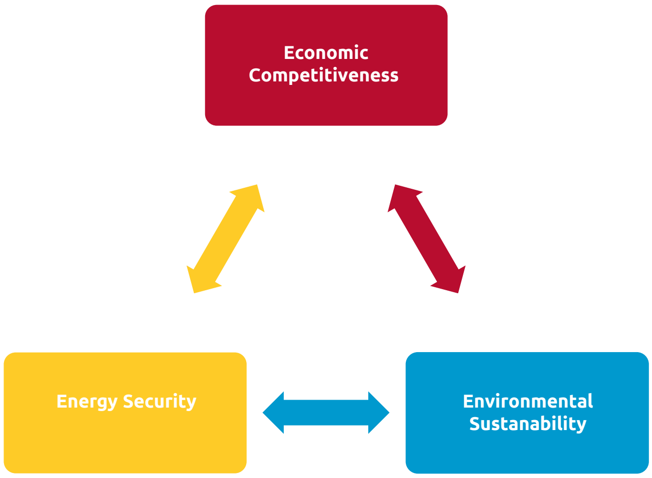
Recently, the perspective has shifted towards integrating the power grids supplied by a variety of resources including coal, natural gas, hydropower and other renewables to meet various demand profiles.

With economic growth driving the need for more electrification, the demand for power in the region will grow significantly and require substantial investment in generation and transmission assets.

Investment in power grid interconnections can be a game changer for SEA.

Enhanced grid interconnections could stimulate economic development by providing more efficient, reliable and resilient electricity service across the region.

Figure 3.1: Implications of regional interconnection[75]

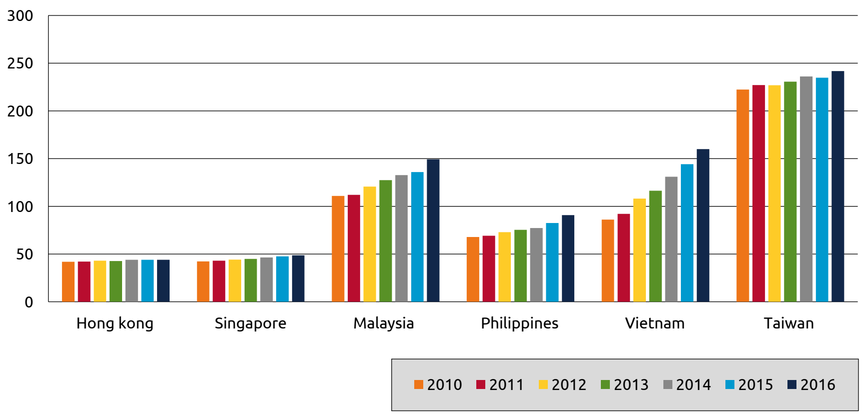


Displacing the use of hydrocarbons to meet demand with hydropower – domestic or imported – could reduce costs and would cut local air pollution and GHG emissions. While investing in and operating cross-border transmission networks are costly, savings from lower demand for fossil fuels and avoided investment in new power capacity can render the investment in network integration economically viable.

Overview of electricity consumption and trend

An increasing trend in electricity consumption from 2010-2016, with highest year-on-year growth in Vietnam (estimated at 11%)

Figure 3.2: Electricity consumption in SEA (TWh), 2010-2016[76]



75 https://www.ceer.eu/documents/104400/-/-/4738276b-5fe6-88f3-48f7-47eab474ed8c

76 https://yearbook.enerdata.net/electricity-domestic-consumption-data-by-region.html

Hong Kong[77]

The total local consumption of electricity in 2016 was 44 TWh, a marginal increase of 0.3% over 2015.

- As in past years, the largest user category was the commercial users, taking up 65.7% of the total local consumption in 2016
- The domestic users consumed 27.2% of the total and their consumption in 2016 increased by 1.8% compared with 2015
- The industrial users consumed 7.1% of the total and their consumption in 2016 decreased by 1.6% compared with 2015

Singapore[78]

Singapore's total electricity consumption rose by 2.3% from 47.5 TWh in 2015 to 48.6 TWh in 2016.

- Contestable Consumers (CCs) made up the bulk of consumption, accounting for 73.8% of the total consumption in 2016
- The majority of CCs' consumption was for Industrial-related activities (54.7%) followed by the Commerce & Services-related sector (38.1%)

Malaysia

Malaysia's total electricity consumption rose by 9.85% from 135.8 TWh in 2015 to 149.2 TWh in 2016.

- Peninsular Malaysia is the major market for electricity accounting for over 80% of consumption in Malaysia other two districts being Sabah and Sarawak

Philippines[79]

Electricity consumption grew significantly (year-on-year growth of 10.2% in 2016) due to the strong El Niño which affected the entire country during H1 2016

- This increase is primarily driven by the growth of residential consumption at 12.7% due to high requirements for cooling system.
- On a per grid basis, Mindanao's electricity consumption grew the highest at 12% boosted by the own-use consumption of newly operational and large coal-fired power plants
- The residential sector, together with the industrial sector, comprised more than half of the total Philippine electricity consumption

Figure 3.3: Total installed capacity for electricity generation[80]

Country	Major Players in Electricity Generation	Total Installed Capacity for Electricity Generation (2016) in MW
Hong Kong	CLP Power Hong Kong Limited , The HK Electric Company Limited	12,625
Singapore	Tuas Power Generation, Senoko Energy, YTL PowerSeraya, SembCorp Cogen, Keppel Merlimau Cogen, PacificLight Power, Tuaspring etc.	13,348
Malaysia	Tenaga Nasional Berhad (TNB), Independent power producers (IPP)	22,919
Philippines	San Miguel Corp. (SMC) ,The Aboitiz Group, Lopez Group, Global Power Corp	21,423
Vietnam	Power plants under state owned Electricity of Vietnam (EVN), Independent power producers (IPP)	38,553
Taiwan	Taiwan Power Company, IPPs and cogeneration generators	49,906

77 https://www.censtatd.gov.hk/hkstat/sub/sp90.jsp?productCode=B1100002
78 https://www.ema.gov.sg/cmsmedia/Publications_and_Statistics/Publications/SES17/Publication_Singapore_Energy_Statistics_2017.pdf
79 https://www.doe.gov.ph/electric-power/2016-philippine-power-situation-report
80 Capgemini Analysis, WEMO 2017

Overview of electricity markets and trades

Enhanced cross border integrations can facilitate efficient use of the region's resources and enhance energy security

Figure 3.4: Impact of electricity flows on the countries' economies[81]

Hong Kong

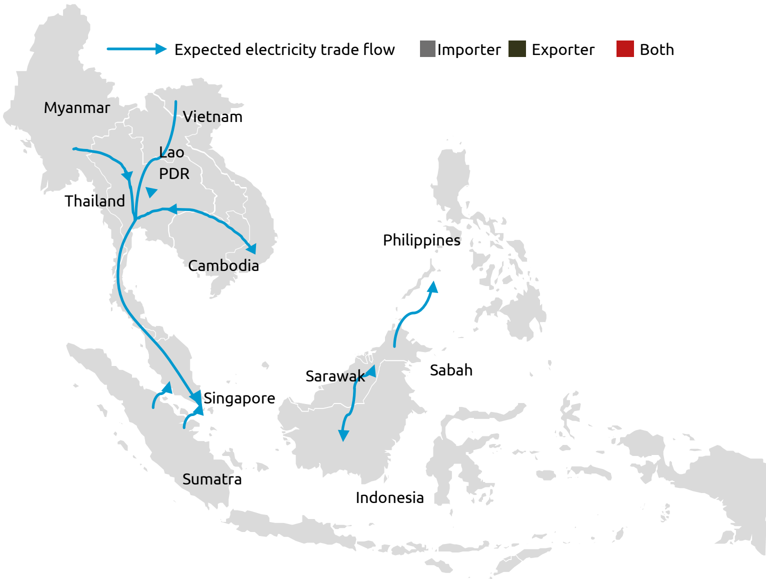
Increased interconnection could allow Hong Kong to access potential sources of clean energy and create a more balanced generation portfolio in the longer term

Singapore

Electricity imports could enhance diversification of power supply from its existing reliance on natural gas, hence reduce electricity costs as well.

Malaysia

Country can increase its hydropower generation in Sarawak owing to electricity trade.



Philippines

Electricity imports expected to enhance country's energy security as it is dependent on imports of fuel for power generation

Vietnam

With electricity imports the need to build new gas-fired and coal-fired power plants expected to lower down, thereby reducing LNG and coal imports.

Taiwan

Massive outages have been experienced in Taiwan (most recent in August 2017).Interconnectedness can improve energy security for Taiwan

In Hong Kong, imports of electricity from the mainland of China in 2016 increased by 8.3% when compared with 2011.[82]

- A public consultation in 2015 on the city's future fuel mix floated the option of importing from the grid to help achieve "greater fuel diversification" and tap into clean sources such as hydro that are otherwise unavailable to the city
- The consultation results showed most residents and businesses opposed buying more electricity from Guangdong province's China Southern Power Grid, citing reliability concerns
- However, the Government has included specific agreements to conduct joint studies looking into bolstering cross-border grid interconnection with the two power firms **(CLP Power and HK Electric)** in the post-2018 regulatory framework, known as the Scheme of Control Agreements[83]

81 https://www.ifri.org/sites/default/files/atoms/files/cornot-gandolphe_energie_asean_2017.pdf

82 https://www.censtatd.gov.hk/hkstat/sub/sp90.jsp?productCode=B1100002

83 http://www.scmp.com/news/hong-kong/health-environment/article/2094446/senior-hong-kong-official-urges-sourcing

For Singapore, the motivation for regional interconnection is a combination of benefits and drawbacks.[84]

- Importing hydropower into the domestic market which is entirely natural gas-based will further reduce the wholesale price. This benefits larger consumer categories (industry), but negatively impacts the domestic power generation companies
- Hydropower imports, on the other side , create benefits by reducing Singapore's dependence on natural gas imports
- **Electricity imports can also bring about economic benefits for Singapore**
  - Overseas power producers could have access to lower-cost fuels, labor and land, which allow them to offer cost-competitive prices even after factoring in the cost of transmission to Singapore, and exert downward pressure on electricity prices in Singapore[85]

Malaysia was a net electricity exporter in the 2000s, but now imports power to meet growing demand as well as providing back-up capacity in the case of potential power emergencies[86]

- Malaysia's electricity demand, met mostly by natural gas and, to a lesser extent, coal, continues to expand rapidly
- The high-demand centers, particularly in Peninsular Malaysia, are facing shortages of natural gas and a need for greater generation capacity
- Sarawak and Sabah in Borneo require more energy to meet the demands of their growing infrastructure and industrial sectors[87]
- Malaysia is seeking to diversify its portfolio of power generation fuels and to reduce the use of more expensive fuels

National Grid Corporation of the Philippines (NGCP) plans of interconnecting major islands and reinforcing transmission grid both internally and across the borders[88]

- NGCP recognized a need to have a strong and reliable power transmission network within country before Philippines can interconnect with other nations
- However, the Chairman, ASEAN Power Grid Consultative Committee(APGCC) divulged a **possible route for Philippines' interconnection, which is through Sabah, Malaysia, in 2015 Philippines Electricity Summit**

Vietnam is importing electricity that accounts for 3.1% of its demand from China and Laos[89]

- Vietnam's electricity generation and imports are 184 billion kWh (estimated) in 2016, well above 164 billion kWh in 2015
- Power generation in northern Vietnam makes up more than 60% of the nation's total while the south runs short of electricity
- Almost all hydropower plants in the country are small, so coal-fired power stations are growing robustly
- Vietnam Electricity Group (EVN) will prioritize renewable and nuclear power in future and will continue buying electricity from China and Laos (a major exporter of hydroelectricity)

84 http://www.kas.de/wf/doc/21842-1442-1-30.pdf

85 https://www.ceer.eu/documents/104400/-/-/4738276b-5fe6-88f3-48f7-47eab474ed8

86 https://www.iea.org/publications/freepublications/publication/WEO2015_SouthEastAsia.pdf

87 https://vcantugakkas.wordpress.com/2017/06/16/malaysia-energy-profile-strategically-located-for-seaborne-energy-trade-analysis/

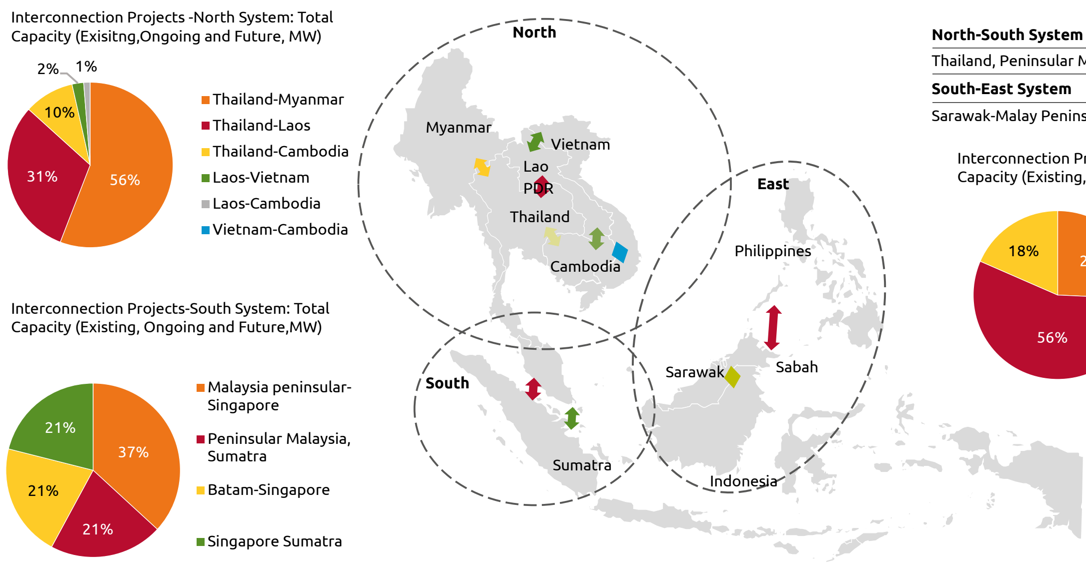
88 http://www.electricenergyonline.com/detail_news.php?ID=567313

89 http://english.vov.vn/trade/vietnam-continues-buying-electricity-from-china-laos-333007.vov

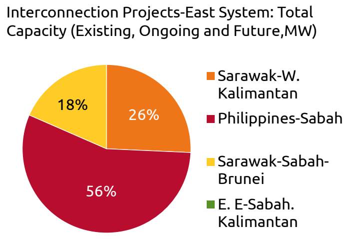
Taiwan currently lacks international energy cooperation policy

- Taiwan needs to boost its expertise in energy policymaking
- Taiwan's current lack of involvement in international energy cooperation present a significant barrier preventing it from learning and implementing latest innovations in energy technology and policy
- Taiwan has very few international energy cooperation connections, such as the Asia Pacific Economic Cooperation (APEC) forum and the World Trade Organization (WTO)[90]

Figure 3.5: Electricity interconnection (existing, ongoing and future) projects[91]



	Total Capacity (MW)
North-South System	**780.0**
Thailand, Peninsular Malayasia	780.0
South-East System	**1600.0**
Sarawak-Malay Peninsular	1600.0



The Interconnection in SEA is broadly planned into three areas: eastern area, southern area and northern area.

- **Sumatra, Singapore, Batam and Peninsular Malaysia** are included in the Southern area.
- While **Kalimantan, Sarawak, Brunei, Sabah, and the Philippines** are included in the eastern area.
- Northern area consists of countries located in mainland Asia such as **Vietnam, Cambodia, Laos, Thailand, and Myanmar.**

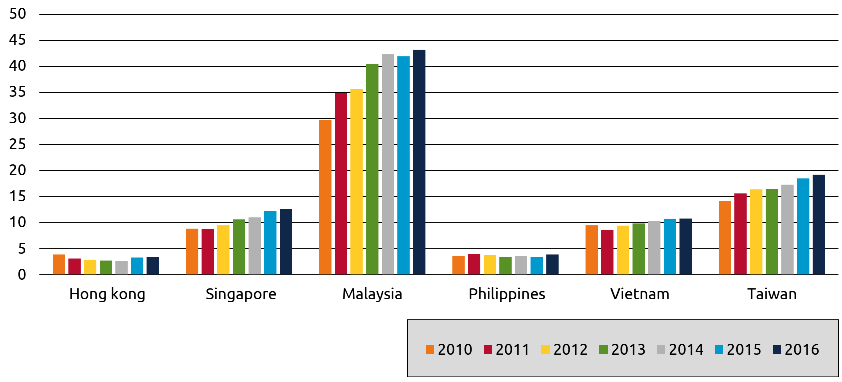
90 https://www.brookings.edu/opinions/taiwans-severe-energy-security-challenges/
91 https://www.ifri.org/sites/default/files/atoms/files/cornot-gandolphe_energie_asean_2017.pdf

Southeast Asia

Overview of gas consumption and trends

Average consumption of Gas increased by 4.6% in 2016 over 2015, with highest growth witnessed in Philippines at 14.6%.

Figure 3.6: Gas consumption in SEA (Bcm), 2010-2016[92]



Source: BP Statistical Review, 2017

In **Hong Kong,** town gas and liquefied petroleum gas (LPG) are the main types of fuel gas used for domestic, commercial and industrial purposes[93]

- LPG is also used as a fuel by nearly all taxis and over 65% of public light buses while natural gas is used for electricity generation and production of town gas

Natural gas being a relatively cleaner source of fuel as compared to coal has been choice of fuel for countries like **Singapore** who lack potential for renewable energy generation[94]

- Natural gas consumption has been dominated by the manufacturing sector accounting for over 80% consumption[95]

Malaysia is the world's third-largest exporter of liquefied natural gas, the second-largest oil and natural gas producer in Southeast Asia[96]

- Gas demand for industrial development is likely to remain strong going forward as the government pursues greater economic development

In **Philippines**, almost 98% of Natural gas is used for generating power and rest is consumed by industrial sector[97]

92 https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf

93 https://www.gov.hk/en/about/abouthk/factsheets/docs/power%26gas_supplies.pdf

94 http://www.straitstimes.com/singapore/from-the-straits-times-archives-singapore-opts-for-cleaner-energy-sources

95 https://www.ema.gov.sg/cmsmedia/Publications_and_Statistics/Publications/SES17/Publication_Singapore_Energy_Statistics_2017.pdf

96 http://www.iberglobal.com/files/2017/malasia_eia.pdf

97 https://www.doe.gov.ph/2016-natgas-stat

Overview of gas infrastructure and supply

Natural gas reserves are unevenly distributed in SEA, with the bulk found in Malaysia and Vietnam[98 99]

- **Currently, Malaysia and Vietnam have natural gas production levels of 73.6 Bcm and 10.7 Bcm respectively**
  - More than half of the Malaysia's natural gas reserves are located in its eastern areas, predominantly offshore Sarawak
  - Petronas (state-owned) dominates the natural gas sector in Malaysia

With increased dependency on imported natural gas, countries across SEA are investing in re-gasification terminals

- **Hong Kong's** re-gasification terminal is in pre-feasibility stage, expected to be completed by 2020[100]
- **Singapore's** first LNG regasification facility located in Jurong Island was completed in 2013[101] and is further boosting efforts to establish itself as Asia's liquefied natural gas (LNG) trading hub, by considering a second LNG terminal in future[102]
- **Petronas Gas (Malaysia)** operates a regasification terminal at Sungai Udang in Malacca with capacity to handle around 3.8 million tonnes per annum of LNG
- **Philippines** is pitching to become Southeast Asia's liquefied natural gas (LNG) hub given its geographical advantage in the region[103]
- **PetroVietnam Gas** is building two LNG-import terminals in southern Vietnam; the country eyes 2023 as start date for LNG imports[104]
- **Taiwan** has two regasification terminals, located in the central and southern parts of the island and is planning to build a third LNG import terminal to serve the northern region near Taipei[105]

In 2014, Samsung Construction and Trading Corp. of South Korea was awarded a contract valued at almost US$500 million to build a second LNG import terminal for Malaysia, which is following an import-export strategy for the fuel[106]

Southeast Asia

98 https://www.iea.org/publications/freepublications/publication/weo2015_southeastasia.pdf

99 https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf

100 http://www.straitstimes.com/business/companies-markets/hong-kong-billionaires-study-offshore-lng-terminal-to-power-city

101 http://www.hydrocarbons-technology.com/projects/singaporelngterminal/

102 http://sbr.com.sg/energy-offshore/news/singapore-mulls-second-lng-terminal

103 http://www.philstar.com/business/2017/06/09/1707995/philippines-eyed-lng-hub-southeast-asia

104 http://www.lngworldshipping.com/news/view,vietnam-eyes-2023-start-date-for-lng-imports_45354.htm

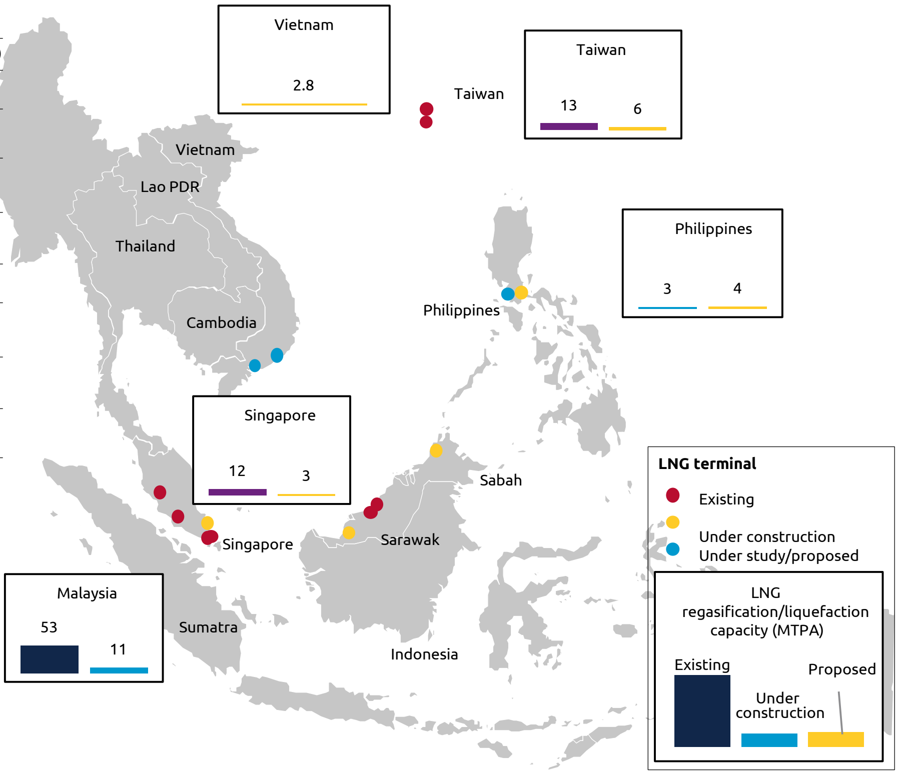
105 http://www.lngworldnews.com/taiwan-yung-an-terminal-to-get-lng-cargo/

106 https://lngjournal.com/index.php/latest-news-mainmenu-47/item/6900-malaysia-to-build-second-lng-import-terminal-at-johor-in-import-export-energy-stategy

Figure 3.7: Pipelines and LNG terminals[107]

Gas Interconnection Projects(Existing and Future)

	Status	Length (km)
Malaysia-Singapore	Existing	5
West Natuna (Indonesia)-Singapore	Existing	660
Malayasia/Vietnam CAA-Malaysia	Existing	270
South Sumatra (Indonesia)-Singapore	Existing	470
Malayasia-Thailand/Malaysia JDA	Existing	270
Malaysia/Vietnam CAA-Vietnam	Existing	330
East Natuna (Indonesia) - Kerteh (Malatasia)	Future	600
East Natuna (Indonesia) - Vietnam	Future	900



107 https://www.ifri.org/sites/default/files/atoms/files/cornot-gandolphe_energie_asean_2017.pdf

Distributed Energy Resource (DER) development is gaining traction in Malaysia and Singapore with ongoing testing and integration projects.

Figure 3.8: Evolving distribution systems ~ Micro grid development dynamics and distribution disruptions at play[108]

Theme	Singapore	Malaysia
DER Integration with Grid Transformation	• Ongoing testing of integration of suitable micro grid technologies • Implementing Advanced Metering Infrastructure (AMI) solution • Investment in pilot and feasibility study: solar PV /Test beds for storage	• Four Lenonic designed stand-alone hybrid micro grids currently developed • Storage solutions being deployed • Residential smart meters to be installed in phases over next five
Structure of Distribution System	• Transmission and distribution network owner: SP PowerAssets • Network Management: SP PowerGrid	• Transmission & Distribution in Peninsular Malaysia : TNB • Sarawak and Sabah: SESCO and SESB (owned 25% of dependable capacity in 2015) respectively
Power issues	• 400/230V low voltage distribution network; underground cables spread over 15,000 km	• Security and reliability of energy supply and fast-depleting domestic gas fields leading to supply shortages; failure in Sabah due to lack of generation capacity
Smart Grid Maturity Level -Triggers and Trends	• Regulatory framework and incentive-driven programs (RE or grids) such as streamlining deployment process, reduced grid connection process from 27 to 7 days and simplifying market registration process, SolarNova Program: (increase solar capacity to 350 MWac by 2020) and to provide up to 8% of Singapore's peak electricity demand by 2030	• Regulatory framework and incentive-driven programs (RE or grids) such as Feed-in-Tariffs (FiT), Five- Fuel Strategy (Targets for 11% renewable in electricity generation amounting to 2,080MW of installed capacity by 2020) and Net Energy Metering (NEM) scheme to encourage private individuals and organizations to self-generate electricity through solar PV and sell excess to TNB; has capacity limit of 500 MW
Grid Modernization / Smart Grid Initiatives	• EMA facilitating new solar business model – Solar leasing and Roof top rental model for pro-business environment • Launch of demand response program and electricity futures market • Implementing Advanced Metering Infrastructure (AMI) solution	• Plans for 99% electrification target in 2020, an increase from 84% in 2010 and 95% in 2015; expected to invest RM 2.3 Billion for strengthening existing transmission & distribution system and connect new lines to main grid • TNB implemented Phasor Measurement Unit (PMU) to prevent grid blackouts from cascading impact of a single error
Micro Grid Penetration	• EMA and Meteorological Service Singapore working to link weather science and grid modeling • Singapore (Reids) project: NTU working with global corporations to test and demonstrate integration of suitable micro grid technologies for deployment • Out of four micro grid projects, one completed in 2016 and remaining to be completed by end of 2017	• Cypark Resources constructed US$22.4 Mn renewable energy park in Panjam, Negeri Sembilan which utilises solar power, biogas and waste products to generate 10MW electricity • Malaysia has four Lenonic designed stand-alone hybrid micro grids.(4.93MW Banggi microgrid, 4.11 MW Tanjung Labian microgrid , 3.45 MW Bario microgrid and 3.30 MW Kema microgrid)
Outlook	• Overall limited maturity regarding technologies and incentives. • Limited area and consumption	• Focus on developing smart grids and smart meters while going ahead with TNB's pilot implementations for energy efficiency and carbon reductions • Plans of diversifying energy sources such as nuclear power and develop infrastructure in 12 years • Develop Sarawak's HP to generate 7,400MW by 2025

Note: [1]. 1RM = 0.24 US$

Southeast Asia

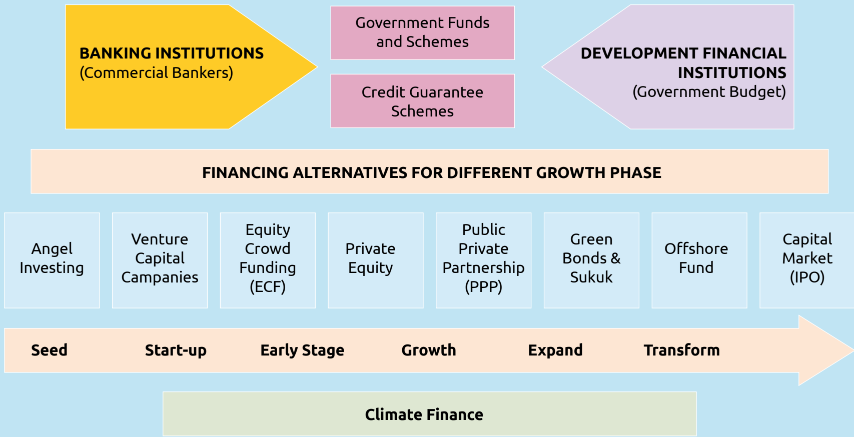
[108] Capgemini Analysis, WEMO 2017

Topic Box 3: Investment models to finance energy transition (renewable base) ~ *Case: Singapore and Malaysia*

Energy efficiency financing mechanism is the method through which funding is made available.

No single mechanism meets all financing needs. An energy efficiency financing program is designed depending on local conditions like consumer lending law, state legislation, political stability, institutional arrangement, degree of awareness, availability of technology etc.[109]

Figure 3.9: Multiple financing solutions for clean energy project[110]



Bloomberg New Energy Finance has cited yield co and green bonds as examples of financing innovations for large renewable assets. Yield co is a dividend growth-oriented public company, created by a parent company to own operating assets that produce a predictable cash flow, primarily through long-term contracts.[111]

Green bonds are like any other infrastructure bonds but may include clean energy, energy efficiency or carbon reduction activities. An example of a yield co is TerraForm Power Inc., set up by the world's largest RE development company, SunEdison Inc.

109 https://www.iea.org/media/workshops/2011/ipeecweact/Kumar.pdf

110 http://ccap.org/assets/Multiple-Financing-Solutions-for-Clean-Energy-Projects-Dato-Kin-Mun-Leong-Primer-Capital-Sdn.-Bhd.pdf

111 http://seda.gov.my/?omaneg=00010100000001010101000100001000000000000000000000&y=45&s=5540

Singapore has initiated several funding and incentive schemes related to energy efficiency (EE) and clean energy, green buildings and construction, water and environmental technologies, green transport and shipping, waste minimization, environmental initiatives, and capability development.

Figure 3.10: Singapore government funding and incentive schemes[112]

Energy Efficiency	Green Building and Construction	Green Community	Green Technology	Green Transport & Shipping
Energy Efficiency Improvement Assistance Scheme (EASe) - NEA	Sustainable contruction capability development fund (SC Fund) - BCA	3P Partnership Fund - NEA	3R Fund - NEA	Early Turnover Scheme (ETS) - LTA/NEA
Design for Efficiency Scheme (DfE) - NEA	Green Building Grant - A *STAR/MND/BCA	Call for Ideas Fund (CIF) - NEA	Technology Pioneer (TechPioneer) Scheme -EWI	Green Ship Programme -MPA
Grant for Energy Efficient Technologies (GREET) - NEA/EDB	Building Retrofit Energy Efficiency Financing scheme (NREEF) -BCA	HDB Greenprint Fund -HDB		Green Port Programme (GPP) -MPA
One-Year Accelerated Depreciation Allowance for Energy Efficient Equipment and Technology (ADAS)	Green Mark Incentive Scheme for Existing Building (GMIS-EB0 scheme -BCA			Green Technology Programme -MPA
Singapore Certified Energy Manager (SCEM) Programme & Training Grant -e2i	Skyrise Greenery Incentive Scheme (SGIS) -N Parks			New Carbon Emissions-Based Vehicle Scheme (CEVS) -LTA
	Green Mark Gross Floor Area Incentive Scheme (GM GFA) -BCA/URA			
	MND Research Fund for the Built Environment -MND			
	Green Mark Incentive Scheme -Design Prototype (GMIS - DP) -BCA			
	Green Mark Incentive for Existing Building & Premises (GMIS-EBP) -BCA			
	Quieter Construction Fund -NEA			

Southeast Asia

112 http://www.nea.gov.sg/docs/default-source/Grants-and-Incentives/adopter---financial-assistance-and-tax-incentives_for-pdf.pdf

Figure 3.11: Incentive and financing schemes for energy efficiency[113]

Scheme	What	How
Design for Efficiency (DfE) Scheme	• Encourages investors in new facilities in Singapore to integrate energy and resource efficiency improvements into manufacturing development plans early in the design stage	• Co-funds up to 50% of the qualifying costs capped at US$600,000
Grant for Energy Efficient Technologies (GREET)	• Encourages the installation of energy efficient technologies or equipment	• Co-funds typically up to 20% of the qualifying costs, capped at US$4 million per project
Energy Efficiency Financing	• Helps kick start EE financing eco-system for industrial sector	• Benefits include: Zero upfront capital, Project paid for from energy savings, End-user enjoys part of energy savings, Off-balance sheet solution (unlike loans), Outsource technical risk – solution providers guarantee performance
Singapore Certified Energy Manager (SCEM) Training Grant	• Targeted at engineering professionals who manage manufacturing facilities and buildings, and provide energy services or engineering consulting services	• Subsidises 70% of the training cost at professional level
Investment Allowance (IA) Scheme	• Encourages industry to invest in capital equipment so that they become more energy-efficient in their operations	• Additional 30% allowance against taxable income on top of normal capital allowance for EE investment
Energy Efficiency Improvement Assistance Scheme (EASe)	• Encourages companies to engage accredited energy services companies to: Conduct detailed energy audits, Identify potential areas for energy efficiency improvement	• Co-funds up to 50% of energy audit fee, capped at US$200,000

Singapore has had great success in rolling out public private partnership (PPP) projects in the waste to energy (WtE) sector[114]

- In 2015, the National Environment Agency (NEA) of Singapore invited tenders for its sixth and largest WtE plant designed to process a minimum of 2,400 tonnes of waste per day under a 25-year concession period
- The scope of the project contract includes design, build, finance, operate and maintain (DBFOM) approach for the plant, which will be one of the world's most efficient WtE plants in terms of energy recovery from per unit waste incinerated
- A consortium comprised of waste to energy technology supplier, Mitsubishi Heavy Industries, and Singapore water company Hyflux, US$ 473 million, 27 year loan for the development, construction and start-up costs of the TuasOne waste to energy plant[115]

Singapore has launched a Private Equity Fund through subscription from high net-worth individuals or social institutional investors to fund projects with the theme of "Environment Sustainable & Governance" - Clean Energy is one of the target sectors.

Armstrong's Southeast Asia Clean Energy Fund, a private-equity fund based in Singapore, manages US$164 million of investments in utility-scale renewable energy and resource efficiency projects in Southeast Asia.

113 https://www.spring.gov.sg/NewsEvents/Events/Documents/SS_ISO50001/7-Industrial%20EE%20Programmes-NEA.pdf
114 https://home.kpmg.com/content/dam/kpmg/sg/pdf/2016/11/Global-Trends-in-Renewable-Energy.pdf
115 https://waste-management-world.com/a/473m-finance-for-singapores-3600-tpd-tuasone-waste-to-energy-plant

Malaysia needs to structure more innovative financing models to pursue sustainable energy agenda in future. While there is a huge potential to drive renewable energy (RE) in the country, industry players believe that it must look beyond the existing financing models.[116] Some of the existing financing models for clean energy include:

- Sukuk (Malaysia) or (Islamic bonds): facilitate financing of Renewable Energy & Energy Efficiency Project
- Project Financing
- Equity Crowd Funding (ECF) for Malaysian SME
- **Green Technology Financing Scheme in Malaysia or GTFS**
  - For Producers: Financing up to US$23.8 million per company (effective from 15 June 2016)
  - For Users: Financing up to US$2.4 million per company

A subsidiary of Asiatic Group (Holdings) Limited, Maju Intan Biomass Energy Sdn Bhd entered into a PPP agreement with TNB

Maju Intan Biomass Energy Sdn Bhd (Malaysia) obtained US$25 million financing from Maybank Islamic Bank Berhad for 12.5 MW Biomass Power Plant project with Corporate Guarantee by Asiatic (holding company). Loan was backed by **Green Technology Financing Scheme (GTFS).** Power Purchase Agreement was done with Electricity Utility Company of Malaysia (Tenaga Nasional Berhad) for a concession period of 21 years. (10MW Exports for TNB, with the remainder being kept for the plant's own use)[117]

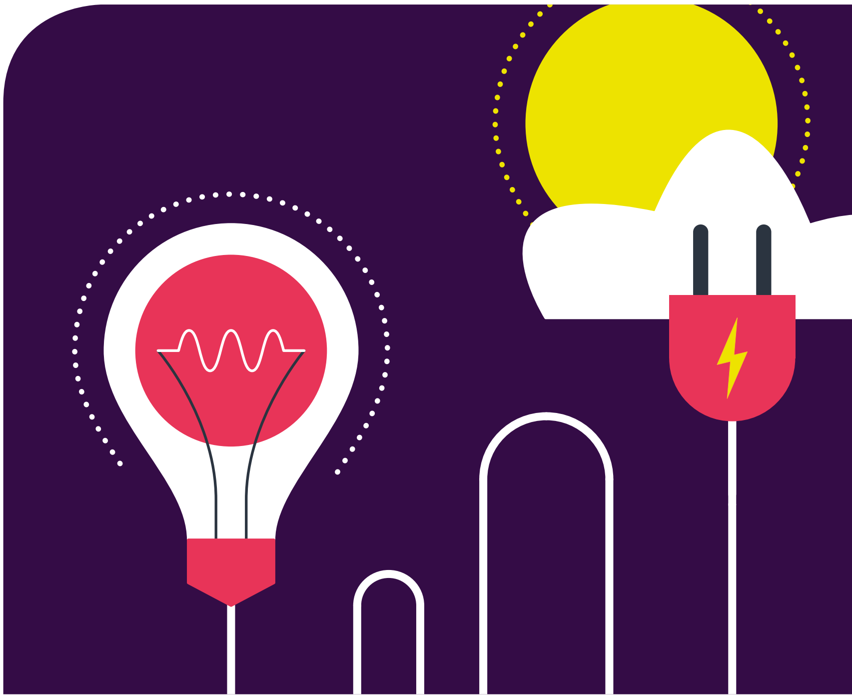
Green Lagoon Technology Sdn Bhd (GLT) became the first biotechnology company in Malaysia to successfully raise funds through an equity crowd-funding platform on CrowdPlus.asia

Since launching its equity crowd-funding offer on 21st June 2016, GLT is has 200% funded as of 22 July 2016, and has surpassed its minimum target of US$95,283. With facilitation by Malaysian Bioeconomy Development Corporation (Bioeconomy Corporation, formerly known as BiotechCorp).[118]

116 http://seda.gov.my

117 http://ccap.org/assets/Multiple-Financing-Solutions-for-Clean-Energy-Projects-Dato-Kin-Mun-Leong-Primer-Capital-Sdn.-Bhd.pdf

118 http://www.bioeconomycorporation.my/green-lagoon-technology-surpasses-crowdfunding-target-of-rm40000/



Supply and Final Customer

SEA's electricity supply market structure is characterized by varied levels of de-regulation, tariff, subsidies, and tariff structure, ranging from countries having deregulated wholesale power markets without fuel subsidies to others having a single-buyer wholesale market with high fuel subsidies.

Currently, most of the countries in SEA operate under a government-influenced single-buyer market structure with fixed tariffs, while competitive wholesale electricity markets exist only in Singapore and the Philippines.

SEA has witnessed consistent investment in grid infrastructure to provide reliable power supply to consumers, with Singapore holding the highest reliability level.

Each market has its own set of challenges which are being addressed by the operators and regulators.

Greater transparency of having reasonably-priced electricity rates through more unbundling of items in the energy supply chain remains part of the major thrusts of the countries.

Signs of cross-border collaborations on the rise...?

There are increased signs of regional collaboration, similar to more mature markets like the US and Europe, where power sectors have tended towards increasing the size and level of their integration.

Driven by the need for energy security and addressing the challenges of individual countries, notable cross-border collaborations are increasing significantly across SEA and the countries are also discussing the potential to set up a regional regulatory body.

- The Singapore-Malaysia interconnection has connected **Singapore** and **Malaysia** aimed at emergency security and peak demand support
  – In 2011, **Malaysia's** Tenaga Nasional Berhad (TNB) in conjunction with Petronas established a commercial exchange deal with Singapore's for cross-border export of electricity caused by capacity

shortages due to lack of adequate gas feedstock supply

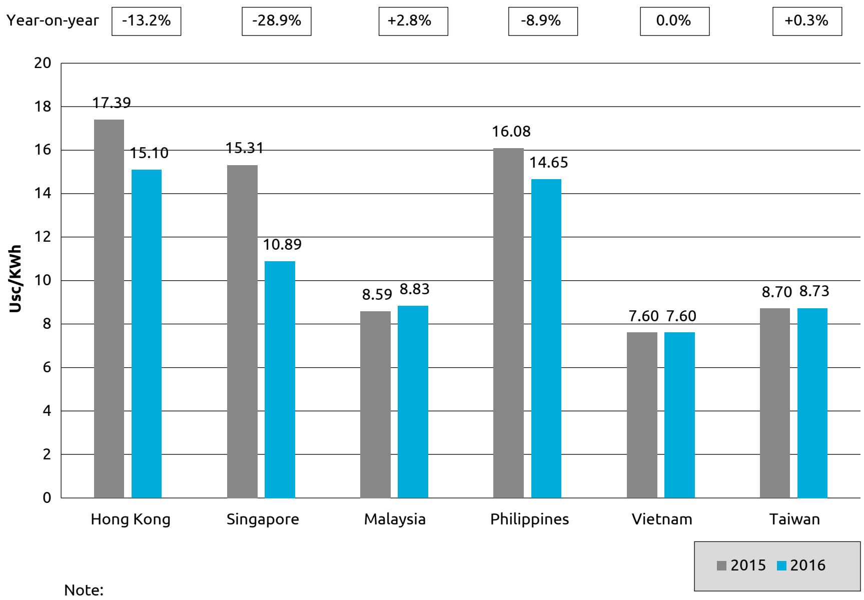
- To support the deal, **Singapore's** Energy Market Authority and the Ministry of Trade and Industry provided exemptions through the Electricity Act

- Similarly, **Vietnam** has collaborated with Thailand in the areas of electricity supply as well as joint collaboration for leakage management

A combination of the current challenges in each country combined with the rapid economic growth, Southeast Asia's electricity market presents a tremendous growth potential across the value chain of these organizations.

Philippine power rates remain one of the highest in Southeast Asia as of end-2016, competing closely with Singapore. However, in recent years, the electricity tariff in the Philippines has decreased with resource prices. Domestic consumers in Peninsular Malaysia and Vietnam enjoy some of the lowest tariff.

Figure 4.1: Average retail electricity prices[119]



Note:
1. USc/KWh excluding VAT but including all other applicable taxes and charges
2. Data for January 2016

In Hong Kong, under the current scheme of control, the fuel clause recovery account serves as a buffer to stabilize tariffs by mitigating fuel cost movements.

- In December 2016, Hong Kong Electric Company (HEC), which powers Hong Kong Island and Lamma announced slashing tariffs by 17.2% for 2017 on the back of a reduction in the fuel clause charge and a special fuel rebate[120]
  - Additionally, customers were also eligible for a rebate of 4 cents per unit as a result of the company winning a court case against the government for overcharging on rents and rates
- At the same time, China Light & Power (CLP) announced freezing tariff as a result of their bloated fuel clause accounts[121]
  - Additionally, CLP, which supplies Lantau, Kowloon and the New Territories announced a 2.3% special fuel rebate to customers

Significant deal signed between the government and the two duopoly power utilities over the extension of the Scheme of Control[122] (SoC) regime in April 2017 to benefit electricity consumers with a 5% reduction in tariffs from next year[123]

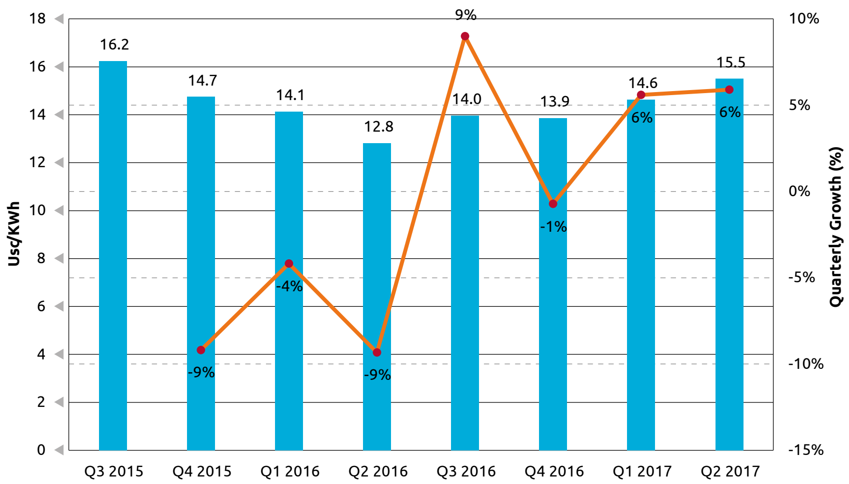
119 Capgemini Analysis, WEMO 2017
120 http://www.scmp.com/news/hong-kong/economy/article/2054260/hk-electric-slash-electricity-tariffs-17pc-while-clp-power
121 http://www.scmp.com/news/hong-kong/economy/article/2054260/hk-electric-slash-electricity-tariffs-17pc-while-clp-power
122 The Scheme of Control is a contact under which the power utility's earnings are linked to investment and emission reduction targets
123 http://www.thestandard.com.hk/breaking-news.php?id=88220

- As per the agreement, the annual rate of return is to be trimmed to 8% from 9.99% under the new SoC, applicable for 15 years
- Although the change will result in a one-off profit drop in 2019, the companies are expected to see modest profit growth in subsequent years since their fixed assets will increase as they build more natural gas-fired generators to replace coal-fired ones to meet the government's more stringent emission standards and environmental goals
- The current regulatory framework that monitors the two power monopolies ends in 2018
  - Contracts with CLP and HEC end in September 2018 and December 2018 respectively
- The Hong Kong Consumer Council has criticized the SoC for not being transparent and excluding consumer participation

Singapore's average electricity tariff declined year-on-year due to lower energy costs.

- However, Q3 2016 witnessed an increase in tariff by an average of ~9% largely due to the cost of natural gas for electricity generation, which rose by 26% compared to Q2 2016
  - The rise was partly offset by lower non-fuel costs, notwithstanding an increase in Market Support Services fee to meet higher market system and development costs
- In Singapore, non-contestable consumers, including households and small businesses, buy electricity from a market support services company, SP Services, at a regulated tariff
  - SP Group reviews the electricity tariffs quarterly based on guidelines set by the Energy Market Authority, the electricity industry regulator

Figure 4.2: Quarterly household electricity tariff ~ SP Group (Q1 2016-Q4 2016)[124 125]



124 http://www.straitstimes.com/singapore/electricity-tariffs-to-increase-from-april-1 , Capgemini Analysis

125 FX Rate: 1.000 S$ = 0.724387 US$ (Average 2016 used as Constant)

Malaysia's electricity tariffs for the consumer, residential, industrial and commercial segments are among the lowest compared to other countries in SEA

- The residential segment enjoys the lowest tariff amid cross-subsidy from the industrial and commercial sectors, besides rebates and government subsidies[126]
  - Currently, the fund comes from renegotiations with the first generation IPPs who had signed power purchase agreements with the Energy Commission (EC)
  - Going forward, the government may impose a surcharge instead of giving a rebate, driven by rising fuel prices (piped gas and coal) or unfavorable exchange rate
  - For the financial period ended August 2016, Tenaga Nasional Bhd (TNB) average coal price was reportedly US$55.7 per tonne; ~25.4 million tonnes of coal consumed to generate electricity[127]
  - According to TNB, demand is expected to increase in tandem with the country's GDP growth of 4-5%; electricity demand growth was at 4% in the financial period ended August 2016
  - Two coal-fired units with 1,000 MW capacity each are being constructed in Port Dickson, which are strategically located and crucial to the security of power supply in Peninsular Malaysia, aimed at increasing the capacity of the country to 26,940 MW by 2020-end from 22,748 MW currently[128]
- The next electricity tariff revision for Peninsular Malaysia is scheduled be take place in January 2018[129]
  - The government has agreed to maintain the power tariff rebate from July 2017 to December 2017
  - Determining the electricity tariff for the peninsular is according to the Incentive Based Regulations (IBR) framework comprising two important components, namely the Imbalance Cost Pass-Through (ICPT) and Base Tariff to cover all costs related to the supply of electricity to consumers
- Persistent high power rates in the Philippines have been driven primarily by the lack of government subsidies as of end-2016.
- The average electricity tariff also remained higher due to lower generation capacities compared to demand
- In addition, taxes, fees, and other charges are also levied on the power industry sectors composed of the generation, transmission, and distribution levels which constitute a portion on electricity rates
  - However, according to the Department of Energy (DOE), this allows for greater transparency in unbundling the items that comprise overall electricity rates
  - Greater transparency of having reasonably-priced electricity rates through more unbundling of items in the energy supply chain remains part of the major thrusts of the DOE
- According to a study by Australia-based International Energy Consultants (IEC), the rates of Manila Electric Co. (Meralco) moved from second highest in Asia to third highest in the region, fourth in Asia Pacific and 16th worldwide[130]
  - Meralco's average rates, excluding taxes, have declined 28% from January 2012 to January 2016, driven by the reduction in cost of power generation, brought down mainly by lower fuel costs, over the four-year period
- Electrification rate per administrative district is almost 100%; however, on a customer base, there are areas with low electrification rates ~ the electrification rate of Mindanao is especially low at 71%[131]
- According to the DOE, a balance between base load, mid-merit, and peaking power is required for stabilizing electricity supply and demand, and improvement of self-sufficiency rate is necessary to enhance energy security

126 http://www.thesundaily.my/news/2017/07/26/malaysias-electricity-tariffs-among-lowest-asean-ec
127 https://www.pressreader.com/malaysia/the-star-malaysia-starbiz/20170401/281543700766061
128 https://www.pressreader.com/malaysia/the-star-malaysia-starbiz/20170401/281543700766061
129 http://www.thesundaily.my/news/2017/07/08/next-peninsular-malaysia-electricity-tariff-revision-january-2018
130 http://www.philstar.com/business/2017/08/25/1732332/philippine-electricity-rates-still-highest-southeast-asia
131 http://www.meti.go.jp/press/2016/03/20170327003/20170327003-1.pdf

Figure 4.3: Philippines: Additional power supply capacity required by 2030[132]

Unit (MW)	Luzon	Visayas	Mindanao	Total
Base Load	4,320	1,968	2,100	8,388
Merit	4,800	1,500	1,500	7,800
Peaking	950	150	50	1,150
Total Grid	10,070	3,618	3,650	17,338

Unit (MW)	Existing	Committed	Capacity Addition
Base Load	11,277	3,091	8,388
Merit	0	876	7,800
Peaking	2,600	111	1,150

Note:
1. Base Load: coal, geothermal, natural gas, biomass, hydraulic
2. Mid-merit: natural gas etc.
3. Peaking: oil, solar power, wind power

Source: DOE "Energy Programs and Investment Opportunities"

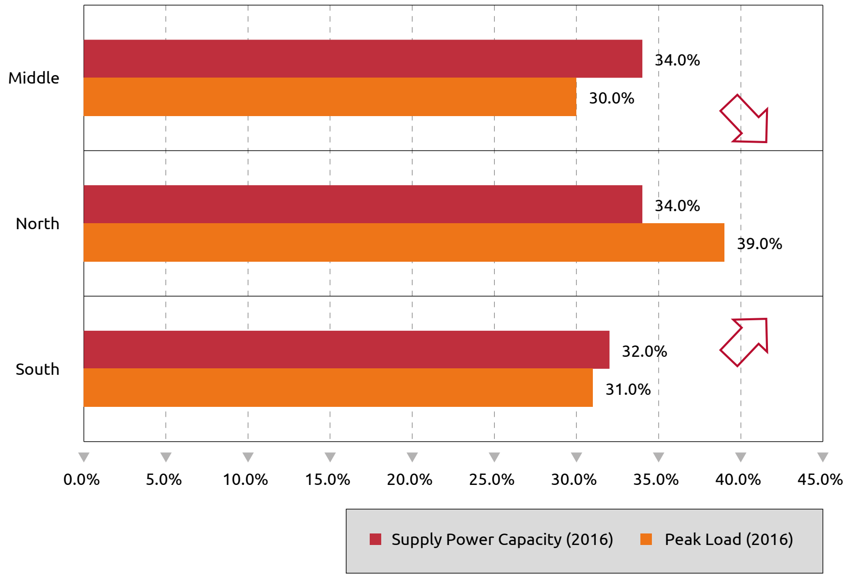
- Key suggestions by DOE:[133]
  - Utilize imported LNG as alternative to future depleting domestic natural gas to improve balance currently dependent on imported coal
  - Utilize domestic coal to improve energy self-sufficiency rate
  - Strengthen power distribution network for areas with low electrification rates
  - Introduce renewable energy (i.e. geothermal, wind power) in regions rich with energy resources
  - Improve power generation efficiency by rehabilitation of power generating facilities which have decreased in efficiency, thereby reducing power generation costs
  - Promote introduction of power generation equipment with high load following capability such as LNG power generation and pumped storage power plants for mid-merit power and to supply peaking

In Vietnam and Taiwan, electricity tariffs remained marginally the same in 2016 as compared to 2015.

- The power retail price in Vietnam has gradually increased in the past ten years, from USc3.5/KWh in 2005 to about USc7.6 in 2016[134]
  - The slow pace of increase of power retail price is among the reasons that discourages investors from pooling their capital into the sector
  - However, Vietnam is planning to increase power prices from 2017, aimed at ensuring capital recovery and reasonable profits for investors
  - Going forward, the power retail price may increase to USc8.0-9.0/KWh by 2020
  - To mobilize funds, the Vietnamese government has adopted a program to restructure the power sector ~ privatization of Vietnam Electricity's (EVN) main generating facilities and distribution subsidiaries
- Supply-demand mismatch persists as one the key issues with Taiwan's power system

132 http://www.meti.go.jp/press/2016/03/20170327003/20170327003-1.pdf
133 http://www.meti.go.jp/press/2016/03/20170327003/20170327003-1.pdf
134 https://uk.practicallaw.thomsonreuters.com/4-628-5349?transitionType=Default&contextData=(sc.Default)&firstPage=true&bhcp=1

Figure 4.4: Taiwan's supply-demand mismatch[135]



- Peak demand in 2016 ~ 35.86 GW
- Demand on the north exceeds local generation
- Part of the power supply in the north comes from the middle and the south

- In November 2016, Taiwan launched a US$56 billion, 8-year effort to develop solar, wind, and other renewable energy sources, as part of the country's denuclearization policy[136]
- In July 2017, Taiwan's Bureau of Energy under the Ministry of Economic Affairs 2017 raised feed-in tariffs for PV, wind power by 6%[137]
  - The bureau is currently processing the release of 200 acres of state-owned land for PV stations to set up projects via an open bid
  - These areas are located in coastal areas in Southwestern Taiwan

135 https://www.emcsg.com/f1671,123955/3_-_Dr_Chuan-Neng_Lin_Bureau_of_Energy_Taiwan.pdf
136 http://mb.ntd.tv/2016/11/28/taiwan-investing-56-billion-renewable-energy/
137 http://asian-power.com/project/news/taiwan-sets-2017-feed-in-tariffs-pv-wind-power

Topic Box 4: Deregulation trends and their impact on markets ~ Case: Hong Kong, Singapore, Malaysia, Philippines

Energy sectors across SEA are turning to deregulation, primarily to improve operational efficiency and sustainability. Given the surge predicted in energy demand, it is imperative that innovative ways to generate power in a socially, economically, and environmentally sustainable manner are uncovered. Countries across the region such Singapore, Malaysia, Philippines and Taiwan have opted for market deregulation in a bid to create sustainability.

Hong Kong[138]

Electricity is provided by two major players ~ China Light & Power (CLP) and Hong Kong Electric Company (HEC), which are investor owned listed companies.

- The government regulates the power industry through its set framework
- The economic regulation of the electricity market is carried out through Scheme of Control Agreement (SCA), which is signed between the government and the individual company for a fixed time period
  - This agreement sets out obligations and rights of the power company
  - The current SCA with the two power companies will end in the year 2018
- To consider new developments for future in the power industry, the government launched a public consultation in 2015
  - Key aspects of the review for 2018 being considered include:
    - Introducing more competition in the market and a follow-up work has been proposed to introduce competition
    - Improving the existing regulatory framework and future fuel mix for electricity generation

Singapore

Singapore's electricity market is gradually being opened up to retail competition. That means competitively priced electricity packages tailored to individual business needs and potential savings to contestable consumers.

- **Scenario:** The national electricity market of Singapore, under the supervision of the Electricity Market Authority (EMA), facilitates the competitive sale of electricity to wholesale and retail markets
  - It introduced large consumers to the retail electricity industry with contestability reaching 45% by 2010 with a view of to eventually achieving 100% by 2020
  - The liberation process started in 2001 with the formation of EMA (Energy Market Company) and ~250 commercial and industrial consumers with demand of over 10 MW were given freedom to choose the supplier to buy electricity
  - In 2003 National Electricity Market was opened which was a single point for retailer to buy electricity in bulk
  - In 2015 the contestable threshold was further reduced to 2000 kWh which helped the completion to cater to small business and other commercial customers as well
  - Instead of buying electricity at the regulated tariff from SP Services (SPS), eligible consumers can choose to buy electricity from electricity retailers under customized price plans or from the wholesale electricity market at prices that fluctuate every half-hour
- **Inching towards Full Retail Competition:** EMA is working towards empowering ~1.3 million small consumers, mainly households, to choose whether they want to remain on the regulated tariff or switch to buy electricity from retailers at market prices[139]
- **Restructuring:** Being the first in Asia to have a competitive wholesale market, Singapore's electricity industry has been restructured with the generation and retail of electricity separated from the natural monopoly of electricity transmission at the ownership level
  - By introducing vesting contracts in 2004, EMA prevented dominant generation companies from exercising their market power to withhold generation capacity and push up electricity pool prices

138 http://www.enb.gov.hk/sites/default/files/en/node3428/EMR_condoc_e.pdf
139 https://www.ema.gov.sg/Electricity_Market_Liberalisation.aspx

- **Transition** ~ The liberalization of the retail electricity market has been implemented in phases to ensure a smooth transition[140]
  – Contestable consumers will have three options:
  1. Buy electricity from a licensed electricity retailer such as Sembcorp Power
  2. Buy electricity directly from wholesale electricity market as a direct market consumer
  3. Buy electricity indirectly from the wholesale electricity market through SP Services Ltd.

Malaysia

Malaysia is phasing out the subsidies provided via Subsidy Rationalization Programme.

- Malaysia has introduced deregulation to its gas and power sector and has paved the way for the introduction of Independent Power Producers (IPPs) to the supply function of the sector, helping the government to reduce the costs and administration involved in the exploration of new natural gas fields
- Tenaga Nasional Berhad (TNB) has started introducing Incentive Based Regulation (IBR) with a trial of the scheme starting in 2017, aimed at improving operational efficiency and transparency towards maintaining a reliable and sustainable electricity supply and help mitigate fuel cost risk

Philippines

Providing services to rural markets competitively remains a challenge in Philippines.

- The Philippines's Energy Regulatory Commission facilitated the privatization of the National Power Corporation which worked very well in the urban centers, with fully liberated markets

Vietnam

In 2016, Vietnam Competitive Wholesale Electricity Market (VWEM) completed its pilot implementation for phase 1: Calculation and simulation on paper, no real payments.[141]

- **Objective:** To facilitate power corporations, who participate in the electricity market for the first time, to get familiar with new mechanisms in electricity generation and business activities, preparing human resources for meeting the VWEM's requirements through training courses from basic to specialized, preparing information technology infrastructure (IT) for further development phases of the VWEM
- Power corporations have completed their IT infrastructures, remote metering systems at boundary points to meet the VWEM's requirements

140 https://mybusiness.singtel.com/techblog/what-smes-need-know-about-liberalisation-singapore-energy-market

141 http://en.evn.com.vn/d6/news/Vietnam-Competitive-Wholesale-Electricity-Market-in-2017-ready-for-official-pilot-operation-66-163-476.aspx

Market Transitions and Innovation

Digitization has gained traction as one of the key factors influencing utilities in SEA, driven primarily by evolving competitive energy markets in Singapore, Philippines, and Vietnam.

The accelerated pace of technological change is disrupting the power industry, with new business models being triggered by smart grids, smart cities and shared economy.

Utilities are building capabilities and developing strategies to manage data on large scale along with platforms to plug-in smart devices into electricity system.

Distributed renewables such as rooftop solar panels and small wind turbines have now become more accessible and affordable. In addition, the arrival of different energy storage means, including chemical batteries, flywheels, thermal storage systems and even electric vehicles, now enable both customers and utilities to store limited electricity easily.

The electricity industry in SEA is undergoing a period of transition. Enabled by technologies, regulatory advancement and customer empowerment, the new interaction between utilities and customers, and among customers themselves, will have to be developed and integrated.

Cloud adoption is expected to remain very high in SEA that will help bring various systems together securely, at scale and at an affordable cost.

IoT gained significant traction in 2016. Although at a nascent stage with mostly component testing ongoing, countries like Singapore and Malaysia have taken a lead by setting up dedicated innovation labs and rolling out pilot projects.

According to Frost & Sullivan, SEA's IoT spending is expected to reach US$7.53 billion in 2020, a 35% growth in value from an estimated US$1.68 billion in 2015.[142]

Singapore has prioritized IoT to be one of the critical elements to realize its vision of a Smart Nation.[143]

- Singapore Power is rolling out an advanced digital platform to enable it to develop IoT-based services
  - The company aims to connect an additional 200,000 residential electricity customers by further weighing on its existing mesh network platform
  - Singapore Power will extend Silver Spring's multi-application IPv6 platform to be more efficient, serve more advanced metering customers and develop a digital data and IoT platform
  - A center focusing on sensors and IoT is one of six capability centers for emerging technology, for which Singapore's GovTech[144] is developing technical expertise and engineering specialists
  - The center will examine the design and implementation of a whole-of-government IoT infrastructure for the larger Smart Nation Platform
  - This infrastructure will enable connectivity by smart objects including static and mobile ones, such as wearables, sensors and mobile devices, and facilitate high-speed transmission of data from the sensors
- A large part of IBM's new Watson Centre at Marina Bay in focusing on leveraging IoT to co-create business solutions
- Singapore Power, together with Singapore's Energy Market Authority (EMA), is also exploring the possibility of a large-scale smart meter deployment for electricity, gas and water supply

Malaysia is following the National IoT Strategic Roadmap that was drawn up by Mimos, the country's national research and development center in ICT under the purview of the Ministry of Science, Technology and Innovation.

- The roadmap aims to turn the country into the premier regional IoT development hub and create a national ecosystem to enable the proliferation of use and industrialization of the IoT as a new source of economic growth
- Pilot projects on how IoT applications are built, used and displayed have been identified while increasing the industry's participation
- Tenaga Nasional Berhad (TNB) intends to use IBM IoT/Maxmio for their Enterprise Asset Management as well as Workforce Management

In the Philippines, Meralco and GE have partnered to announce a program on IoT and leveraging GE's Predix platform in 2017.

Utilities at the forefront of IoT enablement are experimenting with IoT technologies to build resilience, intelligence and interoperability in their grid operations. Some utilities are offering consumer-centric energy services, such as internet-connected thermostats that allow customers to directly control their energy consumption.[145]

Blockchain technology is being integrated into infrastructure to enhance energy efficiency and sustainability, while lowering electricity and gas bills.

In May 2017, Singapore Power entered into a collaboration agreement with a wide-ranging group of energy industry players.[146]

- The consortium of global companies includes:

1. Energy Web Foundation (EWF), a non-profit focused on driving blockchain use across the sector
2. Utility companies Centrica, Engie, Sempra Energy, Stedin, Technical Works Ludwigshafen, and Tokyo Electric Power
3. Oil & Gas giants Royal Dutch Shell and Statoil
4. Transmission system operator Elia

- The partnership seeks to co-develop blockchain solutions aimed at cutting costs and accelerating adoption of renewable energy sources

Southeast Asia

142 http://fintechnews.sg/9677/iot/southeast-asian-governments-pushing-iot-development/

143 http://www.computerweekly.com/news/450404190/Internet-of-things-gains-momentum-in-Southeast-Asia

144 GovTech is a new government agency created to lead Singapore Public Sector's digital transformation in the delivery of anticipatory and citizen-centric government digital services

145 http://www.computerweekly.com/news/450403582/Singapore-Power-deploys-IoT-platform

146 https://www.techinasia.com/singapore-power-to-lower-utility-bills-with-blockchain

- According to Singapore Power, blockchain's ability to enable direct, effective, and secure transactions between multiple parties would facilitate the large scale integration of energy sources and devices such as solar cells, batteries, and electric vehicles onto the grid
- Another potential application includes reconciliation and settlement of payments, lowering the transactional and administrative costs common to existing billing systems
- In January 2017, Singapore Power established a global accelerator program to support startups working in clean energy, energy efficiency and mobility, digitization, and on-demand customer service

Smart Grid/Smart Meter deployment, steered by multiple market dynamics, is poised to change the way utilities and technology companies collaborate in SEA.

According to China Light & Power (CLP), SEA's Smart Metering market is expected to reach US$6.9 billion in 2022. [147]

Hong Kong is notably lacking a comprehensive smart metering program which would enable extensive customer engagement.

- In 2016, Hong Kong implemented selected projects including Distribution Automation, and ~40% of load having smart meters with satellite communications[148]
- In June 2017, CLP announced the launch of a one-year Smart Energy Programme, for which smart meters have been installed for 26,000 selected residential customers[149]
  - The program covers residential customers in 14 districts of Kowloon and the New Territories
  - CLP introduced specific tariff schemes for the Smart Energy Program, namely a Time-of-Use (ToU)[150] Tariff and a Summer Saver Rebate (SSR)[151], drawing on best practices from global trends towards AMI development and application, and the experience of demand side management implementation
- In 2016, CLP joined forces with Hong Kong Telecom (HKT) in the Smart Charge service to promote green driving in Hong Kong, addressing a market of more than 7,000 electric vehicles[152]
- Additionally, CLP is supporting the government's initiatives in developing a pilot project in Kowloon East to explore the feasibility of making Hong Kong a smart city[153]
- CLP's Meter Online Service: Since 2015, an advanced feature of the Meter Online service has combined data from the Hong Kong Observatory's weather projection, smart meter data from CLP's customer consumption archives, and data analytic models to produce a nine-day consumption forecast for our customers
  - In 2016, over 2,100 CLP commercial and industrial customers subscribed to Meter Online, with more than 40% having access to the advanced nine-day consumption forecasting model[154]

In 2016, Singapore committed over US$ 700 million of new public-sector R&D funding for Urban Solutions and Sustainability.[155]

- The planned funding for the next five years is expected to strengthen Singapore's innovation capacity in areas such as clean energy, smart grids and energy storage
- In August 2016, the Singapore Power Centre of Excellence signed partnerships with five private sector companies, worth US$7.46 million on smart grids and data analytics projects, to be completed by 2021[156]
  - It is partnering on grid sensing with 3M, and analytics with NEC and Space-Time Insight, aimed at providing predictive alerts on electricity disruptions
  - It is working with GE's Grid Solutions business on substation digitalization and building smart energy and analytics platforms with IJENKO and OMNETRIC Group

147 http://www.emsd.gov.hk/filemanager/en/content_1226/15_Smart%20Grid.pdf
148 https://www.iea.org/media/workshops/2016/derworkshop1/TRUSCOTT.pdf
149 https://www.clpgroup.com/en/Media-Resources-site/Current%20Releases/20170615_en.pdf
150 The ToU Tariff applies different rates for electricity at different times of the day, divided into a peak period, a shoulder period, and an off-peak period
151 The SSR Tariff encourages customers to reduce their consumption on the hottest days of summer
152 https://www.clpgroup.com/en/Media-Resources-site/Publications%20Documents/CLP_Annual_Report_2016_eng.pdf
153 https://www.clpgroup.com/en/Media-Resources-site/Publications%20Documents/CLP_Annual_Report_2016_eng.pdf
154 https://www.clpgroup.com/en/Media-Resources-site/Publications%20Documents/CLP_Annual_Report_2016_eng.pdf
155 http://asian-power.com/regulation/commentary/solar-power-development-in-southeast-asia
156 https://govinsider.asia/smart-gov/singapore-utility-signs-7-4-million-smart-grid-analytics-projects/

- In September 2017, Silver Spring Networks announced a new agreement with Genus Power Infrastructure[157]
  - Under the agreement, Genus will integrate Silver Spring's standards-based IPv6 network interface cards (NICs) into its single-phase and three-phase smart electric meters
  - Silver Spring-enabled devices will be deployed to connect additional AMI customers of Singapore Power

In Malaysia, both Petronas and Tenaga Nasional Berhad (TNB) are key energy providers with extensive spend on smart meter programs which is expected to be in the US$80-100 million range.

- TNB is embarking on a six-year Advance Metering Infrastructure (AMI) initiative to deploy around 9.2 million smart meters, for a customer base growing at nearly 4% a year[158]
  - This is being planned in a phased manner, with the first phase roll out of 340,000 smart meters rollout in Melaka in 2017, where they have partnered with Siemens (MDM systems), Trilion and SagemCom (Head-End Systems)
  - The balance 8+ million customers will be on-boarded in the next 4-5 years
  - TNB is executing multiple projects for Head End systems implementation, Meter Data Management systems implementation, SMOC implementation and changes/ integrations with other backend systems
  - TNB uses SAP for their back-office functions and has engaged Accenture for implementing SAP Billing & CRM system which went live mid of 2016 and currently under support with Accenture
  - TNB intends to use IBM IoT/ Maximo for their Enterprise Asset Management as well as Workforce Management
- Trilliant and TNB formed a strategic partnership to support TNB's nationwide plan for smart meter deployment, along with a joint go-to market strategy to drive innovation and deliver transformative smart communications solutions to utilities across Asia Pacific and other select regions
  - Built on a Memorandum of Understanding (MoU) signed in 2014 and pilot project and trials over a few years, Trilliant will transfer valuable know-how to TNB, enabling them to deploy and support the advanced smart communications network
  - The strategic alliance facilitates the development of innovative Smart Grid & AMI applications and services that can be deployed to customers locally and internationally
- Accenture and Deloitte have partnered with Petronas on their US$1.0 billion RAPID program
  - Petronas has reached out to Capgemini to engage on analytic, testing and engineering services

Accenture, HP, TCS, SAP and IBM have been very active in the Philippines utility market and have been engaged with all the major players.

- Due to the nature of de-regulation and under invested technology landscape, large players like Meralco, Transco and Aboitiz are all undergoing transformation initiatives on their core platforms
- Meralco is switching to a digital platform starting in 2017 to cope up with the changing business landscape and customer requirements, along with billing transformation
  - The digital transformation started with the rollout of four digital platforms to improve customer experience and is being managed by Accenture on SFDC platform
- Aboitiz and Meralco are also looking to transform their asset management processes and technologies
- The U.S. Trade and Development Agency (USTDA) maintains a robust portfolio in the Philippines to help its partners modernize their transportation networks, adopt best-value procurement policies and meet growing demand for electricity[159]
  - Numerous Agency-funded activities have deployed smart grid solutions that more efficiently manage, monitor and distribute electricity
  - Working with Cagayan Electric Power and Light Company (CEPALCO), USTDA is sponsoring an AMI pilot project

    • The project will pilot 2,000 smart meters and the supporting communications infrastructure across CEPALCO's franchise area

157 https://smartcitiesworld.net/news/news/smart-meter-infrastructure-builds-in-india-and-southeast-asia-2081
158 https://trilliantinc.com/press-releases/tenaga-nasional-berhad-forms-strategic-alliance-with-trilliant-to-support-innovation-and-growth-plans
159 https://www.ustda.gov/program/regions/south-and-southeast-asia

In 2012, Vietnam approved the 'Smart Grid Development Project in Vietnam' which outlines a Smart Grid Roadmap.

- The Project is aimed at the integration of new monitoring, protection and control systems to improve grid reliability and make efficient use of infrastructure while facilitating future integration of scaled-up renewable energy options[160]
- In September 2014, Trilliant signed a contract with EVN HCMC, a subsidiary of EVN for a smart grid project[161]
  - The contract followed a funding approval by World Bank worth US$500 million to work with the Government of Vietnam to improve the capacity, efficiency and reliability of electric infrastructure
  - In addition to using the funding to improve the country's transmission infrastructure, the project will support smart grid technologies for monitoring, control and protecting critical assets to improve reliability and reduce outages
- In September 2016, the USTDA provided technical assistance to Electricity of Vietnam Central Power Corporation (EVNCPC) to modernize their enterprise architecture for smart grid deployment
  - Responding to rapid electricity demand growth, particularly in central Vietnam, EVNCPC is developing an overall IT and smart grid strategy, including an implementation plan and investment schedule, to improve the quality of supply and service to its customers

More efficient, clean and robust smart energy networks are set to emerge from new and wide-ranging research led by Taiwan's Industrial Technology Research Institute (ITRI).[163]

- Emerging smart grid technology is being rolled out in partnership with the state utility the Taiwan Power Company (TPC)
- Among the existing smart grid demonstration projects are microgrid installations on the Taiwanese islands of Dong-Ji and Tai-Ping
- The Taiwan Smart Grid Industry Association was established back in 2009 to facilitate the development of the smart grid industry in the country
  - Sales of smart grid products in Taiwan are growing at a compound annual rate of more than 51% and is already worth above US$500 million a year[164]

160 http://documents.worldbank.org/curated/en/779591468187450158/pdf/103719-WP-P131558-PUBLIC-VN-Smart-Grid-Book-2-21-16.pdf

161 https://trilliantinc.com/press-releases/evn-hcmc-vietnam-trilliant-sign-smart-grid-contract

162 https://www.ustda.gov/news/press-releases/2016/ustda-advances-smart-grid-development-vietnam

163 http://www.renewableenergyworld.com/ugc/articles/2017/05/15/taiwan-spearheads-smart-grid.html

164 http://www.renewableenergyworld.com/ugc/articles/2017/05/15/taiwan-spearheads-smart-grid.html

Topic Box 5: Drivers impacting market transition in SEA

The energy markets in SEA are largely controlled by monopolies and are at the cusp of transformation. The concept of Distributed Energy Resources (DER) will come to play a major role in these regions. The traditional single buyer model is likely to undergo a change and move towards either a deregulated market or offer better services in the existing models. These key energy players are likely to be open to considering moving away from large monolithic systems and consider modular, distributed topology, configurable and flexible billing systems.

SEA has displayed predominantly robust economic development, industrialization and urbanization, resulting in a strong growth in electricity demand.

- The per capita use of electricity is almost half the global average
- However, energy consumption is expected to increase by 80% over the next two decades due to brisk population and GDP growth[165]
- This is driving investment in solutions to boost efficiency, control costs and improved services
- The region is facing multiple challenges of commoditization, integrating renewables into the grid and providing returns on shareholder value.
- Major challenges that the SEA economies face include:
  - Low electrification amid underdeveloped power grid infrastructure,
  - Lack of capital and technologies to advance power grid services

Opportunities exist in asset optimization and management, predictive asset management, grid optimization, new power sources (renewable), cyber security, IT/OT convergence, better customer channels, AMI rollout, asset management, data monetization, IoT and cloud.

- Full Retail Contestability (FRC) in Singapore and Philippines has created big opportunities for IT vendors
  - FRC, coupled with private sector investment in the electricity retail landscape of the Philippines hints at significant technology spends to enhance efficiency and seek customer base
  - One of the key issues faced by electricity retailers in the Philippines is collecting energy bills from the less privileged households, who in turn are being forced to switch to a Pay-as-you-use scheme
  - In Malaysia, building owners face operational losses because of inaccurate meter readings

At a macro level, policy-makers in the SEA economies agree that a transition to smart grid is the fitting solution. Early adopters in SEA are establishing innovative and groundbreaking national programs, while, other governments, utilities, and market stakeholders are seeking lessons from the changes to recognize future benefits.[166]

165 https://trilliantinc.com/press-releases/tenaga-nasional-berhad-forms-strategic-alliance-with-trilliant-to-support-innovation-and-growth-plans
166 https://www.navigantresearch.com/wordpress/wp-content/uploads/2012/08/SGSEA-12-Executive-Summary.pdf

Financials

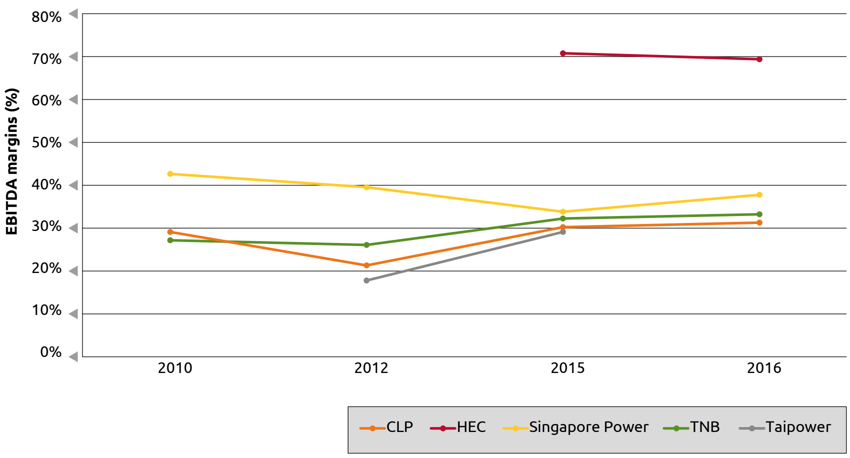
In some of the SEA economies the market is yet to fully open and the deregulation process is still under way resulting in very few companies controlling the major share of the market resulting in stable margins.
Utilities have sustained relatively stable ratings over the last few years.
Overall debt and equity levels of utilities have remained relatively stable over the years. High debt levels are seen in utilities from Hong Kong and Taiwan which shows aggressiveness in investment.

However, a stable and low debt equity ratio is seen for Singapore Power, reflecting stable progress.

SEA has displayed predominantly robust economic development, industrialization and urbanization, resulting in a strong growth in electricity demand.

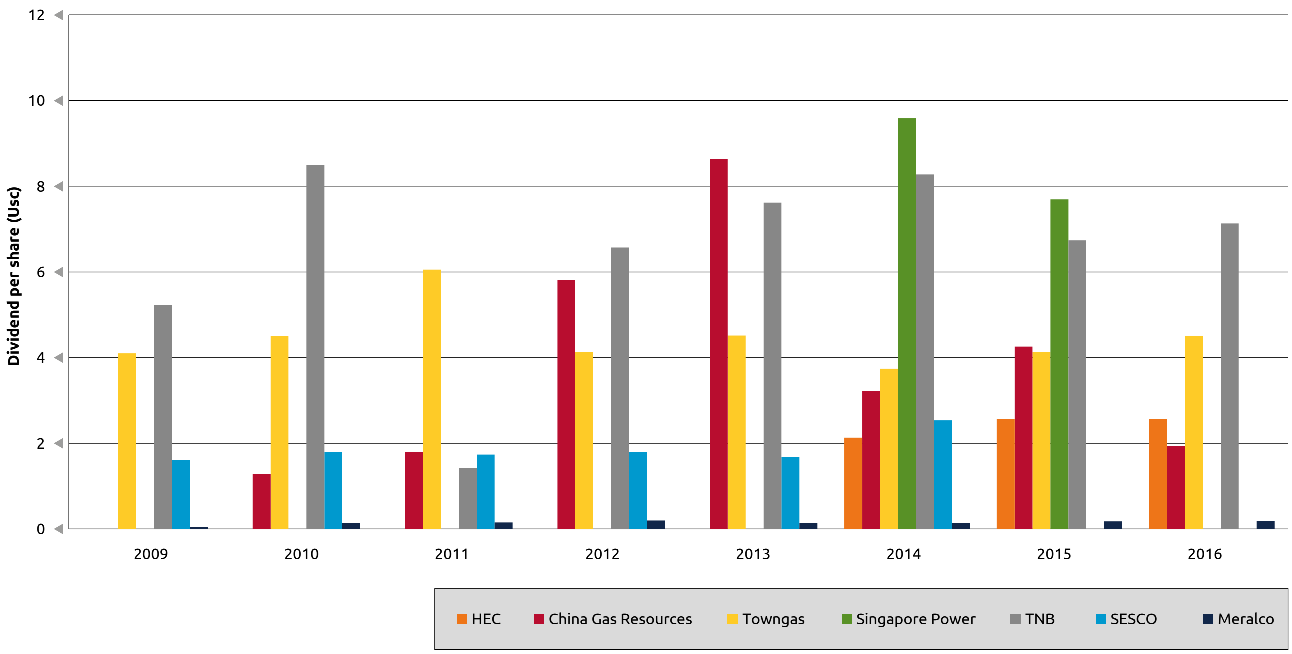
- The per capita use of electricity is almost half the global average
- CLP's 2016 earnings in SEA and Taiwan were impacted marginally by Ho-Ping's tariff adjustment that reflected the lagging effect of lower coal prices in the prior year
- TNB's earning driven primarily by to 4% electricity demand growth in Peninsular Malaysia

Figure 6.1: EBITA margins (2010; 2012; 2015; 2016)[167]



167 Numbers sourced from publicly available sources and databases ~ Annual Reports, Bloomberg

Figure 6.2: Dividend per share (USc), 2009-2016[168]



Significant revision to Hong Kong's Scheme of Control slashes return on net fixed assets to 8% in 2019 from the current 9.99%[169]

- CLP and HEC are expected by analysts to be able to pay investors dividend yields of 3.7% to 4.6% at current share prices under the new regulatory regime
- The revision will result in a one-off profit drop in 2019
- However, modest profit growth is expected in subsequent years, owing to increase in their fixed assets
  - More natural gas-fired generators to replace coal-fired ones to meet the stringent emission standards and environmental goals
- According to estimates by UBS, HEC would realize profit drop over 20% in 2019, compared to CLP's drop of 16%
- Analysts expect the utilities to maintain their dividend yield at levels that will maintain investors' interest

168 Numbers sourced from publicly available sources and databases ~ Annual Reports, Bloomberg

169 http://www.scmp.com/business/companies/article/2093308/why-clp-and-hk-electric-will-still-be-able-feed-dividend-hungry

TNB's share price increased steadily throughout 2016 and the stock ended the year with a remarkable surge by 31.8%

Figure 6.3: Credit ratings, 2010-2016[170]

Credit ratings by Standard & Poor's							
Company	**January 2010**	**January 2011**	**January 2012**	**January 2013**	**December 2014**	**October 2015**	**January 2016**
CLP	-	A	A	A	A	A	A
HEC	-	-	-	-	A	A	A
China Gas Resources	-	-	-	-	-	BBB+	-
Towngas	BBB	A	-	A	BBB	BBB+	-
Singapore Power	-	-	-	-	-	-	AA
TNB	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+
Meralco	-	-	-	BB	-	BBB	-
Taipower	-	-	A+	-	-	A+	-

170 Numbers sourced from publicly available sources and databases ~ Annual Reports, Bloomberg

Topic Box 6: Evolving business models in terms of demand response

Impact of demand response on utility companies

- Decrease in energy generation cost due to reduction in peak demand
- Saving cost of added capacity to meet peak demand
- Reduction in transmission and distribution costs
- Incentives for end customers

How are the utilities gearing up for change?

- Deployment of smart meters
- Fluctuating pricing of power
- Real-time customer engagement (mobile workforce, usage analysis, real-time alerts etc.)

Next generation customer service

- Web Online Service/IVR Portals (billing/Service)
- Web Online Sales (Personalized marketing campaigns and offers)
- Mobile Service (Mobile apps, chats, in-home display)
- Advanced Customer Services (Web Chat, Web TV, Virtual Help Assistant, Social Media)

Cases

- **Singapore** has launched a new mobile app as part of a joint pilot between SP Services, the Energy Market Authority (EMA) and the PUB to help consumers reduce energy and water consumption, lower their utilities bill and conserve the environment
  - Through this app consumers can check their estimated utilities usage of appliances at home and find out which is consuming the most energy and water
  - The app also has feature of Past consumption and peer comparison
  - The new version of the app also allows users to pay electricity bills via mobile
- **Philippines** launched a mobile application for smartphones and tablets to help consumers monitor their consumption and gauge their electricity use

Successful demand response programs are typically found in jurisdictions with deregulated wholesale power markets. New technologies such as smart meters are providing an opportunity to improve performance of demand response initiatives. Implementing demand response strategies could be a valuable tool to help SEA better manage its rapidly growing energy needs.

Australia

Energy Transition in Australia

Editorial by Jan Lindhaus

Climate Change

Australia has been a strong supporter of global climate change policies, supporting the Kyoto Protocol and Paris Agreement and providing strong support to assist developing countries finance their climate change roadmaps. Internally, Australian energy policies have not followed a clear cut agenda since Paris COP22 and have tended to change depending on which government is in power. Given no bipartisan approach to energy policy at the Federal government level, Australia's investment in clean energy technologies began lagging in 2014. The push for renewable technology has been led by state governments who have created their own policies, fast tracking the move to renewable energy generation. It has also been supported by different Generation businesses that have strategically determined their own clean energy policies and are removing themselves from their coal fired plant investments.

Australia is on track to hit the 2020 emissions targets which is 5% of its 2005 greenhouse gas emissions. Official reports state Australia is on track to meet its 2030 targets. Whether this is because of federal government legislation, state government fast tracking renewable energy targets or business determining clean energy policies and shutting down coal generation power plants is up for debate.

At the end of 2016 the Federal Government instigated an Energy Review (Finkel Review) with the results published in June 2017. This review calls for a united approach across governments (Federal and State) as well as business to ensure there is a smooth transition to cleaner energy.

Energy Transition

Policies introduced by state and territory governments, sought to repair the damage to investment confidence since the review of the Renewable Energy Target by the Abbott Government in 2014 and 2015. These efforts have led to sharp increase in the renewable energy generation in 2016, driven by a resurgent hydro sector and a large increase in renewable energy projects under construction in 2017.

In May 2017, total new clean energy investment has been estimated at A$10.3 billion. According to the Clean Energy Council, "more than 3300 MW of new renewable energy capacity will be under construction or completed in 2017."

2015 fossil fuels especially coal produced 84% of Australia's electricity generation. In 2016 this moved to 82%. In 2016 renewable energy generation increased mainly in hydro but wind and solar generation continues to grow as well.

Natural gas accounted for 24% of total fossil fuel energy generation in 2015. The share of natural gas use has increased over the past decade, particularly in the electricity and mining sectors, replacing coal and oil. Australia produces enough natural gas to cover its consumption and to be considered a leading gas exporter. However due to mothballing of coal-fired generators, reliance on gas based electricity and thus reliable exploitation of natural gas resources is likely to increase in future.

The Australian Energy Market Operator (AEMO) has warned of possible gas shortages as early as the summer of 2018-19 if action is not taken by the market or by government.

Australia is actively investing in a number of different clean energy technologies:

- Given the climate in Australia solar generation has had a strong uptake. In 2016 Australia invested in the installation of 752MW of capacity in household and commercial systems, 68 new medium scale solar projects were installed and large scale solar projects continue to be planned and constructed.
- Wind generation is the lowest cost form of new large scale energy generation in Australia. Australia has 79 operating wind farms, 2106 turbines and a generating capacity of 4327 MW placing it 17th in the world for wind power.
- Storage and Batteries. Approximately 6750 batteries with a capacity of 52 MWh were installed in 2016, more than 13 times the 500 installations recorded in 2015,
- With strong Hydro capacity already in existence consideration of Australia's future pumped hydro storage potential and how this could complement the development of other renewable energy technologies is being investigated.
- Other technologies in trial include Solar heating, Bioenergy and Marine energy.

Infrastructure and Adequacy of Supply

Australia has begun its journey from a fossil fuel powered electricity grid to one powered by zero or low emission technologies. Recent events show that Australia is not managing the transition well. The result is an electricity system that is less affordable, less reliable and may fail to deliver the required emissions reductions. Besides the tightening of supply, new vulnerabilities in the NEM have emerged

The majority of Australia's coal fired power stations are old, inefficient and unlikely to be able to be retrofitted with carbon capture and storage technologies. However, the closure of these plants has lead to withdrawal of capacities from the market, disturbing the demand-supply balance in Australia.

The headline-grabber was the blackout in South Australia in September 2016 – the first state-wide blackout since the creation of the NEM in 1998. Although after thorough review the AER determined this particular blackout did not eventuate due to inadequacy in supply it polarised opinion and encouraged a greater focus on Energy Policy in Australia.

In addition to the South Australian blackout Australia's adequacy of supply is being questioned.

- Tasmania's electricity interconnector to Victoria failed in December 2015, leaving the state unable to import or export electricity for six months
- During the 2016-17 summer, it was feared there would not be enough electricity available to meet demand
- In South Australia, despite there being sufficient generation capacity, power to some customers was deliberately cut off during times of peak demand to ensure that supply met demand
- Insufficient generation capacity has not been the problem to date, but supply is tightening in some regions. South Australia and Victoria may need to import additional energy from other regions of the NEM at times of peak demand if wind and solar are unavailable.
- New challenges are emerging from higher levels of intermittent renewable energy and the resulting closure of conventional thermal generation.
- The gap between Australia's natural gas supply and demand is expected to widen as most of the production growth in the next few years is slated to meet LNG export agreements. The Australian Energy Market Operator (AEMO) has warned of possible gas shortages as early as the summer of 2018-2019 if action is not taken by the market or by government. These potential shortages, and domestic prices reportedly higher than export prices, suggest possible failures in the domestic gas market.

These challenges, which include more volatile wholesale market prices and ensuring system security and reliability expectations continue to be met, are expected to require a range of new solutions.

According to the Finkel Review report (an independent review into the future security of the National Electricity Market, completed in June 2017), there is an urgent need for a clear and early decision to implement an orderly transition.

Supply and Final Customer

The past 12–18 months have been some of the most challenging Australia's energy sector has experienced since the National Electricity Market (NEM) was established in 1998. The primary focus has been on wholesale markets, both for electricity and gas.

In electricity, investor uncertainty around the viability of new generation investment, combined with recent coal plant closures, has contributed to a generation mix that is increasingly reliant on intermittent wind and solar energy.

In gas, domestic supply has tightened as Queensland's liquefied natural gas (LNG) projects draw on reserves from southern Australia. At the same time, regulatory restrictions on exploration and subdued international oil prices have delayed the development of new reserves. The result, when coupled with rising production costs, has been significantly higher gas contract and spot prices.

Rising wholesale energy prices are affecting retail prices. These concerns have prompted policy initiatives and inquiries into whether energy markets are delivering for consumers.

It is still a widely held belief that cost-minimising, profit maximising ownership structures are the best means to deliver customer responsive infrastructure with private owners having the best incentives to respond to these drivers. It is also believed that Government organisations face more constraints to adapt quickly to an industry that is changing rapidly. Victoria and South Australia privatized their electricity network in the 1990's, New South Wales is in the process of privatization and Western Australia and Queensland are government owned.

Over the last few years, government reviews have been carried out on the performance of privatized vs. government owned energy companies as well as a review on the causes of large spot price. Prices in states that are fully privatized were seen to have less percentage price increases than states with government-owned enterprises. A review of volatile spot prices within states also identified a number of other reasons for the large increase in electricity prices. These included extended drought and Basslink Interconnector issues, opportunistic bidding and extended reliance on gas fired generation.

Market Transitions and Innovation

Fast paced technology changes are fundamentally altering Australia's energy market. Energy policy and the associated regulatory frameworks are also gradually evolving to adapt to these changes and to provide a dynamic market response

Recent advances include distributed energy resources such as smart metering, rooftop solar PV, battery storage systems, electric vehicles and blockchain technology for peer-to-peer electricity trading.

Emergence of new technologies and business models have challenged the traditional regulatory framework and triggered reform changes initiated by the AEMC; measures required to further streamline the policies.

Some of these reform changes include:

- The Power of Choice Review that has begun changing the monopolistic landscape of the distribution network with modernization of National Electricity and Energy Retail Rules
- The AEMC's new plans for strengthening power system security to accommodate new technologies
- The Energy Efficiency Improvement scheme, which has been extended to 2020. This scheme requires energy retailers to meet energy efficiency targets through approved energy saving activities – the contribution is channelled to finance innovation initiatives, which improve the energy efficiency of households or businesses

Finally the Finkel review report recommends AEMC to review and update the regulatory framework by end of 2018, to facilitate Proof of Concept testing of innovative technologies.

While Australia has an immediate need to consolidate and steer its Energy Transition from the top, it is well advanced and will further benefit from the transition experience of other countries. We trust you will enjoy our first edition of an Australian chapter in Capgemini's annual Energy Markets Observatory.

Jan Lindhaus

Vice President, Head of Energy & Utilities Australia

Anastasia Klingberg

Industry Practice Lead Energy & Utilities, Australia

Climate Challenges & Regulatory Policies

COP22 officially stands for the 22nd Conference of the Parties to the UNFCCC (United Nations Framework Convention on Climate Change). This summit included the 12th Meeting of the Parties to the Kyoto Protocol (CMP12), and the 1st Meeting of the Parties to the Paris Agreement (CMA1).

At COP22, the goal was to define the implementation mechanisms of the Paris Agreement. Two key points emerged:

1 - Assisting the poorest countries technically and financially to strengthen their capabilities in order to reduce their GHG emissions and adapt to the Climate Change.

2 - Apply the "Transparency Principle"; that is to provide a CO_2 reduction report by each country, which will be evaluated by an expert committee, followed by an overall assessment every five years to ensure that the international community is on the right path to reduce the planetary temperature to 2 degrees Celsius.

Climate change is a long-term, global concern, and it requires stable but flexible policy implementation over time.

Australia has been an early adopter, establishing the world's first government agency dedicated to reducing greenhouse gas emissions, establishing the world's first emissions trading scheme (ETS); and pioneering an innovative land-based carbon offset scheme.

However, Australia's commitment to climate action over the last decade has been inconsistent and lacking in direction. Recent events with statewide blackouts in South Australia, increase in electricity and gas prices and the damage of the inter-conductor in Tasmania has put Climate Change policy strongly back on the National Agenda.

COP 22: Australia building a net zero emissions future

Australia has sought over successive governments to make a major contribution to the climate change agenda. This has been backed by broad scientific and technical expertise in emissions reduction, climate science and adaptation, and its 2030 commitments.

- Emissions in 2005 were 594 million tonnes. Australia's climate target would require emissions to reach around 434 million tonnes in 2030, a reduction of 160 million tonnes.
- Emissions from coal power are the largest contributors to Australia's total emissions. In 2013-2014, coal generators emitted 151 million tonnes of greenhouse gas, generating 154 million kilowatt-hours of electricity. This is 29% of Australia's total emissions in 2013-2014 of around 523 million tonnes. (Transport contributed around 18% to total emissions.)

If coal power stations were to reduce emissions by 26-40 million tonnes through a shift to ultra-supercritical generators, then Australia would still be a very long way from meeting its committed targets

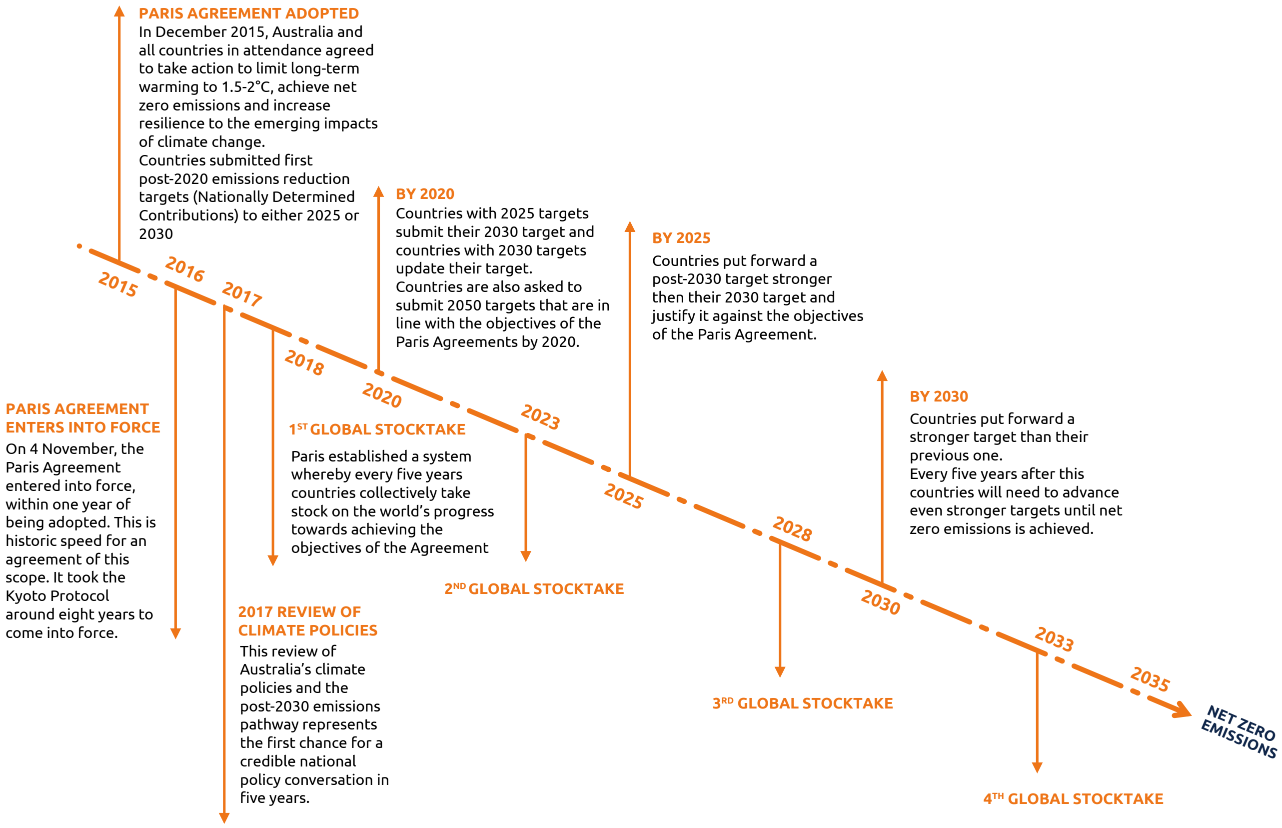
Australia is a strong supporter of the Paris Agreement, and ratified the Agreement on Nov 9th, 2016. Australia has also ratified the Kyoto Protocol Second Commitment Period. Ratification of the Paris Agreement supports these shared objectives by demonstrating Australia's clear commitment to reduce greenhouse gas emissions over time.[1]

1 http://www.climateinstitute.org.au/articles/opinion-pieces/australia-ratifies.html

To comply with the requirements of the Paris Agreement, which will take effect in 2020, Australia has set a target:

- **Australia's 2020 emissions reduction target is 5% based on 2005 levels, and**
- **To reduce carbon emissions by 26-28% on 2005 levels by 2030**

Figure 1.1: Key elements of the Paris Agreement[2]



Australia's stand on reducing GHG emissions

The country plans to cut down the per capita emissions and reduce emissions by two-thirds per unit of GDP. Australia is also supporting other countries to reduce emissions through their Nationally Determined Contributions (NDC), with around 100 NDCs identifying the land sector as a priority.[3]

The Commonwealth Government's current policies (Direct Action) are believed to provide an appropriate framework for the 2020 emissions target although there is uncertainty around providing the appropriate framework to meet the 2030 emissions target.

At the core of Australia's Direct Action climate change policies are the A$2.55 billion Emissions Reduction Fund and its Safeguard Mechanism. This is complemented by the Renewable Energy Target, energy efficiency improvements, phasing out very potent synthetic greenhouse gases, and direct support for investment in low emissions technologies and practices.[4]

For the first time in five years a review of the Direct Action policies and the post 2030 emissions pathway is being undertaken. This review was required as part of the Paris agreement but has added urgency due to current pressures as a result of high electricity prices, infrastructure inadequacies given the speed of the renewable rollout and in response from business leaders requiring certainty of investment. The terms of reference for the review, which was initiated in Feb 2017 and will conclude by the end of 2017, include the following:

- Sector-by-sector basis emission reduction challenges and opportunities
- The impact of policies on jobs, investment, trade competitiveness, households and regional Australia
- The integration of climate change and energy policy, including the impact of state-based policies on achieving an effective national approach

2 http://www.climateinstitute.org.au/verve/_resources/TCI_COP22_FINAL04112016.pdf
3 http://foreignminister.gov.au/speeches/Pages/2016/jb_sp_161116.aspx?w=tb1CaGpkPXper cent2FlS0Kper cent2Bg9ZKEgper cent3Dper cent3D
4 http://www.environment.gov.au/climate-change/publications/factsheet-australias-2030-climate-change-target

- The role and operation of the Emissions Reduction Fund and its safeguard mechanism
- Complementary policies, including the National Energy Productivity Plan
- The role of research and development and innovation
- The potential role of credible international units in meeting Australia's emissions targets
- A potential long-term emissions reduction goal post-2030[5]

In June 2017, Dr. Alan Finkel outlined the new regulatory regime and recommended a new emissions reduction mechanism, to be called the clean energy target. Recommendations included:

A clean energy target (backed by a national emissions reduction trajectory) to stimulate new investment in power generation

A requirement for existing big power stations to give three years' notice of closure, and

Obligations on all new generators to support and maintain voltage and frequency

As per the review, the country's continuous investment in renewable energy technologies will allow Australia to meet the Paris target smoothly. The electricity sector is the cheapest and easiest sector to reduce Australia's emissions and should take a greater share of the Paris target.[6]

Federal Government Incentives to meet 2020 and 2030 targets

The Federal Government's 2017 Budget set aside an A$265 million energy package that will ensure Australia maintains a secure, reliable and competitive energy system. Some of the examples of investment include:

- A focus on buying a larger share of the Hydro scheme to bolster its renewable energy.
- A commitment of up to A$110 million to build a solar thermal plant at Port Augusta in South Australia (The move is seen as a reaction to last year's state-wide blackouts).
- The budget separately provides up to A$36.6 million over two years to target investment in energy infrastructure in South Australia under a bilateral Asset Recycling agreement.
- The Australian Energy Regulator will receive an additional A$7.95 million to scrutinize energy providers to ensure they are serving consumers' needs.
- The budget includes A$28.7 million over four years to encourage the responsible development of onshore gas for the domestic market.[7]

Other areas of incentives the Australian Federal Government have introduced include ARENA (Australian Renewable Energy Agency) which was created in 2011 to accelerate the development of renewable energy for the benefit for all Australians. ARENA provides funding to projects that advance renewable energy technologies or innovate systems that increase renewable energy in Australia's energy mix. ARENA was provided with A$2 billion to invest in renewable energy projects until 2022. Examples of investment include:

5 http://www.nortonrosefulbright.com/files/australians-climate-policy-2-146051.pdf
6 http://www.abc.net.au/news/2017-06-09/finkel-review-why-should-we-care/8605730
7 http://www.energymatters.com.au/renewable-news/federal-budget-solar-energy-em6036/

- The solar plants in NSW at Nyngan, Broken Hill and Moree are 3 of the 93 projects which are currently receiving or have been completed with funding from ARENA. AGL's solar plants at Nyngan and Broken Hill received A$166.7 million funding from ARENA and A$64.9 million from the NSW Government. ARENA also provided A$101.7 million toward the Moree Solar Farm
- A$20 million funding for solar PV research and development announced in May 2017.[8]

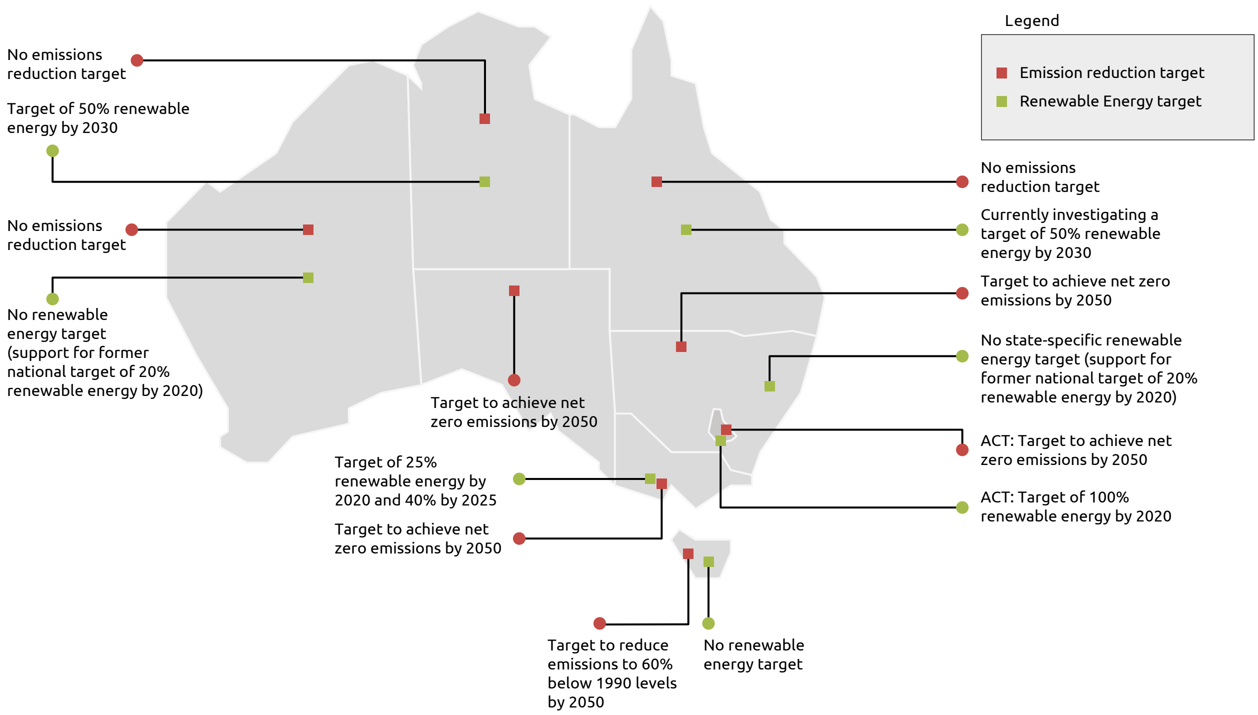
State Governments target to reduce emission

States and territories have been progressing or initiating significant actions in relation to emissions reductions, renewable energy or energy efficiency.[9]

The Federal Government's Renewable energy Target is only to 2020 and there is no national energy policy in place beyond this point. "A decade has now been wasted on the political debate about energy policy and this has resulted in under-investment in new generation. The states are no longer waiting for leadership from the Federal Government."[10]

In parallel to the Federal Government's targets and incentive programmes, State Governments have been setting their own targets that in many instances are forging ahead of the Federal Government.

Figure 1.2: Emissions Reduction and Renewable Energy Targets[11]



8 http://www.nortonrosefulbright.com/files/australians-climate-policy-3-146052.pdf
9 http://www.nortonrosefulbright.com/files/australians-climate-policy-2-146051.pdf
10 http://www.energymatters.com.au/renewable-news/queensland-track-2030-renewable-energy-target/
11 http://www.nortonrosefulbright.com/files/australians-climate-policy-2-146051.pdf

States	Emission reduction target	Renewable energy targets
Australian Capital Territory (ACT)	• A long term goal to achieve zero net emissions by June 30, 2050. • An interim target to reduce emissions to 40% below 1990 levels by 2020	• A target of 100% renewable energy by 2020 – the highest incremental renewable energy target in Australia • The installation of 36MW of energy storage by 2020 – the first energy storage reverse auction in Australia • The ACT government has established a A$12 million Renewable Energy Innovation Fund which will be allocated over five years
New South Wales (NSW)	• NSW Government has now joined Victoria, South Australia and the Australian Capital Territory by setting an ambitious long-term emissions reduction objective of achieving net zero emissions by 2050	• The NSW Renewable Energy Action Plan, released in 2013, supports the achievement of the former national target of 20% renewable energy by 2020 but does not set a State specific renewable energy target
Northern Territory	• Under the previous Labor government, the Northern Territory had an aspirational goal to reduce carbon emissions by 60% by 2050 from 2007 levels • In August 2016, the Labor party was elected to government. The new government has not yet announced any policy details concerning emissions reduction targets or climate change more generally	• The NT Government has planned to adopt a renewable energy target of 50% by 2030 • The Government is looking to further develop Alice Springs as a centre for excellence for solar energy and it is hoping that its pledge of A$5 million will leverage further private sector and Commonwealth funding
Queensland	• No emission reduction target	• For the longer term, the QLD Government has committed to investigating a renewable energy target of 50% by 2030
South Australia	• A long-term target of reducing greenhouse gas emissions within South Australia by at least 60%, to an amount that is equal to or less than 40% of 1990 levels by December 31, 2050	• In 2009, the SA Government committed to a target of 35% of South Australia's electricity generation coming from renewable energy by 2020 • In 2015, the South Australia Government has set a revised state renewable energy target of 50% by 2025 when the earlier target was surpassed
Tasmania	• Tasmania has a legislated target of reducing greenhouse gas emissions to 60% below 1990 levels by 2050	• Tasmania does not have a renewable energy target. However, rainfall permitting, Tasmania does have sufficient renewable energy capacity to turn its fossil fuel generators off and run on 100% of renewable electricity, including hydro, wind and solar power

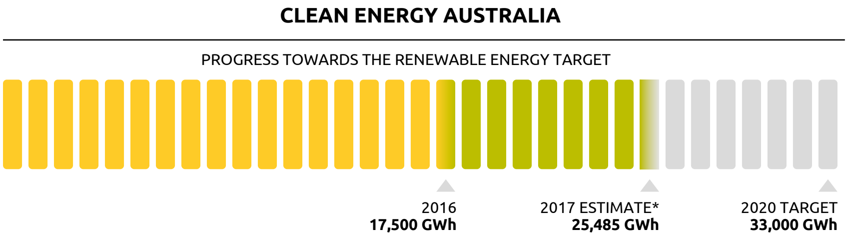
States	Emission reduction target	Renewable energy targets
Victoria	• Announced a long-term target of net zero greenhouse gas emissions by 2050	• In June 2016, the Victorian Government announced renewable energy targets of 25% by 2020 (replacing a target of 20%) and 40% by 2025 • The Victorian Government has committed to supporting renewable energy development through the New Energy Jobs Fund, a A$20 million fund which provides targeted financial support to businesses, research institutes or communities to facilitate the development or uptake of new energy technology
Western Australia	• No renewable energy target (support for former national target of 20 per cent renewable energy by 2020)	• The WA Government has expressed a general desire to contribute to the national renewable energy target of 20% renewable generation by 2020 by continuing to support investment in renewable energy

Australia on track for achieving 2020 Target

Emissions per capita and the emissions intensity of the economy, including the land sector, were both at their lowest levels in 27 years in the year ending June 2016. Emissions per capita have fallen 31.1% since 1990, while the emissions intensity of the economy has fallen 55.6% since 1990.[12]

Australia's annual emissions for the period July 2015 to June 2016, including the land sector, are estimated to be 536.5 million tonnes carbon dioxide equivalent (Mt CO_2-e). This is the fourth lowest emissions level since 2000 (552.7 Mt CO_2-e). It is also 2.9% below emissions in that period, and 10.7% below emissions in 2005 (602.6 Mt CO_2-e).

Figure 1.3: Renewable Energy Target-2020[13]



**This figure represents projects that are underway, have been completed or will start in 2017*

A significant number of new renewable energy projects were announced in 2016, with more new large-scale renewable power generation financed than before. According to Finkel's review, a new regulatory regime should be created and a new emissions reduction mechanism is recommended, to be called the clean energy target. The new requirements will impose costs on the renewable energy sector. There will also be new, system-wide obligations across the national electricity market to ensure faster responses during natural disasters.

South Australia's energy crisis: Indicating infrastructure inadequacy?

A series of events over the past year 2016, particularly in South Australia, has led to government and media debate about the reliability of Australia's electricity system.

Major coal-fired power stations in South Australia and Victoria have closed, wholesale prices have increased, and there are concerns about gas supply.

In the past 18 months, new vulnerabilities in the NEM (National Electricity Market) have emerged.

The headline-grabber was the blackout in South Australia in September 2016 – the first state-wide blackout since the creation of the NEM in 1998. But there have been other smaller blackouts and incidents too.

South Australia, with its high share of wind and solar power and the closure of coal generators means gas generators are providing more power, at a time when gas prices are rising dramatically. A series of events such as blackouts,

12 http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/quarterly-update-australias-national-greenhouse-gas-inventory-jun-2016

13 https://www.cleanenergycouncil.org.au/policy-advocacy/renewable-energy-target.html

power restrictions and alarmingly high prices led to South Australia being the epicenter of this debate.

Amid the ongoing dispute with the South Australian government over the energy crisis, the federal energy department will spend A$5.2m on a detailed study of two potential gas pipelines to Moomba in South Australia, one from the Northern Territory and one from Western Australia. Also the government will investigate other hydro-electricity and pumped storage opportunities in Tasmania, South Australia and in Queensland.[14]

Other major initiatives

Australian Businesses Ratify the Greenhouse Emissions targets and set their own aggressive targets

AGL's energy policy

AGL is a publicly–listed Australian company, providing energy products and services to the Australian economy. The company is involved in both the generation and retailing of electricity for residential and commercial use.

90% of AGL's energy generation is from fossil fuel (mainly coal), from Bayswater and Liddell in NSW, and Loy Yang A in Victoria. AGL launched a rebranding campaign in April 2017, in which the company emphasized its intentions to remove its coal generation to zero by 2050.

AGL's GHG Policy outlines AGL's approach to climate change and presents a pathway for the gradual decarbonization of its generation portfolio by 2050. The policy includes the following commitments and the company will,

- Provide safe, reliable, affordable and sustainable energy options.
- No more build, finance or acquire new conventional coal-fired power stations in Australia (i.e. without carbon capture and storage).
- Not extend the operating life of any of its existing coal fired power stations.
- Close its all existing coal-fired power stations by 2050.
- Improve the GHG efficiency of its operations.
- Invest in new renewable and near-zero emission technologies.
- Provide innovative and cost-effective solutions to customers, such as distributed renewable generation, battery storage, and demand management solutions.
- Incorporate a forecast of future carbon pricing into all generation capital expenditure decisions.
- Support effective long-term government policy to reduce Australia's emissions in a manner that is consistent with the long-term interests of consumers and investors[15]

Engie – Hazelwood power station closure

The State Electricity Commission planned to retire Hazelwood by 2005, but it was privatized by the Victorian Government in 1996.

In the year it was meant to close, the Bracks government extended its life until 2030, under the condition that the plant became more efficient. The facility has supplied Victoria with cheap electricity for 50 years; but with the introduction of the carbon tax, the plant's owners Engie announced that the site was no longer economically viable, and was closed at the end of March 2017.[16]

Engie will move away from coal across international operations, and is also seeking to sell its Loy Yang B coal-fired power station, which supplies 17 percent of Victoria's power needs.

The closure has highlighted the major shift towards renewable energy: Hazelwood is but one of hundreds of coal-burning power stations that have been pushed out of energy markets by global responses to climate change and the rapid rise of renewable energy.

14 https://www.theguardian.com/australia-news/2017/may/09/australia-federal-budget-2017-gas-energy-snowy-hydro-renewables

15 https://www.agl.com.au/about-agl/what-we-stand-for/sustainability/climate-change

16 http://www.abc.net.au/news/2017-03-30/hazelwood-power-plant-shutdown-explained/8379756

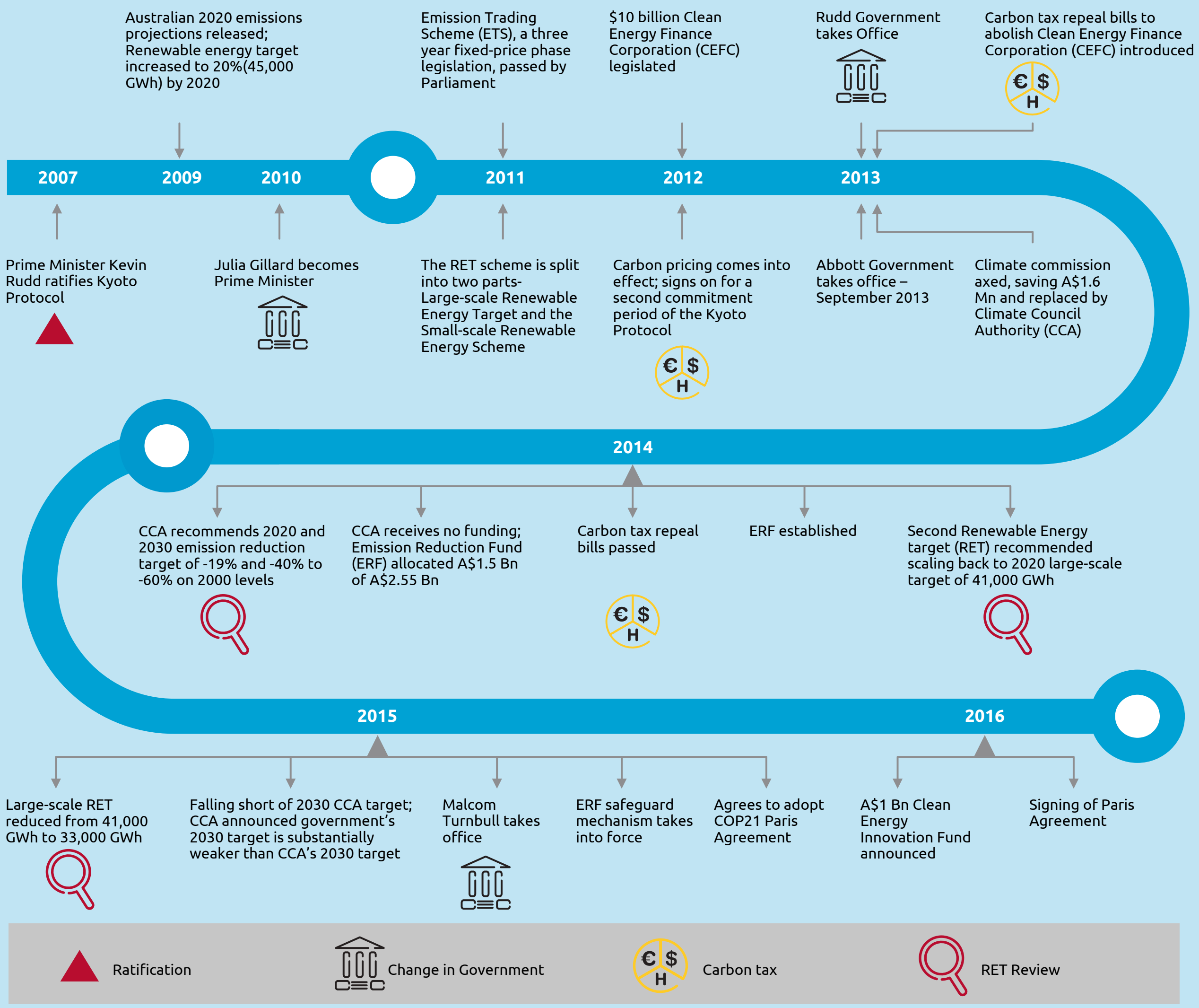
Topic Box 1: Evolution of climate policies and Government priorities

Australia has created a positive image to the delegates at COP22 by ratifying the Paris Agreement in November 2016.

The next goal to achieve emissions reduction commitments submitted to the UNFCCC is 2030, however, a zero emissions timeline of 2050 emerged as a new target for many countries to achieve the climate goal.

The 2017 review of Australia's domestic emissions reduction policies represents a key opportunity to define Australia's position in international carbon markets.

Figure 1.4: Australian Climate Policy Timeline[17]

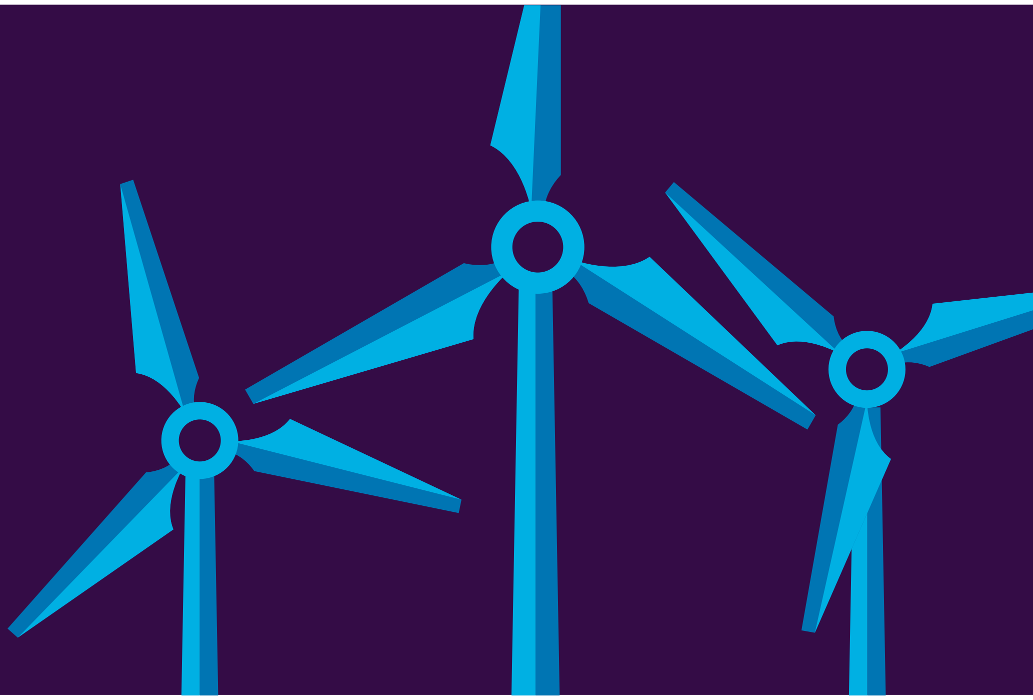


Australia's role in the climate financing road map

Australia, with the United Kingdom, led developed countries to deliver a Roadmap to meet the collective goal of mobilizing A$72 billion a year in climate finance for developing countries by 2020. The Roadmap aims to provide increased predictability and transparency about how the goal will be reached, and sets out the range of actions developed countries will take to meet it. Drawing on analysis by the OECD, the Roadmap shows that developed countries are well-placed to meet the A$72 billion goal, through a combination of public and mobilized private finance. Australia is committed towards doing its own part to meet the A$72 billion goal, and to support the broader transformation of finance flows needed to implement the Paris Agreement.[18 19]

Australia announced A$1 billion climate finance commitment over the next 5 years. Australia will continue to prioritize adaptation, while being responsive to the needs and requests of developing country partners.

17 The Conversation (Timeline: Australia's Climate Policy), Parliamentary Library Research Paper Series, Capgemini Analysis, WEMO 2017
18 http://dfat.gov.au/international-relations/themes/climate-change/Documents/climate-finance-roadmap-to-us100-billion.pdf
19 FX Rate: 1.000 A$ = 0.7208 US$ (Average 2016 used as Constant)

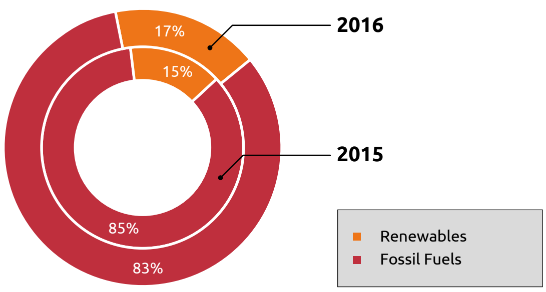


Energy Transition

Policies introduced by state and territory governments, sought to repair the damage to investment confidence since the review of the RET by the Abbott Government in 2014 and 2015. Efforts have led to sharp increase in the renewable energy generation in 2016, driven by a resurgent hydro sector.

More than 17% of Australia's electricity came from renewable sources in 2016, up from 14.6% in 2015, primarily due to greater rainfall in key hydro catchments and a series of new wind and solar projects.[20]

Figure 2.1: Annual Electricity Generation-Fossil and Renewable (2015 & 2016)[21]



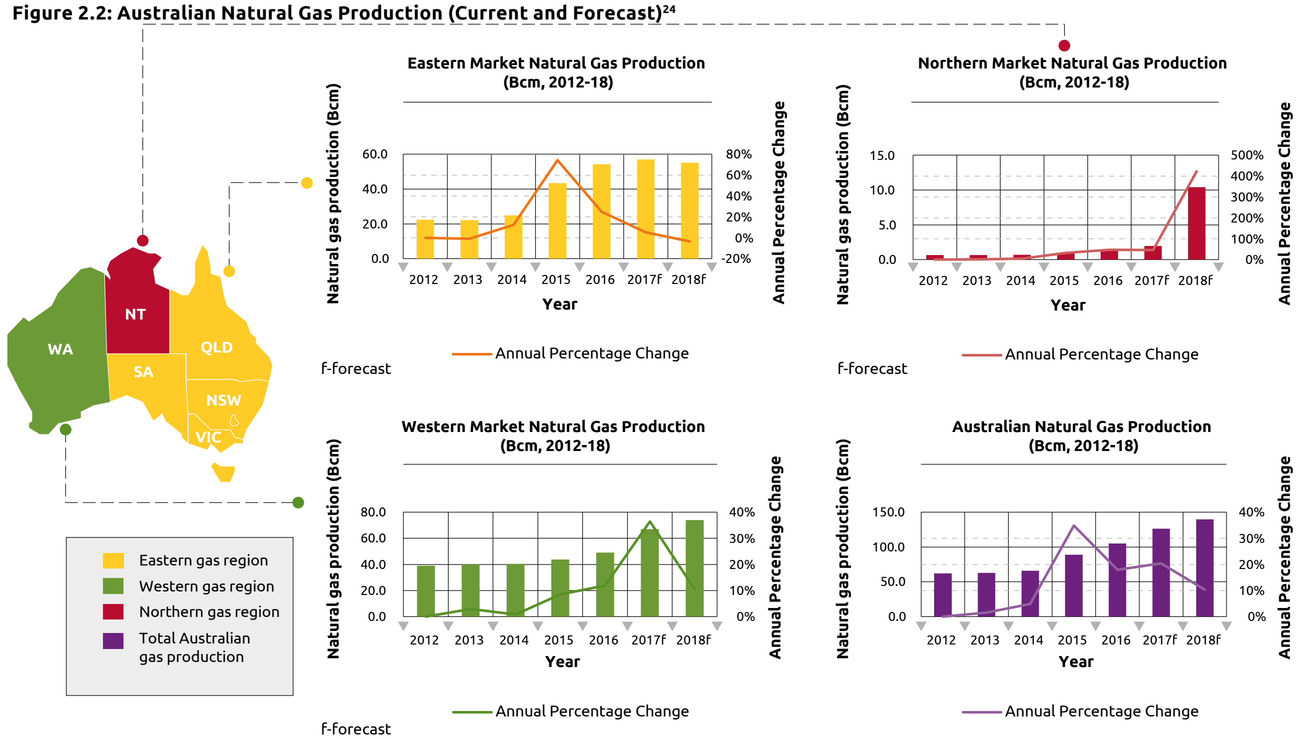
Energy Transition initiatives and impact[22]	
What...	**How...**
• An unprecedented A$10.3 billion in investment and more than 3300 MW of new renewable energy capacity which will be under construction or completed in 2017	• 35 large-scale renewable energy projects are now under construction in Australia • Strong uptake of rooftop solar and emergence of energy storage, provides a clear pathway for Australia's future energy • The cost of large-scale solar in particular has plunged by 50% in last couple of years
• Funding from the Federal Government through the Australian Renewable Energy Agency has had a huge impact in driving down the costs of large-scale solar	• Solar consultancy SunWiz indicates 6750 energy storage units were installed in 2016, which was 13 times on the year before. It is expected that the uptake of battery storage will continue to increase significantly in years ahead

Although fossil fuels, chiefly coal, supplied about 84% of Australia's electric generation in 2015, a push for cleaner and more renewable power has occurred in the last few years.[23]

20 https://www.cleanenergycouncil.org.au/policy-advocacy/reports/clean-energy-australia-report.html
21 https://www.cleanenergycouncil.org.au/policy-advocacy/reports/clean-energy-australia-report.html
22 https://www.cleanenergycouncil.org.au/news/2017/May/2billion-renewable-energy-investment-2017-unprecedented.html
23 http://www.ieee.es/Galerias/fichero/OtrasPublicaciones/Internacional/2017/EIA_Australia_7mar2017.pdf

Natural gas accounted for 24% of total energy generation in 2015. The share of natural gas use has increased over the past decade, particularly in the electricity and mining sectors, and it has replaced some coal and oil use.

Figure 2.2: Australian Natural Gas Production (Current and Forecast)[24]



Australian natural gas production has increased sharply over the past decade as a result of new projects and growing regional demand

As part of the country's goal to reduce greenhouse gas (GHG) emissions by 2020, Australia implemented a fixed-price tax on carbon dioxide emissions to be paid by the top emitting companies in July 2012.

However, the carbon tax was repealed in July 2014 to remove the financial burden on industries that were required to pay for releasing emissions.

The carbon tax put downward pressure on coal consumption during the two years of its existence, but the removal of this tax and low coal prices increased coal's fuel share in the energy balance.

Australia announced a new GHG emissions reduction target of 26—28 % from 2005 levels by 2030, which is likely to promote the use of cleaner fuels in the longer term.

Australia produces enough natural gas to cover its consumption and to be considered a leading gas exporter.

However due to mothballing of coal-fired generators, reliance on gas based electricity is likely to increase in future.

The Australian Energy Market Operator (AEMO) has warned of possible gas shortages as early as the summer of 2018-19 if action is not taken by the market or by government.

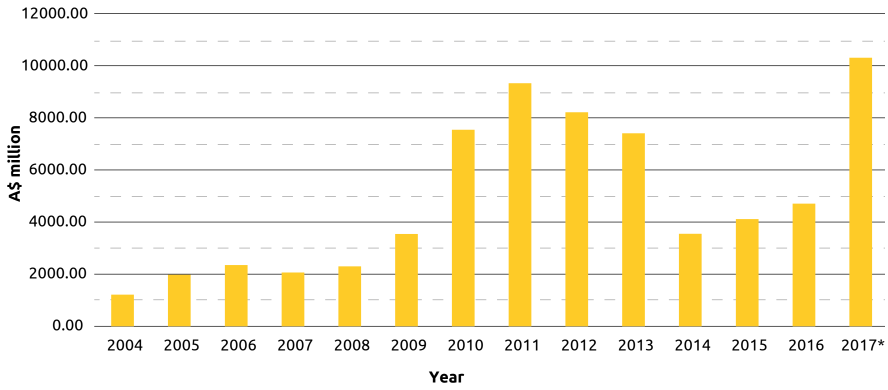
Clean Energy Investment in Australia

In May 2017, total new clean energy investment was an unprecedented A$10.3 billion. According to Clean Energy Council, more than 3300 MW of new renewable energy capacity will be under construction or completed in 2017.[25]

Regional New South Wales and Queensland in particular will enjoy some of the biggest job and investment benefits, while the Victorian Government's state target is expected to drive more project activity once finalized and legislated.

24 https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Resources-and-energy-quarterly.aspx
25 https://www.cleanenergycouncil.org.au/news/2017/May/2billion-renewable-energy-investment-2017-unprecedented.html

Figure 2.3: New Investments in Renewable Energy (A$ million)[26]



FX Rate: 1.000 A$ = 0.7208 US$ (Average 2016 used as Constant)
*Financial commitment for Large-scale renewable energy projects to start in 2017

Source: Bloomberg New Energy Finance-2017, Clean Energy Council

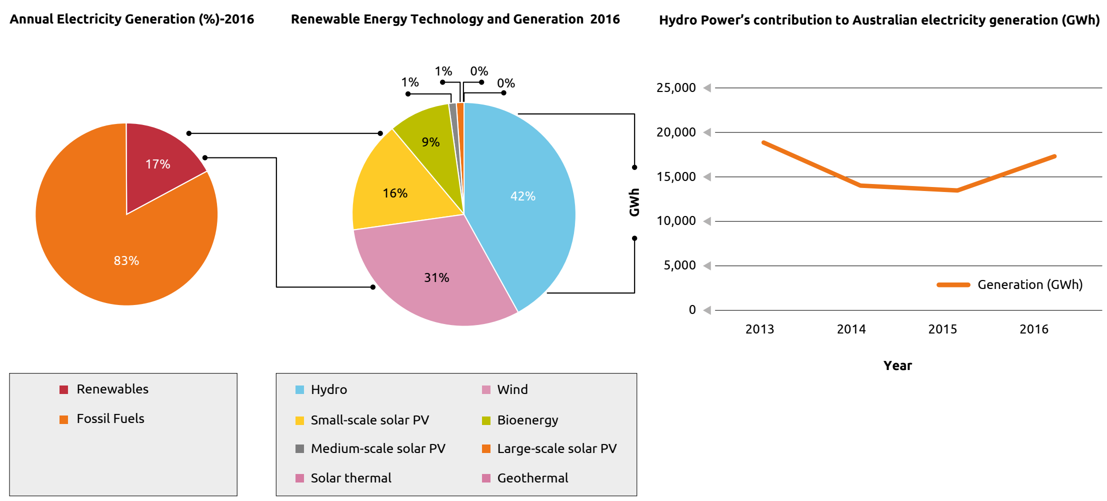
According to Clean Energy Council Chief Executive Kane Thornton, "Following announcements by Infigen Energy, Lyon Solar and Reach Solar Energy, there are now 35 projects (large scale solar projects) that are already under construction, will start construction or have been completed in 2017."

The increasing prevalence of renewable energy is redefining the Australian energy market. The National Electricity Market is shifting from coal and gas generation toward more diverse and distributed forms of power such as wind and solar.

One of the signature trends of the last few years has been the plunging cost of large-scale solar power, a technology that also has shorter project lead times than wind energy – a virtue when the 2020 RET deadline is fast approaching.

Approximately 17,500 gigawatt-hours (GWh) of renewable energy was generated in 2016 towards meeting the large-scale component of the Renewable Energy Target (RET), which is set at 33,000 GWh in 2020. This puts the industry just over halfway towards achieving it.

Figure 2.4: Renewable Energy Technology and Generation[27]



26 http://www.smh.com.au/environment/climate-change/confidence-in-renewable-energy-sector-evaporated-after-abbott-cut-bloomberg-20160114-gm5qbo.html

27 Clean Energy Council Renewable Energy Database, NEM Watch, Australian Energy Statistics 2016, Clean Energy Australia Report 2015 & 2016

Hydro Power

42.3% of total clean energy generated in Australia through hydro in 2016

- Australia has more than 120 operating hydro power stations, most of the nation's hydroelectricity is generated by Hydro Tasmania's network of power plants and the Snowy River Hydro Scheme in New South Wales
- Hydro power generation increased in 2016 by 26.3% after having fallen in 2015 due to scanty rainfalls

Key developments in Hydro power generation

The review of Australia's power system security by Chief Scientist Alan Finkel includes consideration of Australia's future pumped hydro storage potential and how this could complement the development of other renewable energy technologies.

The Australian National University will map Australia's pumped hydro storage potential, with support provided by the Australian Renewable Energy Agency.

The project, The Atlas of Pumped Hydro Energy Storage, will research, integration of the technology into the electricity grid so that it can provide large-scale, reliable clean energy storage at national, state and regional levels.

A resurgent hydro sector was the strongest contributor to a bounce in renewable energy generation

Wind Power

Wind energy is the lowest-cost form of new large-scale energy generation in Australia

- Australia has 79 operating wind farms, 2106 turbines and a generating capacity of 4327 MW, placing it 17th in the world for wind power[28]
- 2016 figures represent the lowest total capacity commissioned since 2004 driven by extended review of the RET under the Abbott Government, combined with long project lead time
- Restored investment confidence and a variety of state renewable energy policies creating additional incentives, the wind sector has been ramping up activity ahead of the final years of the RET

Key developments in Wind Energy

Technological advances in the sector featured strongly in 2016; Wind turbines are now larger and more efficient, as well as making use of intelligent technology.

The ACT Government conducted its final reverse wind auction in 2016, which will help it deliver Australia's most ambitious renewable energy target of 100% by 2020.

It is anticipated that wind farms will make a significant contribution to meeting state targets in Victoria and Queensland. The NSW Government is working through a new strategic plan for the state's Climate Change Fund that could include reverse wind auctions.

Solar Power

Key developments in Solar Power generation		
Household and Commercial Systems up to 100 kW	**Medium scale: Systems between 100 kW and 1 MW**	**Solar Power Large scale: Systems larger than 1 MW**
• 752 MW of new solar capacity was installed, an increase of 46 MW (7%) compared to 2015 • Queensland continues to lead the nation in photovoltaic (PV) installations	• In 2016, 68 new medium-scale solar projects were commissioned, adding 23 MW of new capacity to bring the total of solar capacity in this category up to approximately 200 MW • The sector is expanding quickly as diverse organizations maximize the use of roof space to reduce their electricity bills	• Cost reductions combined with the relatively fast construction timelines of large-scale solar have made it important energy source

28 Global Wind Energy Council, Global Wind Report 2015, April 2016

While there remains strong interest and potential for both large-scale solar thermal and Concentrated Solar Power throughout Australia, these technologies have not yet been able to be deployed at scale.

The Australian Renewable Energy Agency (ARENA) continues to support feasibility and project assessments throughout the country, with the hope of improving the commercial viability for these forms of large-scale solar.

In 2015, ARENA announced A$139 million funding round to encourage 200 MW of new large-scale solar projects to drive down costs and increase competitiveness.

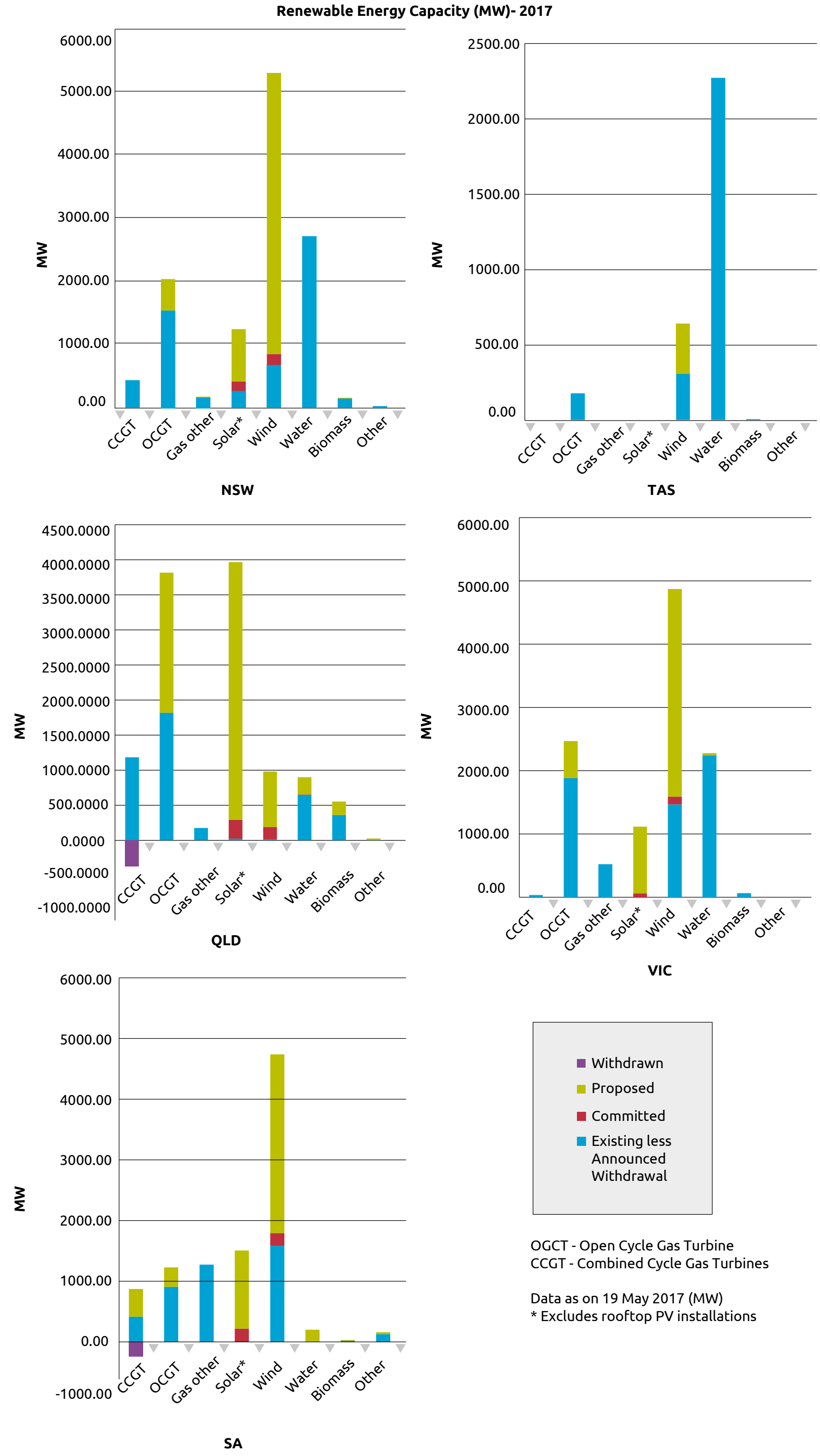
Funding was announced for 480 MW of solar capacity in September across a dozen projects. These were split across Queensland (six projects), New South Wales (five projects) and Western Australia (one project). Many of these are expected to commence construction in 2017.

Other Energy sources

Source	2016 Update
Solar Water Heating	• The uptake of solar water heating peaked in 2009, when Federal Government rebates were introduced to make the technology more attractive ahead of a planned phase-out of electric hot water systems • **Since then solar water heating has continued to lose market share, with sales down 15% in 2016 on the year before**
Bioenergy	• **Bioenergy contributed 8.6% to total clean energy generated in Australia in 2016** • In 2016, the sector saw continued evolution in project design and waste utilization – A$1.1 billion bio-energy project in North Queensland which would be the largest of its type in Australia has secured support from the Australian Renewable Energy Agency.[29] • MSF Sugar is investing A$104 million to build a 24 MW biomass plant to convert cane waste into energy at its Tableland sugar mill • Victoria-based demolition company City Circle Group is commissioning a waste-to-energy timber gasification plant to divert timber waste from civil construction away from landfill
Marine	• **Although, Marine energy technology and resources remain very promising, no grid electricity was produced in Australia from marine energy in 2016** • Projects currently in the demonstration phase include Carnegie Energy's CETO 6 Project, located offshore of Garden Island in Western Australia • BioPower Systems has progressed its bioWAVE project in Port Fairy, Victoria, completing project installation of a full-scale 250 kW pilot plant – The project is scheduled for operation and testing in 2017, with the intention of demonstrating the technology's capability at a grid-connected site for up to 12 months • A 2.4 metre-wide tidal energy turbine is being tested by the Australian Maritime College (AMC) in the Tamar estuary in Launceston, Tasmania

29 http://www.energybusinessnews.com.au/latest-news/800m-qld-bio-energy-project-looks-good/

Figure 2.5: Renewable Energy Technology in Australia (2017)[30]



OGCT - Open Cycle Gas Turbine
CCGT - Combined Cycle Gas Turbines

Data as on 19 May 2017 (MW)
* Excludes rooftop PV installations

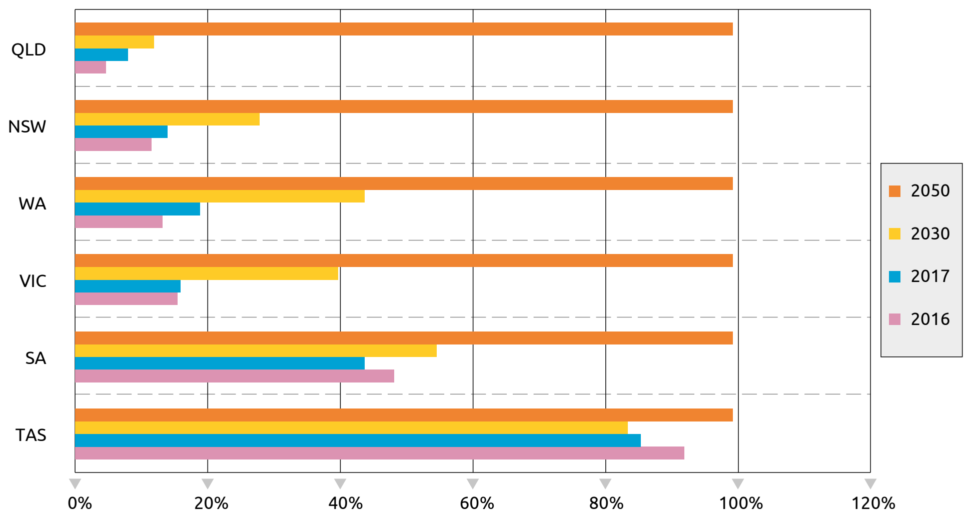
30 http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information

Penetration of Renewable Energy in Australia

Tasmania remained the leader in the use of renewable energy as a percentage of its power use, with renewable energy supplying more than 90% of the state's electricity, largely due to hydro power.

- However, a **damaged Basslink cable** and low dam storages leading into 2016 meant the island used higher levels of gas – and also some diesel generation – to secure its energy supply than it had in the past
- With the **Northern coal-fired power station shutting down** in South Australia for economic reasons, 48% of the state's electricity came from renewable energy
- **Wind power** was the leading source of energy for the first time during 2016, delivering 40% of the state's electricity and just edging out gas-fired power

Figure 2.6: Projected Renewable Generation Mix by State (%)[31]



Emergence of new or rising technologies used for renewable electricity production

Rising electricity costs, changing tariff structures and rapidly falling technology costs are creating the ideal conditions for the continued adoption of 'behind the meter' technologies.

At the same time, the closure of some large coal power plants and high wholesale gas prices are driving increased interest in large-scale energy storage.

Energy Storage

Energy storage is the final piece of the energy puzzle that can enable substantially higher levels of variable sources of generation – such as wind and solar – while also providing services that will deliver a resilient and robust energy system.

31 https://www.cleanenergycouncil.org.au/policy-advocacy/reports/clean-energy-australia-report.html
http://www.energynetworks.com.au/sites/default/files/media_release_energy_plan_can_deliver_millions_in_customer_savings_and_increased_energy_security_0.pdf

Energy Storage uptake in Australia and Benefits	
Key Installations	**Benefits**
• The New South Wales market accounted for a third of all installations, with Queensland in second with 29% • Although only 10% of the installations were in South Australia, the state has the most favorable market conditions for batteries, given its superior solar resource, high electricity prices and support programs from the government, AGL and SA Power Networks	• Meeting peak and fluctuating energy demand, ultimately reducing the need for additional network investment and augmentation • Empowering residents and businesses by helping them to better manage the production and use of electricity • Replacing diesel in remote locations and support mini-grids and embedded electricity networks • Complementing and support greater deployment of renewable energy technologies • Providing network support services such as rapid frequency response and synthetic inertia (mimicking some of the useful characteristics of large thermal power generators); Batteries requiring a much shorter time to deploy compared to other technologies such as open-cycle gas power

Approximately 6750 batteries with a capacity of 52 MWh were installed in 2016, more than 13 times the 500 installations in 2015, according to consultancy SunWiz.

SunWiz predicts market growth in 2017 will be at least treble that of the year before.

With the September state-wide blackout in South Australia leading to a national debate about energy security, grid scale storage such as pumped hydro and battery arrays became the focus of intense interest late in 2016 and into the New Year.

Key Initiatives include:

- The Victorian Government has called for expressions of interest to build a 20 MW battery array
- The South Australian Government will fund 100 MW of battery storage to be completed in time for the 2017/2018 summer
- The Federal Government announced early in 2017 that the Australian Renewable Energy Agency (ARENA) would set aside $20 million for storage demonstration projects under its Advancing Renewables Programme
- In March 2017, Prime Minister Malcolm Turnbull announced plans for Snowy Hydro 2.0, which would expand the original scheme to include 2000 MW of pumped hydro storage
- A feasibility study has also been announced into the expansion of Tasmania's hydro power network to include up to 2500 MW of pumped hydro storage
- Several large-scale storage projects were completed in 2016, including the 2 MWh installation at the Sandfire Resources Copper Mine and the 1.1 MWh community installation at Alkimos Beach in Western Australia
- The ACT announced the winners of the second round of its battery storage auction in 2016, and it aims to roll out 36 MW of storage across 5000 homes in the territory at subsidized rates by the end of the decade

Virtual Power Plants of the future – tested

- Two 'virtual power plants' were trialled in Melbourne and Adelaide during 2016, providing a glimpse of the near future starring home storage technology with smart energy system management
- Utility company United Energy (UE) worked with Energy Makeovers and Clean Energy Council member Sunverge to install 50 kW of solar and energy storage on its distribution network
- The combination of technologies was able to shave off energy use during peak times and reduce the money which needed to be spent on extra poles and wires
- Cloud-based software provided by Sunverge was used to operate energy storage units remotely; they could be called on to cut the strain on the power grid during busy evening periods and hot summer days
- In Adelaide, AGL embarked on a three-phase project that will connect 1000 home batteries to deliver 5 MW of peaking capacity that will make it the world's largest solar virtual power plant once complete
- Sunverge is also involved in this project, supplying batteries and control systems for its first phase

The Australian Renewable Energy Agency is providing up to A$7 million support towards the A$28 million project, which will pool disparate energy resources into a single power plant that is visible to the network and can provide high level reliability.

Industry Outlook for 2017-2020

The Renewable Energy Target

Despite fall in the price of wind and solar power over the last decade, new renewable energy in the Australian market must compete against existing coal and gas generators, the majority of which were wholly built by state governments many decades ago

- The RET is split into two parts: **the Large-scale Renewable Energy Target (LRET)** and the **Small-scale Renewable Energy Scheme (SRES)**
  - The SRES is uncapped and provides a modest incentive for households to install renewable energy systems such as solar power or solar hot water
  - The LRET level is capped at 33,000 GWh of renewable energy generation by 2020, following a legislative change in 2015

Progress towards the Renewable Energy Target	
LRET	**SRET**
• The majority of the Large-scale Renewable Energy Target (LRET) will be met by a combination of wind and solar plants • A variety of state and federal government programs has helped deliver substantial cost reductions in large-scale solar technology – Advantage of solar projects is that they can be built rapidly	• Many solar businesses operating in Australia are now targeting the commercial solar market, and strong growth is expected in systems between 30-100 kW as the business case improves year on year. • With strong consumer interest in energy storage and prices dropping quickly, energy storage is set for a big future • Trials of virtual power plants, microgrids in remote areas and off-grid property developments suggest that many businesses, individuals and governments are considering new and innovative ways to harness the technology

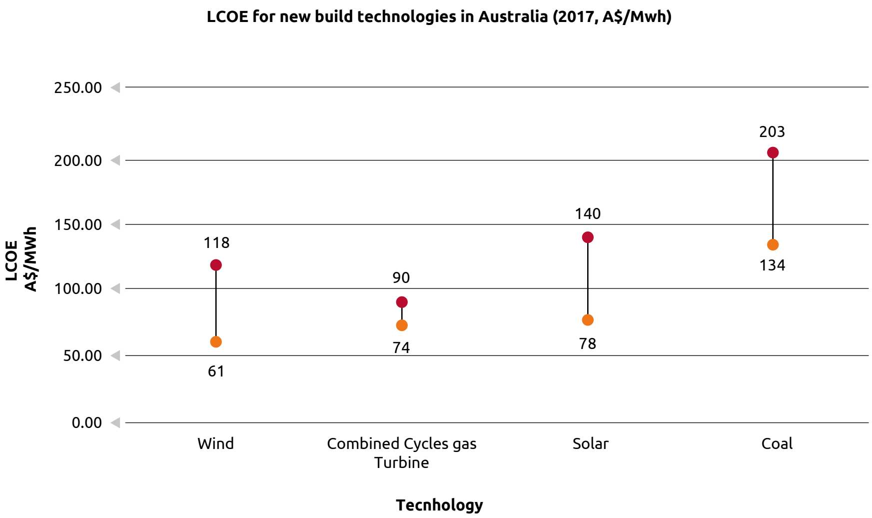
During 2016, about 17,500 GWh of renewable energy was generated under the LRET, putting the industry just over halfway towards meeting the target of 33,000 GWh.

Combined with a strong wind and solar project pipeline and with more project announcements expected in 2017, the industry is confident that the policy will be successfully delivered, provided the policy settings remain unchanged.

Plummeting costs drive rise of Renewables

- According to Bloomberg New Energy Finance (BNEF), renewable energy is now the cheapest form of new energy generation that can be built in Australia. The cheapest renewable energy projects are now below the cost of gas – which continues to struggle with securing affordable fuel supplies

Figure 2.7: Levelized Cost of Energy (LCOE) - 2017[32]



32 https://www.cleanenergycouncil.org.au/policy-advocacy/reports/clean-energy-australia-report.html

BNEF's latest data puts the Levelized Cost of Energy (LCOE) of new wind generation at A$61-118/MWh, combined-cycle gas generation at A$74-90/MWh, solar generation at A$78- 140/MWh and ultra-supercritical coal fired generation at A$134-203/MWh.

- In 2017, Australian Prime Minister Malcolm Turnbull had moved to fund and support the development of 'ultra-supercritical coal-fired power stations' (new-coal) — a type of coal-fired power plant which is said to run at a much higher efficiency than traditional coal-fired power plants
  - However, Australia's division of Bloomberg New Energy Finance (BNEF) published a new report, which shows that any move to build new coal of any level of efficiency is the least economically viable option available
  - Specifically, Bloomberg reports that the Levelized Cost of Energy (LCoE) of new ultra-supercritical coal-fired power in Australia sits at AUD$134-$203/MWh ranking well above the current LCoE for new build wind, solar and combined-cycle gas
- As a result, new build coal would only serve to increase electricity prices across the country, whereas a combination of wind, solar, and natural gas would only serve to drop electricity prices for all Australians

The need for an orderly transition……

According to the Finkel Review report (an independent review into the future security of the National Electricity Market, completed in June 2017), there is an urgent need for a clear and early decision to implement an orderly transition.

The orderly transition package will integrate emissions reduction and energy policy. The package includes a long-term emissions reduction trajectory and a Clean Energy Target to drive clean energy investments and support a reliable electricity supply. Generators will be required to provide three years' notice of closure

- The clean energy focus of the Finkel report is consistent with the increased global focus upon sustainable, renewable energy production
- The report recommends a clean energy target for Australia that is technology neutral
- A low emissions target (LET) is recommended that is anticipated to operate in a manner akin to the existing RET however, 'clean energy' is explicitly defined as emanating from sources that produce no more than 700 kilograms of carbon per megawatt

> The scope of clean energy includes not only renewable energy production such as wind and solar but also nuclear energy, gas - which the report indicates must play a particularly important role as a transition resource - and coal production incorporating carbon capture and storage technology.

Topic Box 2: Level of dependence on intermittent energy and interconnections to avoid state-wide blackout

The state-wide blackout in South Australia on 28 September 2016 led to the politicization of energy policy and criticism of the state's use of renewable energy, which provided almost 50% of its power during the year following the shutdown of its last coal-fired power plant. This was despite the Australian Energy Market Operator (AEMO) providing advice that the blackout was the result of a once-in-50year storm, not renewable energy.

Analysis by the Clean Energy Council before the state-wide blackout showed that South Australia had met all the reliability standards set by AEMO for the last decade. The state was as reliable as anywhere in the country following the closure of its last coal fired power plant.

One of the positives to come out of the blackout was an extensive review of national energy security led by the Chief Scientist Alan Finkel, which will deliver its final recommendations in June 2017.

In March 2016, The Australian Energy Market Operator (AEMO) published its fourth and final incident report into the South Australian (SA) state-wide power outage illustrating the technical challenges of the changing generation mix and the need for these to be managed with the support of efficient and effective regulatory and market mechanisms that work together for the least cost and long-term interest of consumers.

AEMO report outlined 19 recommendations, of which three have already been implemented which address more rigorous weather warning monitoring and improvements in System Restart Ancillary Service testing.[33] Work has commenced on a further eight recommendations, with the remaining items due to be completed by December 2017

AEMO has started working on its recommendations...

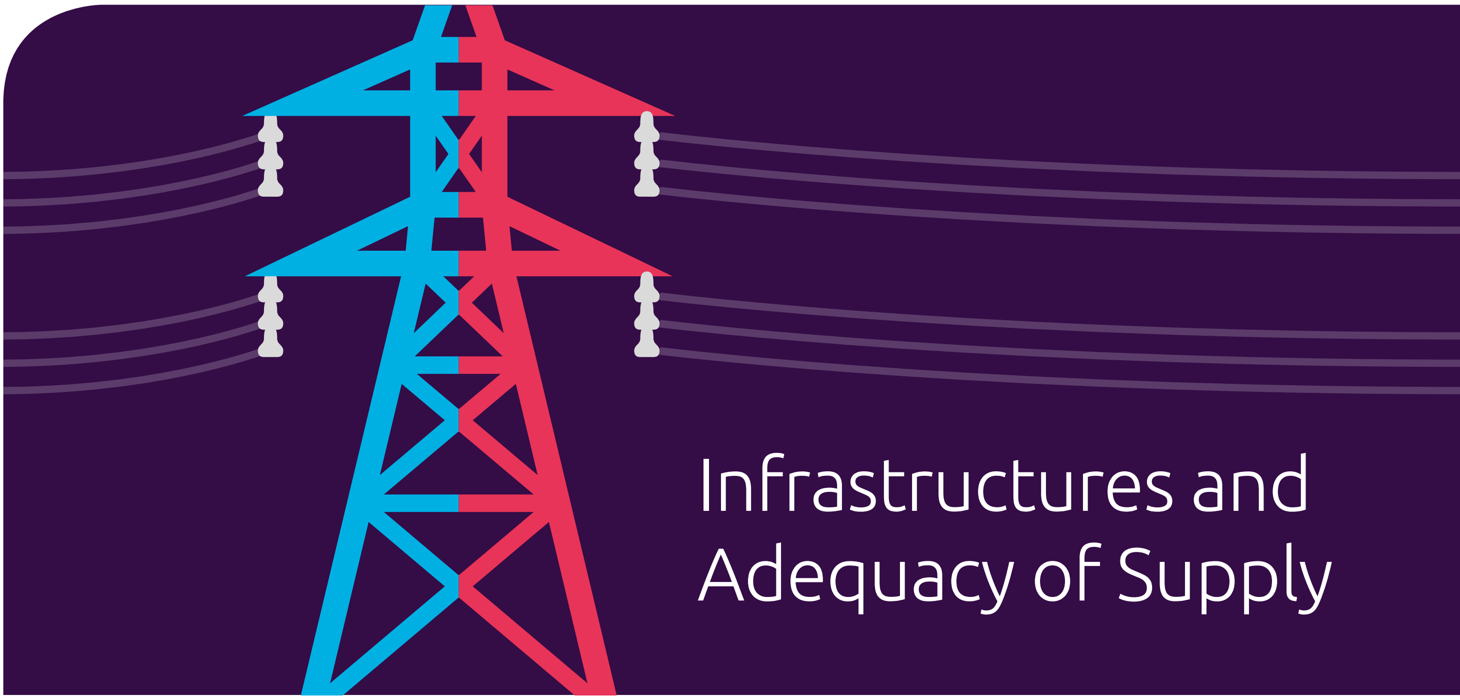
AEMO will continue to support the transition to a power system of the future, including working with stakeholders on the Future Power System Security (FPSS) program, and collaborative engagement with the Australian Energy Market Commission (AEMC) and the Finkel review.

AEMO has also begun work with the Australian Renewable Energy Authority (ARENA) and others on proof-of-concept trials of promising new technologies, starting with use of the new Hornsdale Stage 2 wind farm to provide grid stabilization services. These projects can deliver engineering solutions to make the grid more resilient and protect customer supply as the transformation of Australia's energy system continue.

A link between energy insecurity and a large renewable energy share has been continuously identified by the nation's dominant Murdoch-owned papers since blackouts occurred during a storm in South Australia last year ;however, AEMO has maintained that it was not the high share of wind energy that was to blame, but settings that have been corrected.

> The Finkel Review report highlights an urgent need for a clear and early decision to implement an orderly transition that includes an agreed emissions reduction trajectory, a credible and enduring emissions reduction mechanism and an obligation for generators to provide adequate notice of closure

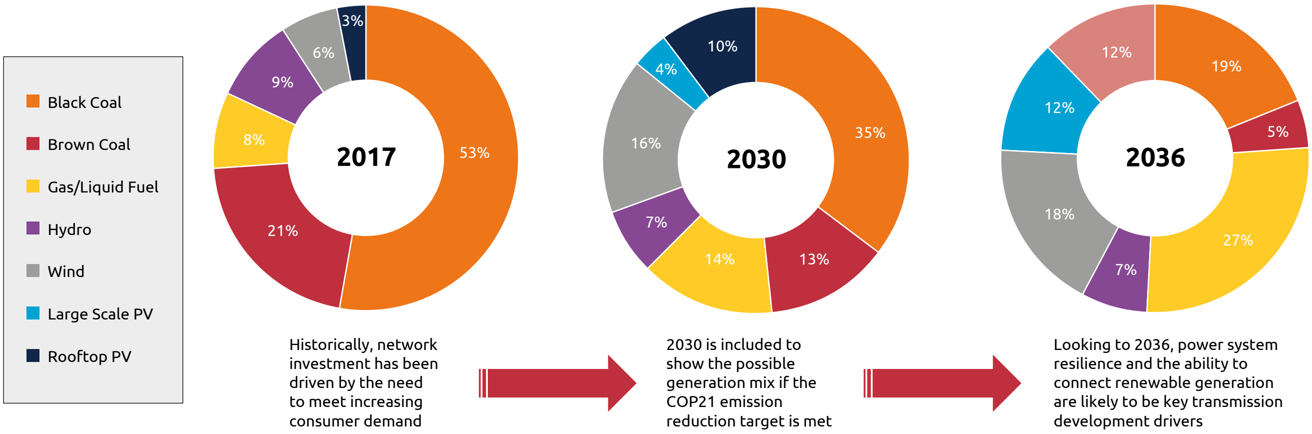
33 https://www.aemo.com.au/Media-Centre/AEMO-publishes-final-report-into-the-South-Australian-state-wide-power-outage



Infrastructures and Adequacy of Supply

Australia's electricity generation system has changed dramatically. Ten years ago almost all generation came from conventional fuel sources – coal, gas and hydro. Now wind and solar account for 8% of electricity generated in Australia.[34]

Figure 3.1: Annual Electricity Generation Mix (Current and Future)[35]



Australia has to make the transition from a fossil-fuel powered electricity grid to one powered by zero- or low-emissions technologies. But recent events show that Australia is not managing the transition well.

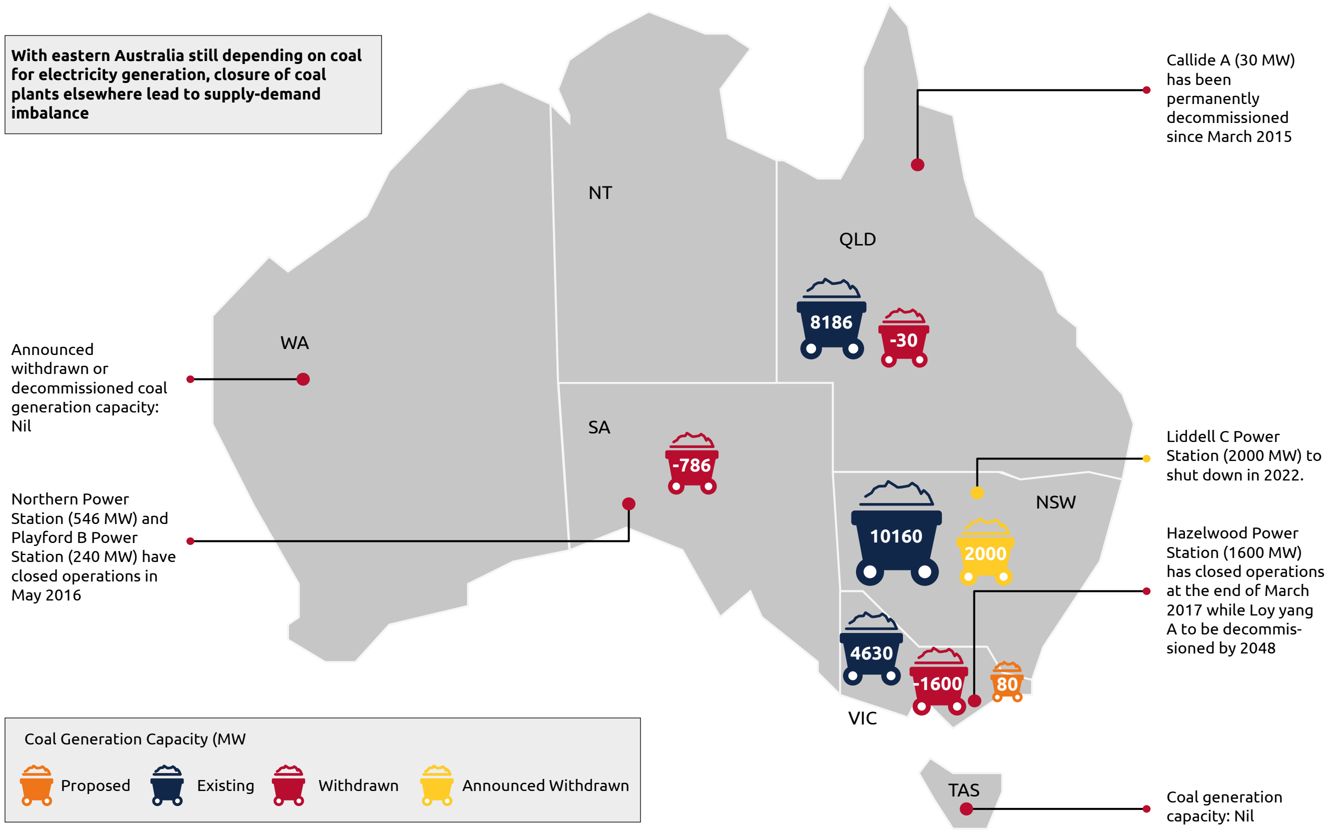
The result is an electricity system that is less affordable and less reliable. Besides the tightening of supply, new vulnerabilities in the NEM have emerged.

34 https://www.cleanenergycouncil.org.au/policy-advocacy/reports/clean-energy-australia-report.html

35 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NTNDP/2016/Dec/2016-NTNDP_Infographic.pdf

Ageing coal fired power stations are recognized as very high producers of pollution. An estimated three-quarters of Australia's coal fired power stations are operating beyond their original design life, requiring costly investment in electricity generation.

Figure 3.2: Australian Coal Generation Capacity (2017)[36]



The majority of Australia's coal fired power stations are old, inefficient and unlikely to be able to be retrofitted with carbon capture and storage technologies. However, the closure of these plants has lead to withdrawal of capacities from the market, disturbing the demand-supply balance in Australia.

After limited growth for several years, peak grid demand is again rising, particularly in Queensland and NSW.

Declining electricity demand and new investment in renewable generation led to surplus generation capacity in the NEM for several years. That surplus peaked in 2014-2015. But the trend then reversed, with all regions recording a declining surplus in 2015-2016, and again in 2016-2017 (except Tasmania).

[36] http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information

National Electricity Market : Key developments

- Peak demand is rising, particularly in Queensland (reaching a record level in January 2017) and NSW
- An influx of wind and solar generation affected the viability of existing thermal generation, with several coal generators being retired, including South Australia's Northern power station in 2016 and Victoria's Hazelwood plant in 2017
- These closures withdrew over 2000 megawatts (MW) from the market, equivalent to around 50% of South Australia's generation capacity
- The Australian Energy Market Operator (AEMO) projected the retirement of Hazelwood Power Station may lead to potential breaches of the reliability standard in Victoria and South Australia from 2017–18 under a neutral growth scenario

The closures have also led to escalating electricity futures prices, as the market factored in reduced supply on top of already tight market conditions.

System security is the immediate challenge, as 2016-17 saw rising incidences of security issues across NEM

The headline-grabber was the blackout in South Australia in September 2016 – the first state-wide blackout since the creation of the NEM in 1998.

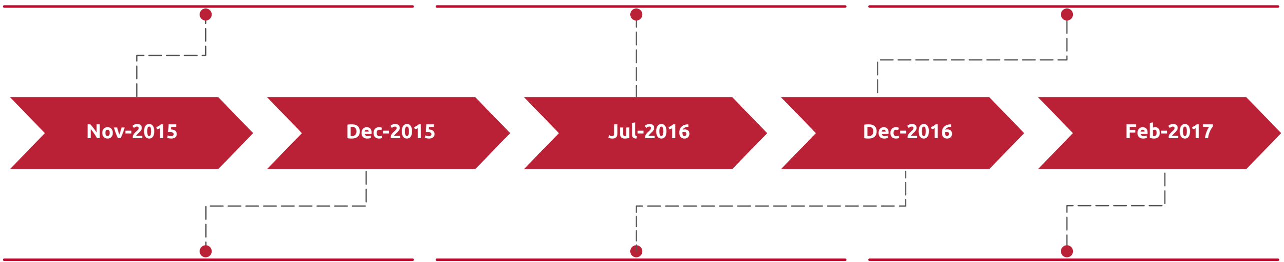
- Tasmania's electricity interconnector to Victoria failed in December 2015, leaving the state unable to import or export electricity for six months
- During the 2016-17 summer, it was feared there would not be enough electricity available to meet demand
- In South Australia, despite there being sufficient generation capacity, power to some customers was deliberately cut off to ensure that supply met demand
- Insufficient generation capacity has not been the problem to date, but supply is tightening in some regions. South Australia and Victoria may need to import additional energy from other regions of the NEM at times of peak demand if wind and solar are unavailable

Figure 3.3: Recent Events In The National Electricity Market[37]

Heywood Trip
The Heywood interconnector tripped resulting in 'synchronous separation' of South Australia from Victoria. There are two interconnectors between South Australia and Victoria but only the Heywood interconnector can provide grid-stabilising services

Price spikes in South Australia
The wholesale price of electricity shot up to $8,900 per megawatt hour, a staggering figure given that wholesale prices in the eastern states had been averaging about $50 per megawatt hour

Partial blackout in South Australia
A severe storm caused extensive damage to the distribution network in South Australia. About 20 % of households (155,000 homes) lost power. Half of these homes lost power for more than 12 hours, and about 1,000 were without power for four days



Basslink outage
A fault in the Basslink cable between Tasmania and Victoria cut Tasmania off from the rest of the NEM. Tasmania was unable to import or export electricity for six months.

Alcoa outage
Alcoa's Portland aluminium smelter lost power for the first time in its 30-year history. Aluminium in production at the time of the blackout solidified, reducing the plant's capacity by more than half.

Heatwave load-shedding
Power was cut to 90,000 South Australian homes in a series of rolling 30-minute blackouts initiated by the market operator. Unexpectedly high demand had created a shortage because additional generation could not be brought online quickly enough

Problems with system security have emerged because synchronous generators are operating less or being decommissioned. Technologies could provide grid-stabilizing services ('ancillary services') in different ways, such as synchronous condensers, synthetic inertia controllers and large-scale battery storage, but these have not yet been adopted in Australia.

Increased investments in interconnections between South Australia and eastern states should help to ensure resilient security of supply.

New challenges are emerging from higher levels of intermittent renewable energy and the resulting closure of conventional thermal generation.

These challenges, which include more **volatile wh olesale market prices and ensuring system security and reliability** expectations continue to be met, are expected to require a range of new solutions. Stronger interconnection is one of these solutions.

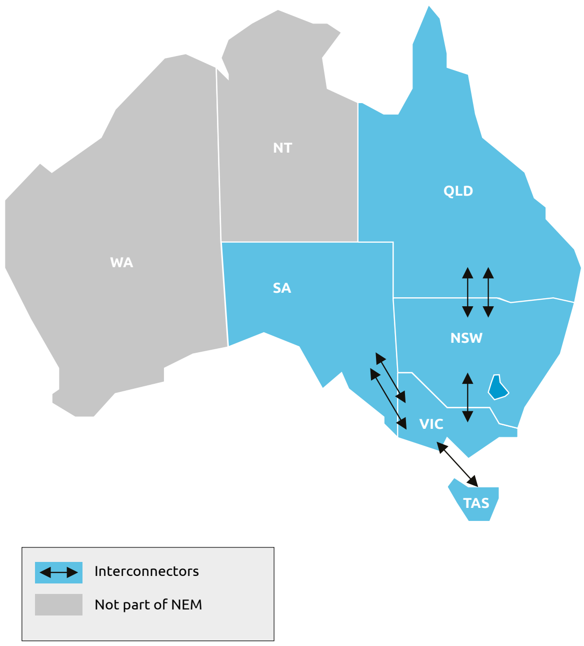
37 https://grattan.edu.au/wp-content/uploads/2017/05/889-Powering-through.pdf

The South Australia's renewable energy penetration is remarkable especially because of the low level of interconnection between South Australia and other regions – import capacity is only about 30% of South Australia's peak demand. By comparison, Denmark – which also generates more than 40% of its electricity from intermittent (wind) energy – can meet more than 80% of its peak demand via interconnectors with Norway, Sweden and Germany

International experience such as this shows that stronger interconnection is needed to support the increasingly high levels of intermittent renewable energy in South Australia, and Australia's transition towards a renewable energy future.

The NEM operates across an interconnected power system and incorporates Queensland, New South Wales and the ACT, Victoria, South Australia and Tasmania. The NEM has around 51,000 km of transmission lines and cables and serves over nine million customer connections. The system combines and schedules outputs from all generators in real-time to meet the electricity demand of customers.

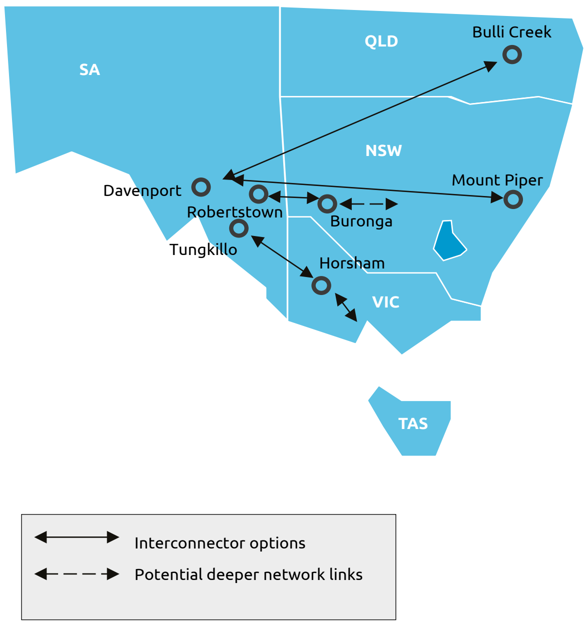
Figure 3.4: The National Electricity Market (NEM) - Interconnector Options[38]



38 https://www.electranet.com.au/wp-content/uploads/resource/2016/11/20161104-Fact-Sheet-Exploring-South-Australias-Energy-Transformation-PSCR.pdf

Benefits of increased interconnections
Increased interconnection between South Australia and the eastern states can...
• Improve wholesale market competition in South Australia and deliver positive price impacts for customers, by allowing greater access to lower cost generation at times of high demand • Improve system security by allowing frequency control services to be sourced from a wider pool of generators, which in turn will allow customers to continue to pursue decentralised choices for home-based generation and storage, while enjoying the back-up provided by a stable grid • Provide access to a more diverse range of supply sources, allowing greater sharing of reserves across regions and improving fuel and supply security for South Australia • Insure against wide-spread loss of supply and disruption following a system event that could separate South Australia from the National Electricity Market (NEM) • Open up access to the market for more renewable generation in South Australia, which has among the best renewable resources in Australia, allowing its clean, renewable energy to help the nation meet renewable energy targets more efficiently

Figure 3.5: The National Electricity Market (NEM): Potential new interconnector options[39]



39 https://www.electranet.com.au/wp-content/uploads/resource/2016/11/20161104-Fact-Sheet-Exploring-South-Australias-Energy-Transformation-PSCR.pdf

Work to explore South Australia's energy transformation had begun long before the storm. While another interconnector may not completely prevent a similar event from happening in future, it would make the network more resilient.

A new high-voltage electricity interconnector between South Australia and the eastern states is one option that could be economic and help facilitate lower electricity prices, system security, and renewable energy goals.

ElectraNet[40] has identified four credible network options, all of which involve constructing a new interconnector between South Australia and the eastern states, and these are explored more in the first stage of the Regulatory Investment Test for Transmission (RIT-T)[41] process

Interconnectors will play an increasing role in Australia's energy future. Investment in this infrastructure may reduce the long term cost to consumers, and deliver a more robust energy system.

The costs and benefits need to be carefully considered, along with the lessons drawn from international markets. Going forward, Australia will need to ensure that regulatory frameworks can adapt to the changing role of interconnectors, and provide a foundation that allows for private sector participation in this rapidly evolving asset class.

South Australia's energy crisis: Need to make infrastructure more resilient to climate change.

Investments in new kinds of capacities: There is enough built capacity for now, but there are capacity risks ahead. Generation capacity has been withdrawn in recent years because of overcapacity in the market. With further withdrawals expected, and new kinds of capacity needed through the transition, new investments will be required over the next decade.[42] New kinds of capacity will also be needed through the transition. The generation capacity currently in the market will not deliver sufficient emissions reductions to meet Australia's 2030 targets and longer-term ambitions.

Investments in Smart grid technologies: The current grids' over reliance on aging twentieth-century technology based on centralized power generation and interconnected distribution architecture will create future systematic vulnerabilities. Transitioning away from large scale fossil fuel power stations to smart-grid technologies with energy storage systems can increase generation and distribution resilience.

Dispersed Portfolio of Intermittent generation :[43] A recent report by the International Energy Agency (IEA) "Getting Wind and Sun onto the Grid", highlights the challenges of intermittent energy integration. A failure to keep pace with rising intermittent generation is expected to lead to increased costs in the long run, and may threaten the security of the grid, as currently witnessed in South Australia.

With Queensland and Victoria setting high state renewable energy targets these risks are also relevant to those states. International experiences throughout the report show that a well-balanced portfolio of wind and solar PV power plant can have complementary electricity output profiles, which may enable the better use of existing grid assets. The report expresses concern for South Australia where the concentration of intermittent generation has led to energy reliability issues rather than the state having a dispersed portfolio which would have provided smoother overall output.

40 Network service provider in https://www.electranet.com.au/wp-content/uploads/resource/2016/11/20161104-Fact-Sheet-Exploring-South-Australias-Energy-Transformation-PSCR.pdf

41 The RIT-T is a cost benefit test that applies to major network investments in the National Electricity Market (NEM) and is overseen by the Australian Energy Regulator (AER)

42 https://grattan.edu.au/wp-content/uploads/2017/05/889-Powering-through.pdf

43 https://www.energycouncil.com.au/analysis/getting-wind-and-sun-onto-the-grid-iea-report/#_edn2

In June 2017, The Finkel Review report recommended, as a part of the orderly transition, generators should also be required to provide three years' notice of their intention to close.

This will provide time for replacement capacity to be built and for affected communities to plan for change. AEMO should also publish a register of expected closures to assist long-term investor planning.

Generators retire with much shorter notice to the market than the time it takes for new capacity to be planned, financed and constructed.

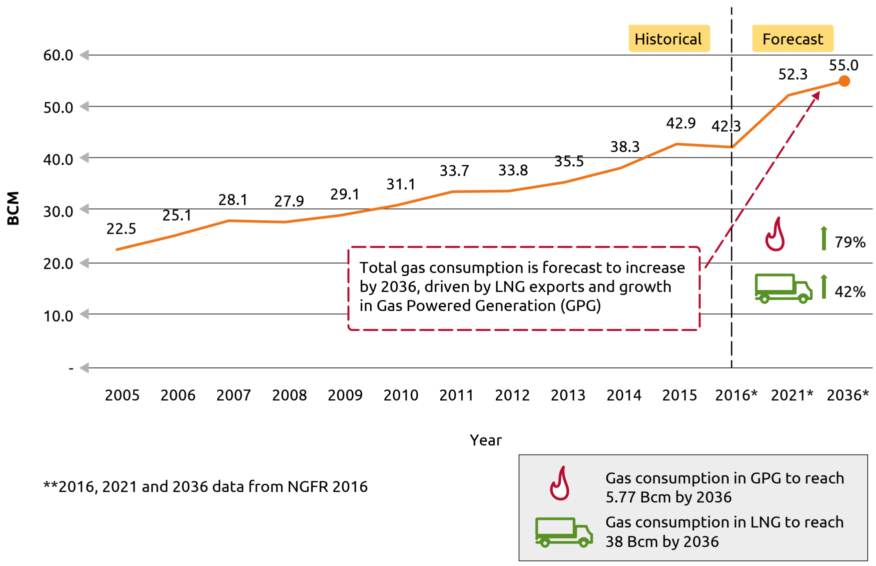
The security and reliability services that these generators provide can and will be met by other means, but the transition will need to be more closely monitored and managed. Existing large generators will need to do more to assist the market to adjust to the impacts of their retirement.

Australian Gas markets

Even though Australia has experienced a steady rise in domestic natural gas consumption over the past decade, the market for domestic consumption of natural gas in Australia is somewhat limited.

- The repeal of Australia's carbon tax in 2014 weakened growth in demand for natural gas, especially in the power sector
- However, the government is interested in reducing carbon dioxide emissions through the use of cleaner fuels such as natural gas and renewables, which is expected to drive natural gas consumption growth at a rate of 2.1% per annum over the next 10 years[44]
- Domestic markets consume most of Australia's natural gas supply, but since 2005, production and LNG sales began expanding
- The gap between Australia's natural gas supply and demand is expected to widen as most of the production growth in the next few years is slated to meet LNG export agreements

Figure 3.6: Australian Gas Consumption (Bcm, 2005-2016; 2021; 2036)[45]



44 http://www.ieee.es/Galerias/fichero/OtrasPublicaciones/Internacional/2017/EIA_Australia_7mar2017.pdf

45 https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-full-report.pdf

Domestic supply of gas has tightened as Queensland's liquefied natural gas (LNG) projects draw on reserves from southern Australia. At the same time, regulatory restrictions on exploration and subdued international oil prices have delayed the development of new reserves. The result, when coupled with rising production costs, has been significantly higher gas contract and spot prices.

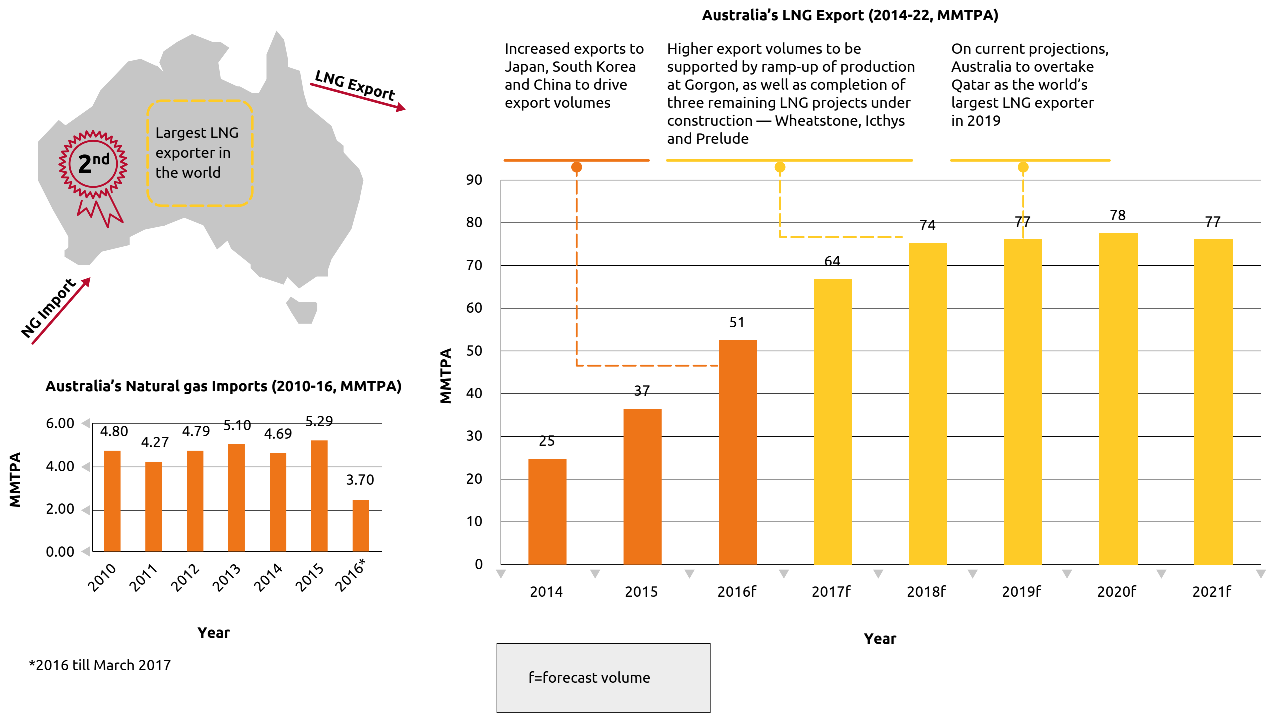
The Australian Energy Market Operator (AEMO) has warned of possible gas shortages as early as the summer of 2018-19 if action is not taken by the market or by government. **These potential shortages, and domestic prices reportedly higher than export prices, suggest possible failures in the domestic gas market.**[46]

Australia has become a leading LNG exporter in the Asia-Pacific region in the past decade. Greater expected natural gas production and new LNG capacity in the next few years is likely to boost natural gas exports even higher.

Over the past decade, Australian LNG exports have increased nearly three times, and they are expected to rise substantially in the medium term as developers usher in new upstream and liquefaction capacity.

Australia is poised to overtake Qatar as the world's largest LNG exporter by 2020 as capacity of its liquefaction terminals builds. Exports rose to 2.1 Tcf in 2016, up from about 1.4 Tcf in 2015.[47]

Figure 3.7: Australia LNG Trade Movements[48]



Australia exports natural gas almost exclusively to Asian markets, with Japan purchasing about 51% of Australia's exports in 2016, mostly through long-term contracts.

The Asian LNG market is currently oversupplied as regional demand has slowed. However, Australia is set to expand its LNG exports through long-term contracts and stronger LNG demand growth in Asia's emerging markets.

Australia's burgeoning LNG industry has faced acute capital cost escalation, requiring much larger investments for new greenfield projects.

High development costs, coupled with a low global oil and gas price environment during the past two years, competition for limited upstream natural gas supply, and an overcapacity of global liquefaction supply, have dampened the investment climate and prompted project owners to delay or cancel many proposed projects.

46 https://grattan.edu.au/wp-content/uploads/2017/05/889-Powering-through.pdf

47 http://www.ieee.es/Galerias/fichero/OtrasPublicaciones/Internacional/2017/EIA_Australia_7mar2017.pdf

48 https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Australian-petroleum-statistics.aspx

Australia's high-cost environment has prompted international companies to focus investments in more advanced export projects and has delayed, downsized, or cancelled projects that encountered greater regulatory challenges, lack of sufficient upstream reserves, or inertia from project partners.

Government response to Australian domestic gas crisis

Government and regulatory responses include a new power to limit exports to apply from 1 July 2017, new Australian Competition and Consumer Commission (ACCC) wholesale gas markets monitoring, reforms to the gas pipeline sector and new incentives in South Australia for gas exploration.

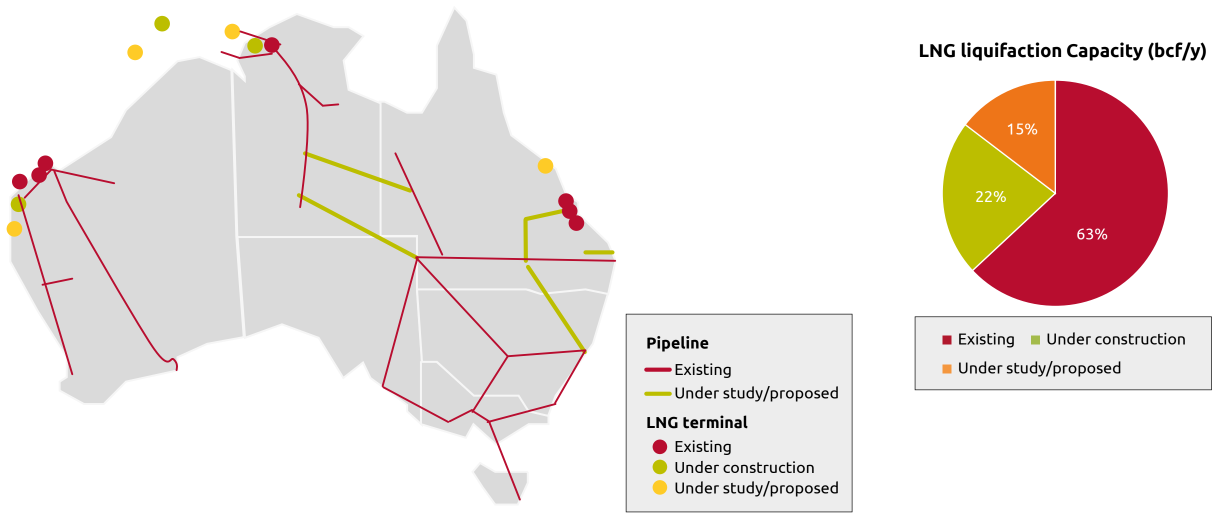
Government Policy Initiatives:

- In April 2017, the government directed the ACCC to monitor wholesale gas markets in eastern Australia, using its inquiry powers to acquire information compulsorily as necessary
- The ACCC inquiry and AEMC recommendations included reforms to spot market design, better quality information to market participants, and easier access to gas pipelines
- The CoAG Energy Council in August 2016 set up a new Gas Market Reform Group to implement the inquiry's and review's recommendations
- In response to escalating concerns about gas prices and the security of east coast gas supplies, the Australian Government in April 2017 announced it would impose export limits from 1 July 2017 on LNG producers that draw more gas from the domestic market than they supply into it

For efficient Gas market, Finkel Review[49] recommendations included:

- By end-2017, the Australian Energy Market Operator should require generators to provide information on their fuel resource adequacy and fuel supply contracts, to enable it to better assess fuel availability
- By mid-2018, the Australian Energy Market Operator should be given a last resort power to procure or enter into commercial arrangements to have gas-fired generators available to maintain reliability of electricity supply in emergency situations
- Governments should adopt evidence based regulatory regimes to manage the risk of individual gas projects on a case-by-case basis. This should include an outline on how governments will adopt means to ensure that landholders receive fair compensation
- By mid-2019, the COAG Energy Council should bring together relevant regulatory and scientific data on gas in an informative and easily accessible format

Figure 3.8: Pipeline and LNG Terminals (Proposed, Operating and Under Construction)[50]



49 https://www.environment.gov.au/system/files/resources/1d6b0464-6162-4223-ac08-3395a6b1c7fa/files/electricity-market-review-final-report.pdf
50 http://www.ieee.es/Galerias/fichero/OtrasPublicaciones/Internacional/2017/EIA_Australia_7mar2017.pdf

As of the beginning of 2017, three new projects and one expansion project under construction in northwestern Australia are expected to begin production by 2019.

New LNG projects such as Gorgon, Wheatstone, and Ichthys are expected to support the country's natural gas exports and produce condensate as a by-product. Ichthys, a natural gas field heavy in condensates, could reach a peak production level of 100,000 b/d by 2020. Altogether, these new LNG projects are expected to add about 175,000 b/d by 2020.[51]

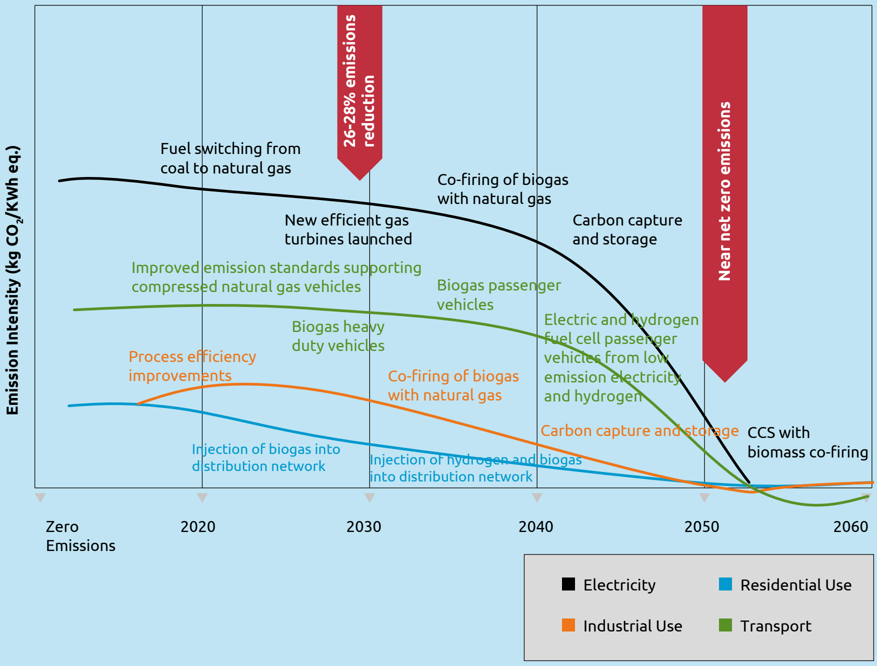
Several proposed projects are waiting on regulatory approvals or final investment decisions. However, project owners have suspended or cancelled any projects not under construction until regional LNG market conditions become more favorable for investors.

Topic Box 3: Gas evolution and regulatory policies "Gas supporting energy transformation to a cleaner future"

Australia's journey towards decarbonization will present many opportunities. The gas sector is well-placed to provide reliable and secure energy and cost-effective carbon reductions by 2050 across the entire economy, from power generation, industry, transport and within the home. These opportunities will require deployment of three key transformational technologies:

- Biogas production
- Carbon capture and storage
- Hydrogen

Figure 3.9: Evolutionary Role of Gas in a Near Zero Emission Scenario[52]

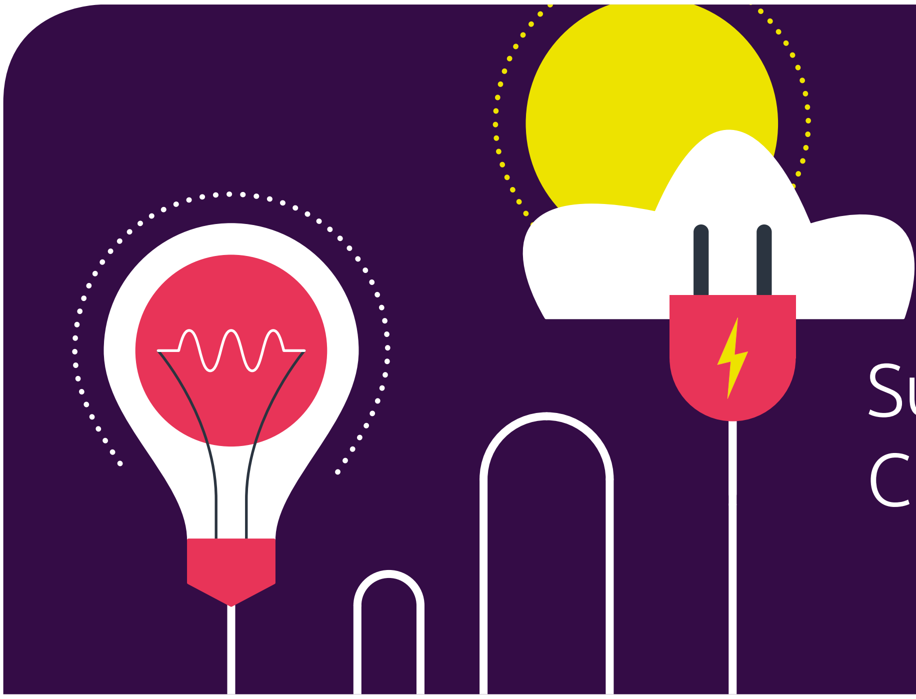


What will drive energy transformation?

- Australia's ageing power fleet and the closure of coal-fired power stations, such as the planned closure of Victoria's Hazelwood power station in early 2017
- The increased level of residential rooftop photovoltaic (PV) throughout the network will reduce electricity generation demand from other sources
- The projected growth in electrical vehicles will require additional electricity generation
- Gas infrastructure already reaches 6.5 million homes. Leveraging this existing infrastructure makes economic sense
- Growing gas distribution networks to new regions in Australia
- Reduction of household gas consumption due to improved housing efficiency and warming weather
- The intermittent nature of renewable generation and the additional cost for energy storage to allow it to be dispatchable
- A tighter gas supply market with exploration and development restrictions for onshore gas in many Australian jurisdictions

51 http://www.ieee.es/Galerias/fichero/OtrasPublicaciones/Internacional/2017/EIA_Australia_7mar2017.pdf

52 http://www.energynetworks.com.au/sites/default/files/gasvision2050_march2017.pdf



Supply and Final Customer

The past 12–18 months have been some of the most challenging Australia's energy sector has experienced since the National Electricity Market (NEM) was established in 1998. The primary focus has been on wholesale markets, both for electricity and gas.

In electricity, investor uncertainty around the viability of new generation investment, combined with recent coal plant closures, has contributed to a generation mix that is increasingly reliant on intermittent wind and solar energy.

In gas, domestic supply has tightened as Queensland's liquefied natural gas (LNG) projects draw on reserves from southern Australia. At the same time, regulatory restrictions on exploration and subdued international oil prices have delayed the development of new reserves. The result, when coupled with rising production costs, has been significantly higher gas contract and spot prices.

Rising wholesale energy prices are affecting retail prices. These concerns have prompted policy initiatives and inquiries into whether energy markets are delivering for consumers.

Governments around Australia have embraced privatization over the past two decades. Both the Commonwealth and other State Governments have leased or sold government-owned businesses and assets, and used the capital raised to either pay down accumulated debt or recycled the proceeds into new public infrastructure assets.[53]

The Productivity Commission (Australian Government's independent research and advisory body) in 2013 found that 'state owned network businesses appear to be less efficient than their private sector peers'.

The case was further strengthened by the release of Infrastructure Australia's Australian Infrastructure Plan in February 2016. The Plan noted that- **"Domestic and international evidence shows that cost-minimizing, profit maximizing ownership structures [which incidentally were the original objectives of the National Competition Policy and the National Electricity Market reforms] are the best means to deliver efficient and customer responsive infrastructure. Private owners have the best incentives to respond to these drivers when compared to public ownership, but the integrity of the model relies on governments retaining an active role of market maker and sophisticated regulator".**

The pace of change and disruption in the energy sector is significant – increased distributed generation (for example residential solar panels), battery storage, and electric vehicles will all influence the use of the grid going forward.

Electricity networks retained in government ownership face many more constraints in this evolution exposing the government to potential lower returns and greater risk, which would influence future network value.

In WA, this will be further influenced by the proposed State energy reform encouraging more transparent prices, including changes to the capacity mechanism for generators and introduction of full retail contestability.

Australia's electricity grid is well established in the eastern and southern states under the National Electricity Market (NEM), a wholesale market that connects five Australian states and the Australian Capital Territory.

The NEM infrastructure is owned by a mixture of state-level governments and the private sector.

Western Australia and the Northern Territory each have separate transmission networks.[54]

Over 300 registered generators sell electricity into the NEM spot market in Australia

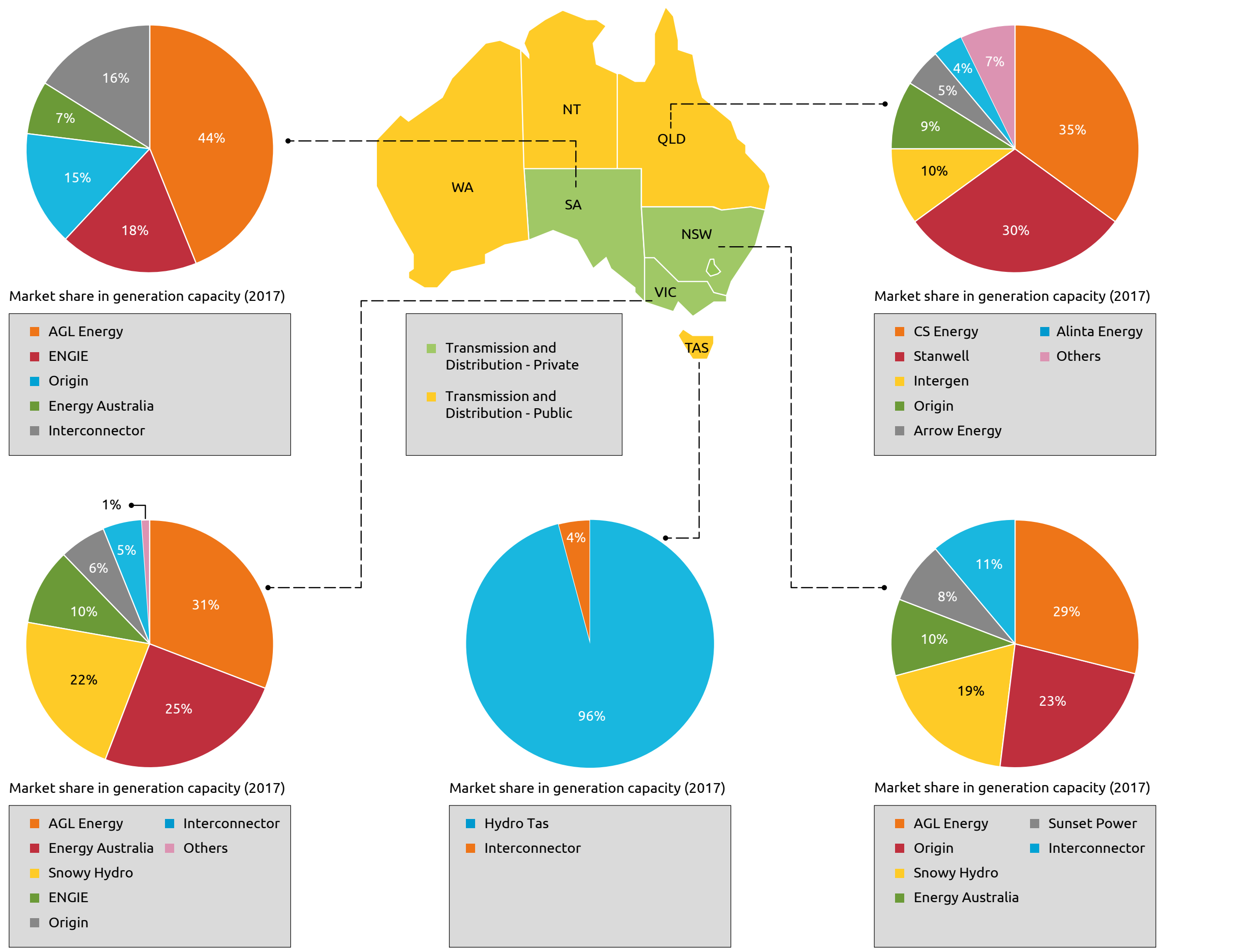
- Market concentration in Victoria and South Australia has risen following recent plant withdrawals
- Private entities own most generation capacity in Victoria, NSW and South Australia
- Government owned corporations own or control the majority of capacity in Queensland and Tasmania
- In Tasmania, the state owned Hydro Tasmania owns nearly all generation capacity

> Timing for privatization therefore appears optimal with the ability for private sector capital targeted at innovation to address these technological and consumer challenges, and better enabling productivity improvements.

53 http://www.pwc.com.au/publications/assets/power-case-for-change-oct16.pdf

54 http://www.ieee.es/Galerias/fichero/OtrasPublicaciones/Internacional/2017/EIA_Australia_7mar2017.pdf

Figure 4.1: Market Shares in Generation Capacity - 2017[55]



Notes: Capacity is based on summer availability for January 2017, except wind, which is adjusted for an average contribution factor.Interconnector capacity is based on observed flows when the price differential between regions exceeds $10 per MWh in favour of the importing region; the data excludes trading intervals in which counter flows were observed (that is, when electricity was imported from a high priced region into a lower priced region). Capacity that is subject to power purchase agreements is attributed to the party with control over output

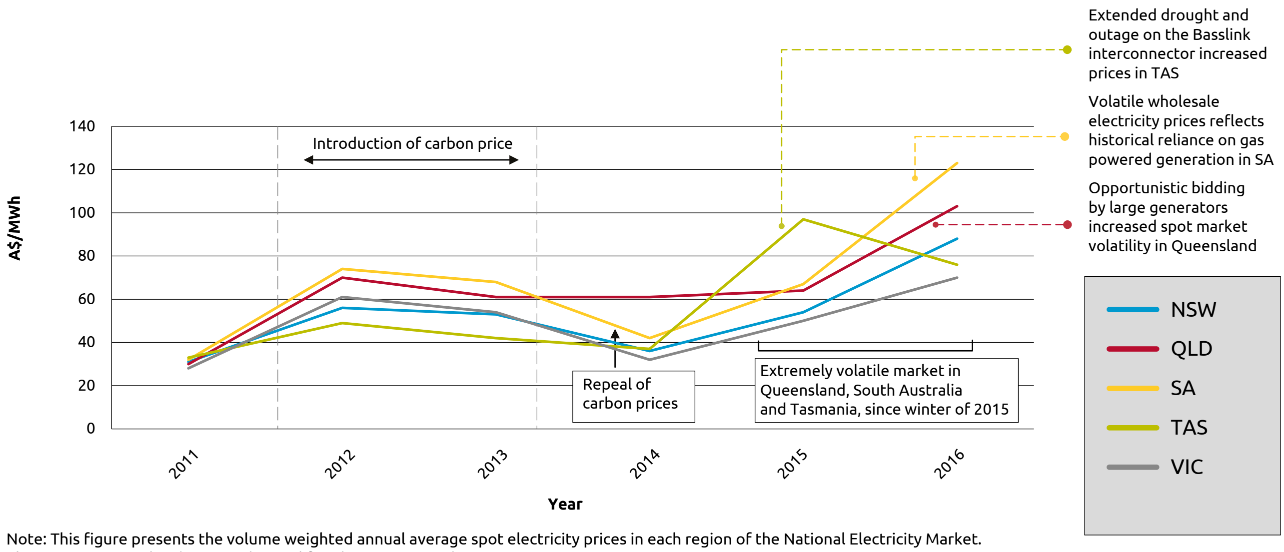
Victoria and South Australia Governments privatized their electricity networks in the 1990s. NSW is currently in the process of privatizing its transmission and distribution businesses.

Wholesale electricity price rise was observed in every NEM region in 2015–16, with rises around 50–60 % in Victoria, NSW and South Australia

- Tasmanian prices rose by 160% (to a regional record) when a six month outage on the Basslink interconnector to Victoria coincided with depleted dam levels for hydro generation
- Prices continued their upward trajectory on the mainland in the nine months to 31 March 2017, with the steepest rises occurring in South Australia, Queensland and NSW
- Against this pattern, Victorian prices held relatively steady over this period, and Tasmanian prices eased off their historical peak of the previous year
- Volatility affected many regions in summer 2016–17, when high temperatures drove up peak demand and contributed to a series of price spikes in Queensland and NSW, with Queensland recording a new record peak demand on 18 January 2017

55 https://www.aer.gov.au/system/files/AER%20State%20of%20the%20energy%20market%202017%20-%20A4.pdf
http://www.pwc.com.au/publications/assets/power-case-for-change-oct16.pdf

Figure 4.2: Wholesale Electricity Spot Prices (A$/MWh, 2011-2016)[56]



Note: This figure presents the volume weighted annual average spot electricity prices in each region of the National Electricity Market. The average is weighted against demand for electricity. YTD data current at 30 June 2017

The market has been extremely volatile since winter 2015, particularly in Queensland, South Australia and Tasmania.

Thirty minute prices exceeded A$ 277 per MWh almost 4000 times in 2015–16, which was an unprecedented number. And another 2100 instances were recorded in the first nine months of 2016–17.

South Australian Market	
Price rise and Volatility - Key Factors	**Policy responses**
• Higher and more volatile in wholesale electricity prices reflects historical reliance on gas powered generation, and its higher ratio of peak to average demand • Other factors : Relatively concentrated generator ownership, generator bidding behavior, thermal plant withdrawals, and limited import capability • High levels of wind capacity also contribute to price swings, given wind's intermittent nature	• The South Australian Government in March 2017 announced construction of a 250 MW gas powered generator to provide emergency back-up power and system stability services[57], along with: – Incentives for increased gas production – Investment in large scale battery storage • 29 March 2017, Engie announced its mothballed capacity at Pelican Point would return to service by 1 July 2017[58] – The return to service will add 240 MW of capacity to the South Australian market

Queensland Market	
Price rise and Volatility - Key Factors	**Policy responses**
• Opportunistic bidding by large generators has caused periods of spot market volatility in Queensland for several years – Similar patterns occurred in the Queensland market in summer 2015–16 – Generators rebid capacity into high price bands on days when hot weather drove very high demand, typically when import capacity across the interconnectors to NSW was constrained – In some instances, network limitations forced counter price export flows––that is, Queensland exported power to NSW when its own capacity was stretched and its prices were high	• The AER in 2016 revised its Rebidding and technical parameter guidelines to reflect the new rules – The guidelines set out the information that must be provided to AEMO to support a rebid of capacity, and bids or rebids of technical parameters – They also explain how the AER requests additional information from generators on their bidding behavior • Opportunistic bidding by large generators can be profitable because dispatch and settlement prices are determined over different timeframes – The AEMC was considering a rule change proposal in 2017 to align the timeframes for dispatch and settlement prices to five minutes[59]

56 https://www.aer.gov.au/wholesale-markets/wholesale-statistics/annual-volume-weighted-average-spot-prices
57 https://www.premier.sa.gov.au/index.php/jay-weatherill-news-releases/7198-south-australia-is-taking-charge-of-its-energy-future
58 http://www.gdfsuezau.com/media/UploadedDocuments/News/Pelican%20Point%20return%20to%20service%20-%20media%20release.pdf
59/ http://www.aemc.gov.au/getattachment/b712c6c7-3650-4856-9a3a-d0a2e4c7fa64/Information-sheet-Directions-paper.aspx

Tasmanian market	
Key Factors	**Policy responses**
• Two key factors accounted for wholesale price rise: – Extended drought conditions- The onset of drought coincided with already low dam levels due to Hydro Tasmania's decision to raise output in 2012–13 and 2013–14 when carbon pricing made hydro-generation more profitable – A six month outage on the Basslink interconnector to the mainland- Difficulties in identifying the fault's location and undertaking repair work meant the interconnector remained out of service from December 2015 to June 2016	• AEMO reported in December 2016 that a second Bass Strait interconnector would provide A$67 million in market benefits by increasing the transmission network's resilience to potential interconnector failures • The Tasmanian Energy Security Taskforce recommended Tasmania develop a more rigorous framework to manage water storages, and retain the Tamar Valley gas powered generator as a back-up power station

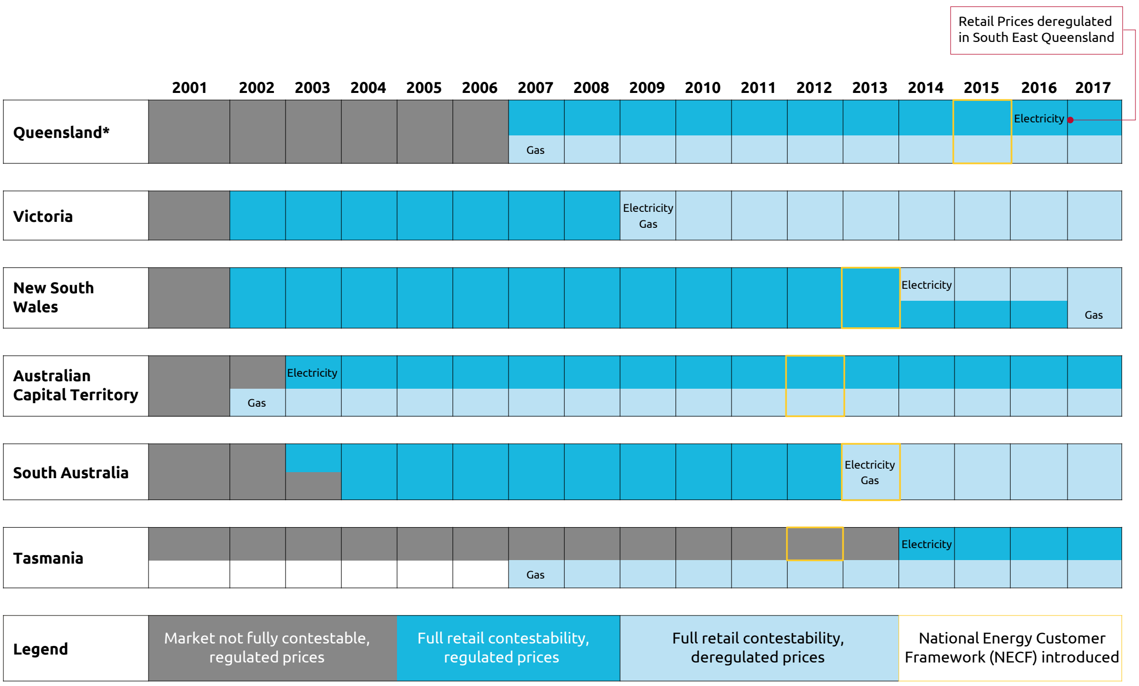
Causes of this volatility are complex and differ between regions, although common factors are evident...

- One common thread is a tightening in the supply– demand balance, particularly, the mothballing of significant coal fired plant has coincided with a resurgence in peak demand, particularly in NSW and Queensland
- The reduction in supply meant gas fired generation was setting the dispatch price, at a time when gas fuel costs were extremely high
- The market stabilized in most regions in July 2016, but prices remained high in South Australia, as work to upgrade the Heywood interconnector constrained the state's import capacity in a period of low wind generation

Energy retail markets in Victoria and New South Wales became fully contestable in 2002. Gas retail markets in the Australian Capital Territory also became fully contestable and deregulated (gas retail prices) around same time.

Over time other NEM jurisdictions have opened up retail energy markets to competition and removed price regulation. At the same time, regulation of energy retail markets has evolved to promote competition and influence the pace of these markets' transition through the competitive stages.

Figure 4.3: Progress of retail energy market reform across jurisdictions[60]



Note: Queensland has two distinct energy markets – South East Queensland and regional Queensland based on their electricity distribution areas. In South East Queensland, retail electricity prices were deregulated on 1 July, 2016 while in regional Queensland electricity prices are subsidized through the Uniform Tariff Policy (UTP).

60 http://www.aemc.gov.au/getattachment/d5a60d5b-d2dc-4219-af60-51c77d8aaa4f/Final-Report.aspx

Retail electricity prices rose significantly between 2008 and 2013, mainly due to escalating network costs. During this period, network businesses invested heavily in assets to accommodate expected demand growth, and financial market instability raised debt costs. The carbon price also contributed—raising retail prices by 5–13% in 2012 —although an assistance package offset the impact on low and middle income residential customers.

In 2014, the repeal of carbon pricing reduced retail electricity prices in most regions. Declining network costs, accompanied by an oversupply of generation capacity, further eased pressures on retail electricity prices in most jurisdictions in 2015.

This trend reversed in 2016, when the retirement in May of the large Northern coal fired generator in South Australia tightened wholesale market conditions and drove up costs in spot and derivative markets. These higher costs began to flow through to residential electricity prices during the year.

Overall, electricity retail prices trended higher in 2016 in all jurisdictions other than Victoria. The rise was highest for South Australia (13%), followed by NSW (8%), the ACT (6%), Queensland (6%) and Tasmania (3%). In Victoria, significantly lower network charges following an AER determination offset the impact of rising wholesale costs. As a result, retail bills fell by 3–5% in most of the state.

Figure 4.4: Movements in Energy Bills for Customers on Regulated or Standing Offers[61]

During 2014-15, repeal of carbon prices, declining network costs and oversupply of generation capacity lead to reduced electricity prices. However, the trend reversed in 2016 with increase in gas prices.

Note: Prices are based on regulated prices of the local area retailer in each distribution network area, or on standing offer prices where prices are not regulated average price reduction of 4% in Victoria was offset by 40% increase for Citi power distribution network customers.

61 https://www.aer.gov.au/system/files/AER%20State%20of%20the%20energy%20market%202017%20-%20A4.pdf

- **The AEMC found market costs (wholesale and retail costs) were the main driver of higher retail bills in 2016, with most jurisdictions recording double-digit rises in this cost component. The AEMC cited generation plant closures as a significant contributor to these cost increases**
- **Rising wholesale gas prices have also affected electricity prices, particularly where gas generation sets the wholesale price**
- **The retirement of Victoria's Hazelwood power station in March 2017 will likely put further pressure on wholesale market costs in the short to medium term. This development was already reflected in significant price rises notified by Victorian retailers in January 2017**

As traditional generators leave the market, liquidity in electricity financial markets may further tighten, putting additional upward pressure on wholesale costs

State of retail competition in Australian Electricity Market: is it working for consumers?

According to survey data published by Energy Consumers Australia in December 2016, around 50% of energy customers in Victoria, NSW and South Australia (where retail electricity prices are not regulated) were satisfied with levels of competition in energy retail markets[62]

- This satisfaction rate was around 30% in Queensland and the ACT, and 15% in Tasmania

The AEMC assessed in 2016 that competition was effective for electricity markets in NSW, Victoria, south east Queensland and South Australia[63]

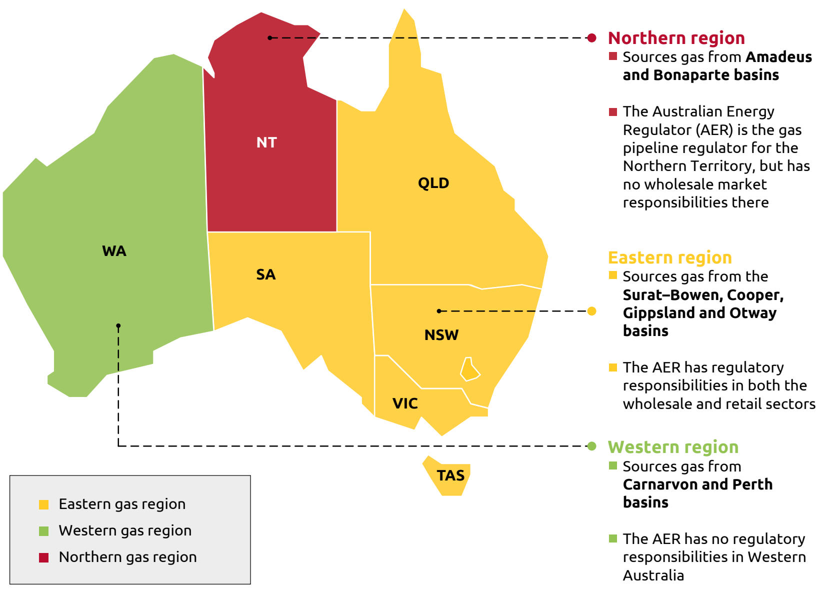
- Those markets had evidence of new retailer entry and second tier retailers attracting customers from more established firms, resulting in lower rates of market concentration

The AEMC estimated in 2016 that electricity customers in NSW, Victoria, south east Queensland and South Australia could save A$194–531 annually by regularly shopping around[64]

- Competition is less effective in the ACT and yet to emerge in Tasmania and regional Queensland
- Retailers commonly cite ongoing price regulation and the dominance of incumbent retailers as barriers to entry in those regions
- In Tasmania, no energy retailer has entered the residential electricity customer market to compete with Aurora Energy

Australia's domestic gas market consists of three distinct regions, separated on the basis of the gas basins and pipelines that supply them.

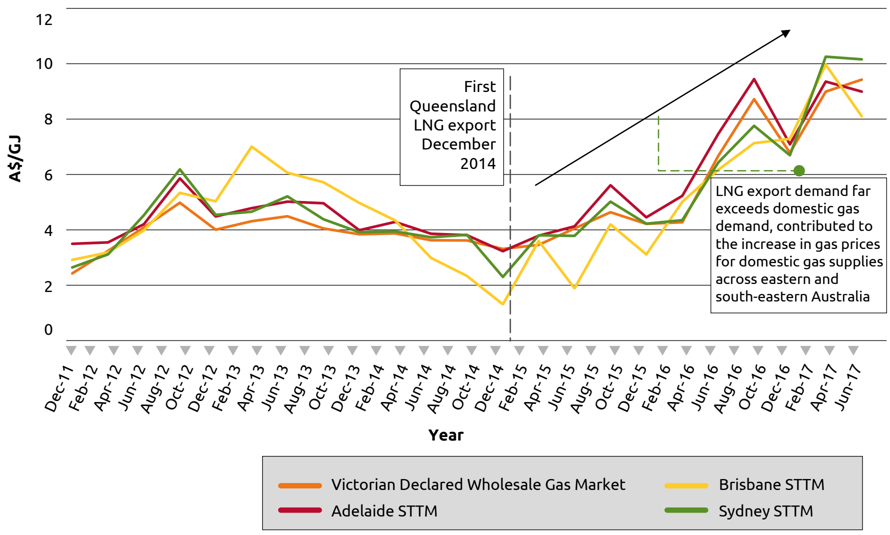
Figure 4.5: Natural Gas Markets In Australia[65]



62 http://energyconsumersaustralia.com.au/wp-content/uploads/Energy-Consumer-Sentiment-Survey-Findings-National-Dec2016.pdf
63 http://www.aemc.gov.au/getattachment/d5a60d5b-d2dc-4219-af60-51c77d8aaa4f/Final-Report.aspx
64 http://www.aemc.gov.au/getattachment/d5a60d5b-d2dc-4219-af60-51c77d8aaa4f/Final-Report.aspx
65 http://www.aemc.gov.au/Australias-Energy-Market/Markets-Overview/National-gas-market

Recent increases in wholesale electricity prices are not solely due to a tightening of electricity supply. In the past 12 months gas prices increased rapidly, which fed through to the price of electricity.

Figure 4.6: Quarterly Gas Prices (A$/GJ)[66]



Note: Victorian gas market average daily weighted prices by quarter are shown with the average daily ex ante gas prices by quarter for each Short Term Trading Market hub (Brisbane, Sydney and Adelaide)

With the advent of liquefied natural gas (LNG) export projects on Australia's east coast, the domestic price for gas has risen to compete with international prices.[67] Gas prices are now much higher than the historical A$ 4.2 to A$5.6 a gigajoule.

In March 2017, Origin Energy recently signed a contract with the South Australian power station, Pelican Point, to purchase gas for at least A$11 a gigajoule (plus network costs).[68]

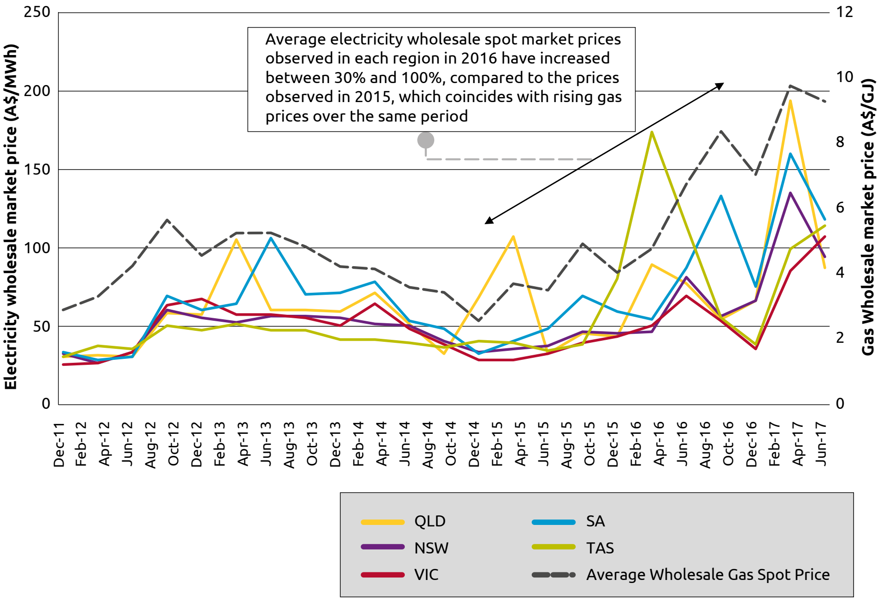
In 2016, winter, gas prices in the spot market reached A$61 a gigajoule in Melbourne, A$42 a gigajoule in Adelaide, A$42 a gigajoule in Sydney and A$26 a gigajoule in Brisbane.[69]

Gas now matters more in electricity generation than it used to. The exit of major coal-fired power stations – Northern and Hazelwood – means the NEM now relies more on gas-fired power when demand is high, or when there is little wind or sunshine.

Increases in gas prices and an increased need for gas generation means higher wholesale electricity prices.

66 https://www.aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/GSOO/2017/2017-Gas-Statement-of-Opportunities.pdf
67 https://grattan.edu.au/wp-content/uploads/2017/05/889-Powering-through.pdf
68 http://www.afr.com/business/energy/electricity/origin-energy-to-provide-gas-to-pelican-point-plant-in-sa-20170328-gv8nau
69 https://grattan.edu.au/wp-content/uploads/2017/05/889-Powering-through.pdf

Figure 4.7: Average Regional Electricity Prices Compared to Average Gas Prices (A$/MWh)[70]



Note: Victorian gas market average daily weighted prices by quarter are shown with the average daily ex ante gas prices by quarter for each Short Term Trading Market hub (Brisbane, Sydney and Adelaide); Electricity figure presents the volume weighted annual average spot electricity prices in each region of the National Electricity Market. The average is weighted against demand for electricity. YTD data current at 30 June 2017

On an annual basis, average electricity wholesale spot market prices observed in each region in 2016 have increased between 30% and 100%, compared to the prices observed in 2015, and this coincides with rising gas prices over the same period.

The increased prices in Tasmania coincided directly with the outage of the Basslink interconnector from December 2015 to June 2016.

If electricity prices continue to increase in line with rising gas prices, this could ultimately threaten the viability of vulnerable electricity customers.

The convergence of energy markets in eastern and south-eastern Australia demands a single energy view – gas and electricity markets can no longer be viewed in isolation.

Reforms and Initiatives to mitigate gas price volatility and supply shortfalls…

In current uncertain market environment, industry is taking or exploring measures to manage the risks of possible gas supply shortfalls. The initiatives include:

- Transmission pipeline investment and upgrades, including pipeline re-engineering and new interconnections: The gas transmission pipeline industry is investing in new infrastructure and providing more flexible arrangements to meet customer requirements
- Gas field development: Various gas development proposals were on the table in 2017, although EnergyQuest assessed only two as showing material progress: Cooper Energy's Sole project and Senex's south west Queensland project
- LNG imports: AGL Energy is exploring options for an LNG import terminal by 2021, to source lower cost gas for its customers

Policy Initiatives to help alleviate pressures in the eastern gas market

- Reform of gas spot markets: The AEMC also proposed immediate actions to improve market and price transparency
- Reform of the gas transmission pipeline sector: The CoAG Energy Council tasked an expert panel led by Dr. Michael Vertigan with examining the regulatory framework for gas pipelines, including the adequacy of the coverage criteria
- Pipeline capacity trading reforms: The CoAG Energy Council agreed to establish a trading platform, day ahead auctions of contracted but un-nominated capacity, the standardization of contractual terms, and the publication of secondary capacity trade information

70 https://www.aemo.com.au/-/media/Files/Gas/National_Planning_and_Forecasting/GSOO/2017/2017-Gas-Statement-of-Opportunities.pdf

Topic Box 4: Cascading government interventions likely to transfer investment risk and cost to consumers

High wholesale prices are the signal to build new power generation. Until the market responds, high prices will flow through to consumers.

- Household bills in Sydney and Adelaide increased by around 10% in 2016
- In Victoria, similar bill increases were announced at the start of 2017
- The above price increases come on top of a real 70% increase in electricity bills across the NEM over the past decade

Cascading government interventions would likely lead to an approach where investment risk and costs are transferred to consumers, prices are higher than necessary, security of supply is dependent on imperfect forecasts, and emissions reduction targets may still not be achieved.

However, the better way to address above concerns is through urgent action on stabilizing a physical system with increasing levels of wind and solar.

- Rule changes are needed to ensure there can be quick and efficient responses if there are shortages in generation
- Power generators should be rewarded for being flexible and responding quickly
- Consumers should be offered a financial incentive to reduce their demand at peak times, thereby reducing pressure on the system

Consumers can help to manage system security and capacity problems by reducing their demand at peak times. Some large industrial consumers are already paid to do this, but not enough is done to encourage households and small businesses to do the same. Some electricity network businesses and retailers have developed demand-response options, but these are not yet widespread.

While there may be no regulatory barriers preventing demand-side participation, accessibility is still an issue. When security issues arise or supply is tight, market responses are still heavily on the supply side.

But demand-side responses may represent better value. While demand-response options are available to large consumers, it is not clear that they are being taken up, or that all businesses are aware of them.

Market Transitions and Innovation

Fast paced technology changes are fundamentally altering Australia's energy market. Energy policy and the associated regulatory frameworks are also gradually evolving to adapt to these changes and to provide a dynamic market response

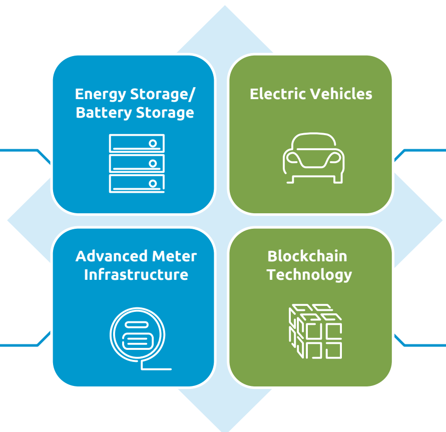
Figure 5.1: Technology Advances and Innovation in Australia's Energy Market

'Behind the meter' applications and off grid remote locations have been identified as core opportunity areas for energy storage

Battery storage Virtual Power Plant projects have been initiated in South Australia and Victoria to improve grid stability during peak times

2.8 million smart meters have been installed across the state of Victoria

Other states like NSW and Queensland are also engaging in voluntary market led roll out of smart meters, supported by a more robust metering safety and compliance regime



EV uptake is likely to increase significantly due to combined effect of declining battery prices and industry level initiatives

Electric vehicles expected to account for 27% of all vehicle sales by 2035-36, up from a share of only 0.2% in 2015

Australian startups exploring blockchain based trading schemes for energy distribution - encouraging consumers to trade excess renewable energy leveraging this technology

Supporting regulatory initiatives

In an effort to drive market innovation, AEMC proposed 'Competition in Metering' rule change in 2015 which is scheduled to commence from Dec1, 2017

Introduction of cost reflective tariff recommended by AEMC to provide customers with greater visibility on their electricity usage

Finkel review published in June 2017, recommended financial rewards to customers sharing their resources like solar PV and battery storage

Supporting regulatory initiatives

Electric Vehicle Council launched in May 2017 to drive adoption of electric vehicles and lay out the future roadmap for national public charging infrastruc-ture

Clean Energy Target, proposed by Finkel review outcome will incentivize new low emissions generators to enter the market in an effort to lower long term emissions

AEMC exploring policies to enable customers to buy and sell electricity in DER market

Rapid uptake of renewable technology and leaps forward in energy efficient and storage systems have been game changers for generators, distributors, retailers and consumers of electricity. The benefits of it can be harnessed effectively provided the evolution of regulatory framework keeps pace

Regulation Evolution

Emergence of new technologies and business models have challenged the traditional regulatory framework and triggered reform changes initiated by AEMC; measures required to further streamline the policies

Regulated monopoly landscape of distribution network is changing with modernization of National Electricity and Energy Retail Rules, following the Power of Choice review by AEMC in 2011

Competition in metering reforms:

- In 2015, AEMC made a final rule to open up competition in metering services and provide consumers with more opportunities to access a wider range of services – the new arrangement will take effect on 1 December 2017[71]
- The policy changes are designed to 'facilitate a market-led approach to the deployment of advanced meters' to 'promote innovation and investment

Empowering customers with more visibility on their energy usage :

- The outcome of Finkel review highlighted 'rewarding customers' as of the top priorities of National Electricity Market going forward[72] – providing customers with better access to information to support their choice will be one of the key focus areas
- AEMC is exploring ways to enable customers to buy and sell energy at the distribution level, in a more dynamic way, in response to price signals[73]
- Cost reflective pricing - From 2017, the prices paid by households and businesses will better reflect the different ways they use electricity and the costs of providing it to them, thus helping them in informed decision making.[74] As per the Finkel review outcome, ACCC[75] price inquiry is examining the electricity retail market, which will provide an opportunity to improve the transparency and clarity of electricity retail prices and help customers be aware when the terms of their offer change or discounts expire

71 http://www.aemc.gov.au/Rule-Changes/Expanding-competition-in-metering-and-related-serv#
72 http://www.environment.gov.au/system/files/resources/1d6b0464-6162-4223-ac08-3395a6b1c7fa/files/electricity-market-review-final-report.pdf
73 http://www.aemc.gov.au/getattachment/124ababc-74a8-4fb2-8813-fbd385dfc1dd/Infographic.aspx
74 http://www.aemc.gov.au/Major-Pages/AEMC-work-overview/Network-regulation-and-cost-reflective-pricing
75 Australia Competition and Consumer Commission

AEMC highlighting new plans for strengthening power system security to accommodate new technologies; Finkel review outcome echoes similar trend:

Non synchronous intermittent generation like wind and solar have low inertia, indicating less recovery time from sudden equipment failure. To support the efficient use of these low inertia systems, clear standards have been set

- New rules put forth by AEMC require network companies to provide a designated operating level of inertia at all times – investment incentives for those which deliver above the requisite level
- Rules mandating non-synchronous generators to be built in a way that makes them capable of providing FFR[76] services if required in the future
- Finkel review report recommends a package of Energy Security Obligations[77] to be adopted by mid-2018. It mandates new VRE[78] generators to provide essential security services and more conservative operation in each region through maintaining system inertia and tighter frequency control

Despite the progress, further scope for improvement exists in the regulatory front - Finkel review report recommends AEMC to review and update the regulatory framework by end of 2018 and to facilitate Proof of Concept testing of innovative technologies:

- As the scope for competition for network services expands, the regulatory regime will need more dedicated mechanisms to define the boundaries of regulation and competition for each service and market
- Alternative regulatory approaches which are less resource intensive but provide better incentives requires further exploration, for e.g. the TOTEX (total expenditure) approach -under this approach, regulated networks would be given a single operating and capital investment allowance, driving least cost outcomes for consumers, and removing any potential

76 Fast frequency Response

77 https://www.environment.gov.au/system/files/resources/1d6b0464-6162-4223-ac08-3395a6b1c7fa/files/electricity-market-review-final-report.pdf

78 Variable Renewable Electricity

bias towards expensive capital investment solutions [79]

- Recommendations from Finkel review suggest that the deployment of new technologies and improved integration of VRE generators needs to be supported by better data – like access to best weather impact and forecasting capabilities, early testing of technology, cyber threat awareness and workforce preparedness[80]

Australian market taking significant technological leaps forward to achieve its renewable energy and emission reduction targets

Electric Vehicle adoption to gain significant traction in the next 20 years

Uptake of electric vehicles has been relatively modest to date, accounting for about 0.2% of electric vehicle sales in 2015[81] . Despite the current low adoption, the combined impact of industry support and declining battery prices will drive Australia's uptake of electric vehicles through 2036, as key components of the future low-carbon, distributed renewables grid.

Electric Vehicle Council (EVC) launched in May 2017 to drive uptake of electric vehicles in Australia[82]

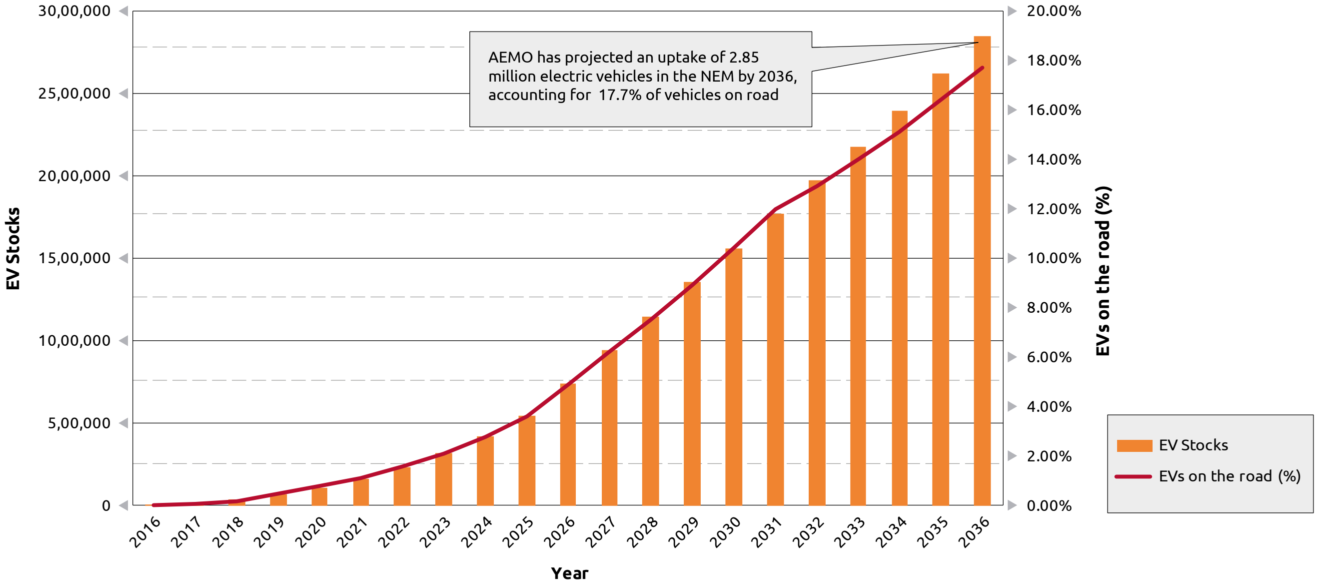
- EVC is an industry-led organization representing and coordinating the broader electric vehicle industry in Australia
- The council is being funded by a A$390,000 grant from ARENA[83]
- The funding will be leveraged to formulate policy measures, including incentivizing purchase of electric vehicles in short term, through upfront incentives and taxation measures
- The council will also recommend a roadmap for national public charging infrastructure

Key regulatory developments are underway to incentivize energy efficiency, innovation and help NEM cope within technological advances. Policies and framework needs to further evolve in future to support the market transition

79 https://www.environment.gov.au/system/files/resources/1d6b0464-6162-4223-ac08-3395a6b1c7fa/files/electricity-market-review-final-report.pdf
80 https://www.environment.gov.au/system/files/resources/1d6b0464-6162-4223-ac08-3395a6b1c7fa/files/electricity-market-review-final-report.pdf
81 https://www.environment.gov.au/system/files/resources/97a4f50c-24ac-4fe5-b3e5-5f93066543a4/files/independent-review-national-elec-market-prelim.pdf
82 http://electricvehiclecouncil.com.au/new-national-body-to-drive-uptake-of-electric-vehicles-in-australia/
83 Australian Renewable Energy Agency

Australian councils and businesses such as shopping centers are installing electric charging points for electric vehicles typically containing IoT equipment, thus supporting adoption of such technologies - Willoughby City Council renewable energy program and electric charging points at Westfield Chatswood, NSW are some of the examples of this initiative[84]

Figure 5.2: Projected Uptake of Electric Vehicle in NEM By 2035-2036 (neutral outlook)[85]



84 https://www.its-australia.com.au/wp-content/uploads/Smart-Transport-for-Australia.pdf

85 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEFR/2016/AEMO-insights_EV_24-Aug.pdf

Figure 5.3: Annual Electric Vehicle Sales in NEM by 2035-2036 (neutral outlook)[86]

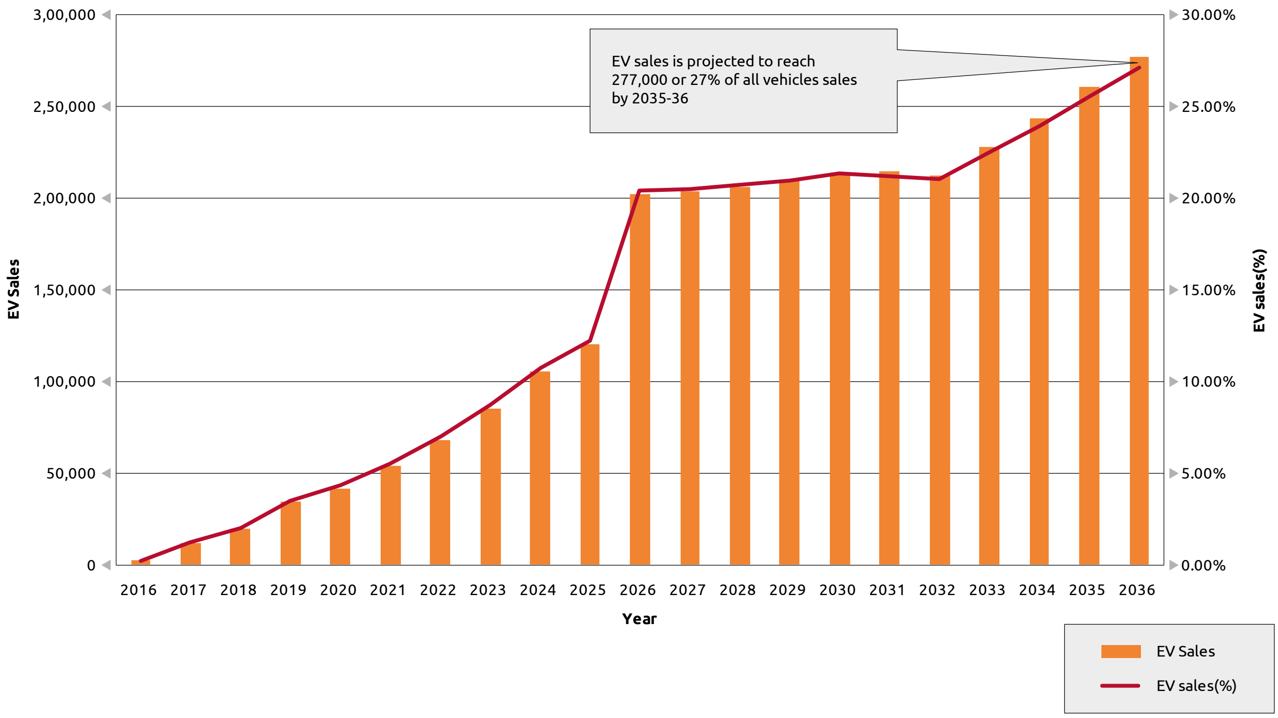
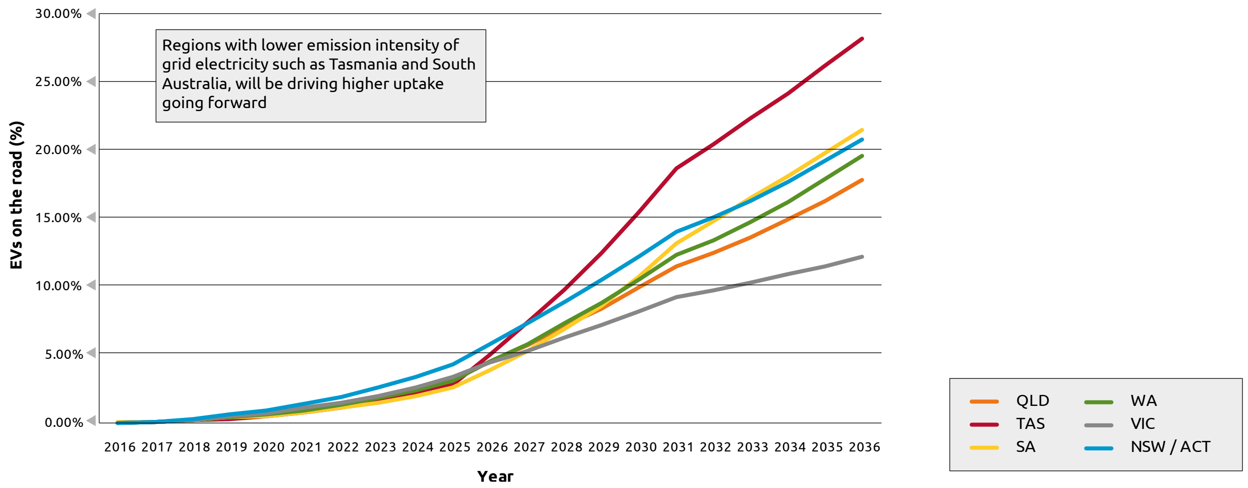
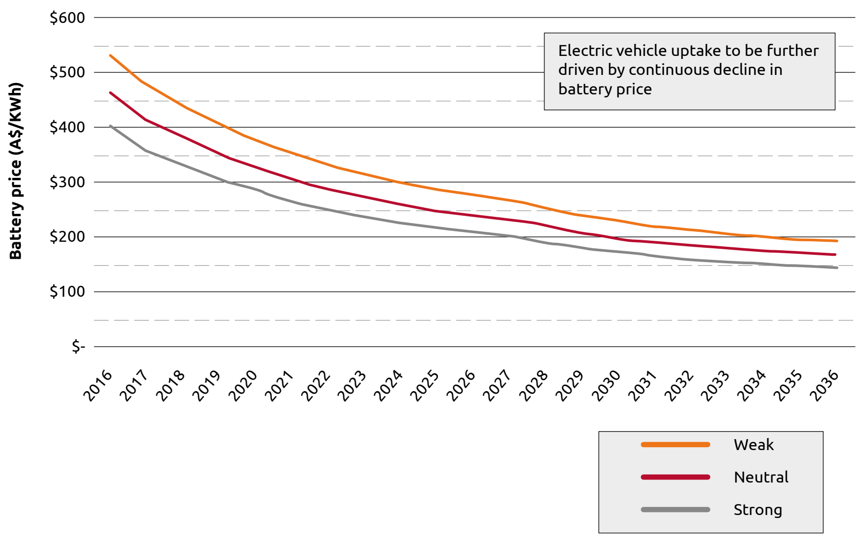


Figure 5.4: Uptake of Electric Vehicles in NEM by 2035-2036, across Regions (neutral outlook)[87]



86 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEFR/2016/AEMO-insights_EV_24-Aug.pdf
87 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEFR/2016/AEMO-insights_EV_24-Aug.pdf

Figure 5.5: Lithium price by 2035-2036 (weak, neutral and strong outlook)[88]



Electric vehicle uptake could significantly change electricity usage patterns in Australia. If properly managed, electric vehicles can be used as distributed energy storage facilities releasing electricity during peak demand time and help in improve grid stability during periods of high VRE output

Australia is in the cusp of a battery storage revolution and is poised to emerge as the biggest market for energy storage technologies over coming years

There is a rise in solar storage innovation with strong focus on battery storage technologies; increasingly affordable solar PV and battery prices making battery storage options attractive in both residential and commercial sectors

- Installation of solar PV systems (up to 100 KW) across household and commercial sector surpassed 1.5 million as of 2016
- This has also resulted in higher penetration of rooftop solar PV per household in most of Australia's states and territories (and the country as a whole) compared to other countries

88 https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEFR/2016/AEMO-insights_EV_24-Aug.pdf

Figure 5.6: Annual Solar PV installations (up to 100 KW)[89]

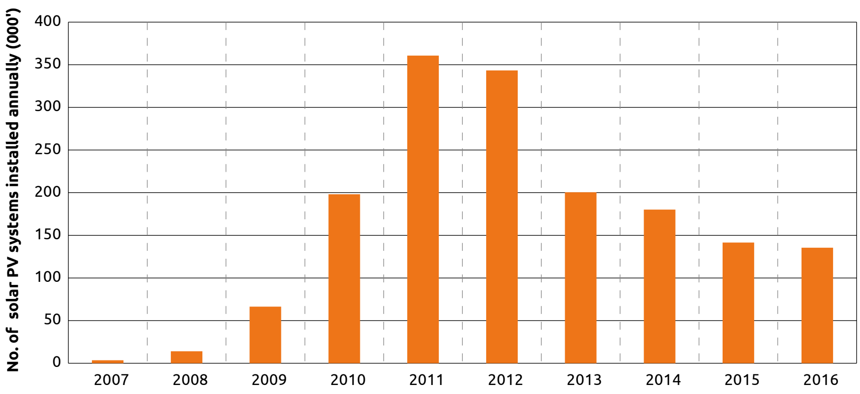
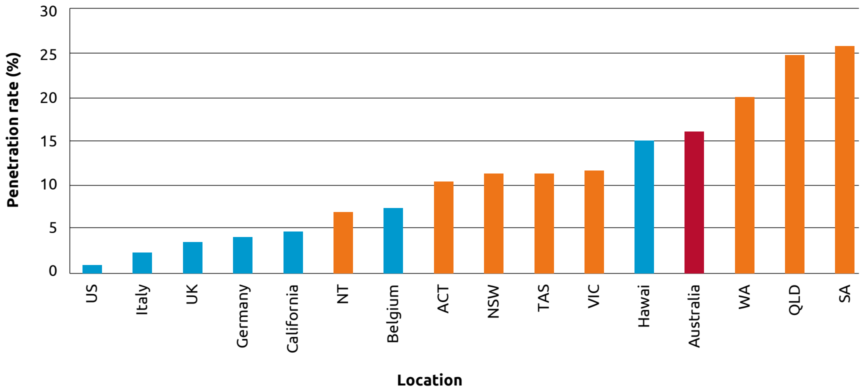


Figure 5.7: Rooftop PV penetration rates as a % of households[90]



- Solar PV installation in Australia is being largely driven by Queensland, Western Australia and South Australia
- CSIRO[91] and Energy Networks Association forecasts that by around 2050, up to 50% of Australia's annual electricity consumption could be provided by millions of distributed energy resources, mostly rooftop solar PV systems[92]
- These rooftop solar PV systems will increasingly be complemented by other technologies like battery storage systems

89 Clean Energy Australia Report 2016

90 https://www.environment.gov.au/system/files/resources/97a4f50c-24ac-4fe5-b3e5-5f93066543a4/ files/independent-review-national-elec-market-prelim.pdf

91 The Commonwealth Scientific and Industrial Research Organisation

92 https://www.environment.gov.au/system/files/resources/97a4f50c-24ac-4fe5-b3e5-5f93066543a4/files/independent-review-national-elec-market-prelim.pdf

AEMO forecasts that more than 1.1mn new battery storage systems will be installed in Australian households by 2035, alongside new rooftop solar PV systems across the NEM[93]

Trends in battery storage technology

- **Low cost Lithium ion batteries:**
  - Australia has been identified by innovators like Tesla and Enphase as a proving ground for battery storage innovation
  - The second generation of Tesla Powerwall rolled out in early 2017 was considered as probably the cheapest lithium ion battery for the home ever made - Despite having more than double the capacity of Powerwall 1, and an inverter built in, it involves nearly half the installed cost/ KWh of its predecessor[94]
- **Experimentation with gel-based battery technologies:**
  - While there is currently no front-runner to replace lithium ion batteries, battery makers are exploring means to solve some of the key limitations of the product, the prime one being scant supply of raw materials required to manufacture them
  - Startups like Gelion is experimenting with batteries using zinc and bromide - elements that are stable and more abundant in supply; it is currently raising funds to get its prototype into commercial production[95]
- **Product and service innovation from several battery storage start-ups that are experimenting with new prototypes :**
  - Queensland based Nano-Nouvelle is currently experimenting with its Tin Nanode product as a tin-based anode for lithium ion batteries, in order to increase energy density resulting in longer lasting batteries[96]
  - Redback Technologies is producing solar invertors equipped with a software platform that allows remote monitoring, intelligent operational strategies including peak time tariff support, and relay support for pool pumps and water heaters
  - In an effort to reach out to customers, some of the battery vendors are also partnering with Australian utility retailers to provide different storage purchase options including upfront payment only, upfront payment with ongoing monitoring and support or an ongoing lease with no upfront costs
- **Changing competitive landscape driving storage innovation beyond the utilities sector**
  - Telecommunications major Telstra is foraying into the utilities sector with investments in battery storage technology
  - In early 2016, the company announced plans of offering home energy services including solar and battery storage, as part of its bundled services that includes internet and telephone[97]
  - In May 2017, Telstra entered into a long term power purchase agreement with RES Australia, to build a new 70MW solar farm near Emerald in northern Queensland, which will be utilizing battery storage capacity in its network to generate electricity in times of peak demand[98] ; construction of the power plant, which is expected provide power to 35,000 homes in the region, will commence in H2, 2017 and is expected to begin generating electricity in 2018

93 https://www.environment.gov.au/system/files/resources/97a4f50c-24ac-4fe5-b3e5-5f93066543a4/files/independent-review-national-elec-market-prelim.pdf

94 https://onestepoffthegrid.com.au/tesla-effect-means-australian-battery-storage-prices/

95 https://www.theguardian.com/sustainable-business/2017/apr/06/salt-silicon-or-graphite-energy-storage-goes-beyond-lithium-ion-batteries

96 http://www.ecoinvestor.com.au/Stories/Unlisted-Companies/Nano-Nouvelle-Boosts-Lithium-Battery-Performance.htm

97 https://www.greentechmedia.com/articles/read/Will-Telecom-Companies-Kill-Utilities

98 https://exchange.telstra.com.au/driving-new-solar-investments-reining-in-energy-costs/

- **Significant opportunities for battery storage in 'behind-the-meter' applications and in off grid areas where the cost of back-up power from connecting to grids are high**
  - Australian tech startup Reposit is partnering with electricity retailers to market software that upgrades the "smarts" in residential solar inverters to support more effective integration with behind-the-meter storage
  - Australia also has vast areas that are off-grid and many island communities that rely on expensive imported fuels to meet their power needs - Batteries are an alternative way to increase the supply of renewable electricity to these off-grid and island areas while ensuring a reliable supply of electricity
  - King Island in Tasmania is an example of an off-grid, island community using battery storage to boost its reliance on renewable energy[99] - The island's 3 MW / 1.6 MWh advanced lead acid battery system is designed to enable wind power to provide up to 70% of the Island's electricity demand while maintaining grid stability
  - Since installation of the new energy storage system, King Island has halved its diesel consumption from 4.5 to 2.6 million litres per year

Australian states exploring battery-storage-technology driven Virtual Power Plants to boost grid stability, reduce power price volatility and support the transition to renewable energy

Two 'virtual power plants' were trialed in Melbourne and Adelaide during 2016[100]

- **VPP project in Melbourne**
  - United Energy, in collaboration with Energy Makeovers and Clean Energy Council member Sunverge, installed 50 kW of solar and energy storage on its distribution network
  - Combination of technologies reduced demand during peak time and investment on extra poles and wires, while cloud-based software provided by Sunverge was used to operate energy storage units remotely
- **VPP project in Adelaide**
  - AGL in collaboration with ARENA and Sunverge embarked on a 3 phased project to connect 1,000 home batteries installed in households and businesses to provide 5 MW of peaking capacity
  - Considered to be world's largest solar VPP project, once completed, it will be able to store 7 MWh of energy

99 https://www.climatecouncil.org.au/uploads/ebdfcdf89a6ce85c4c19a5f6a78989d7.pdf
100 Clean Energy Australia Report 2016

Deployment of advanced metering infrastructure gaining pace across Australian states

Smart meter technology will play an integral role in providing customers with greater control of their electricity consumption and enable retailers to offer new services such as real time monitoring; appropriate policy methods and consumer protection frameworks are imperative to realize its full benefits

- **State of Victoria**
  - Victoria was the first jurisdiction in Australia to consider a state-wide roll out of smart meters
  - The roll-out began in late 2009 and distributors were mandated to install smart meters at all homes and businesses, by December 2013
  - The roll out in Victoria is now effectively complete with almost 2.8 million[101] smart meters installed across the state, however the program has been widely reviewed, criticized and subject to changes prompted by customer concerns and cost overruns
  - Cost estimates had risen through the program from an initial estimate of A$1.6 billion to over A$2 billion
  - In December 2016, AER published its final decision on the advanced metering infrastructure (AMI) transition charges, which mandates Victorian electricity distributors to return A$75.8 million to customers, through a reduction in the metering portion of electricity bills[102]

Regulatory advancements to rectify the pitfalls from the Victorian roll out

- A competitive market framework for the national introduction of digital meters was proposed by the COAG Energy Council[103] and is currently being implemented based on market rules finalized by the AEMC in 2015[104]
- This proposed framework requires metering companies, retailers and distribution network businesses to develop a business case to deploy digital meters
- The new rules are designed to drive investment in digital meter deployment based on the value they offer to consumers and the market
- Given the Victorian roll out mishap, other states have now become cautious and are favoring the voluntary market-led roll out policy instead of a mandatory roll out mechanism

101 http://www.mbie.govt.nz/info-services/sectors-industries/energy/electricity-market/nz-smart-grid-forum/meetings-year-1/meeting-6/case-study-victorian-smart-meter-rollout.pdf

102 https://www.aer.gov.au/news-release/aer-releases-findings-on-smart-meter-spending

103 The Council of Australian Governments Energy Council

104 https://www.environment.gov.au/system/files/resources/97a4f50c-24ac-4fe5-b3e5-5f93066543a4/files/independent-review-national-elec-market-prelim.pdf

- **New South Wales:**
  - On 28 October 2014, Resources and Energy Minister, Anthony Roberts had announced that smart meters will be made available to electricity customers across NSW, through a voluntary market-led rollout[105] ; this was designed not only to ensure competition in metering services coupled with customer choice but also to achieve an uniform, flexible and cost reflective meter policy
  - In March 2016, legislative changes were made to the NSW smart meters roll out framework[106] to further enhance competition in electricity metering by allowing both retailers and meter providers to compete for customers. It also ensured that consumer protection, safety and privacy standards were met
  - Resources and Energy Minister, Anthony Roberts, also highlighted that 40,000[107] smart meters have already been installed in NSW and it is expected to continue to grow under the government's policy to support a voluntary, market-led rollout of smart meters
- **Queensland**
  - The state has been considering customer-driven rollout, where a range of different service providers can compete to offers customers advanced metering services and associated product choices
  - Based on the Victorian experience, the Queensland Government has ruled out a mandated rollout of advanced meters in Queensland and is most likely to support the customer-driven approach[108]

Experimentation with blockchain technology and its application in energy distribution and grid management is on the horizon

Blockchain technology has the potential to play a game changing role in the transition of Australia's electricity system into a resilient, cost-effective and low carbon grid

- Australian start-up PowerLedger is using blockchain technology to offer a transparent, automated, and auditable market trading and clearing mechanism for the sale of excess renewable energy – the energy is produced onsite at multi-unit residential and commercial developments and at businesses and homes connected to the distribution network[109]
- PowerLedger is currently piloting in a retirement village at Busselton, Western Australia, to allow residents to trade electricity amongst themselves, leveraging the technology, at a price greater than available feed-in tariffs but lower than residential retail tariffs

Australia is making significant strides in tech-innovation to ensure a future of sustainable energy system; however market regulations need to continually evolve to adapt to these changes and provide further impetus to the innovation drive

105 http://www.resourcesandenergy.nsw.gov.au/energy-consumers/energy-providers/smart-meters-in-nsw
106 http://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0006/597633/Smart-meter-rollout-to-drive-choice,-savings-and-innovation.pdf
107 http://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0006/597633/Smart-meter-rollout-to-drive-choice,-savings-and-innovation.pdf
108 http://www.mbie.govt.nz/info-services/sectors-industries/energy/electricity-market/nz-smart-grid-
109 http://www.energynetworks.com.au/news/energy-insider/blockchain-grid-edge

Topic Box 5: Australia emerging as the focal point of international battery storage market with three state governments – South Australia, Victoria and Queensland spearheading the move to battery technology

SA, Victoria and Queensland commissioning their own battery storage to ensure energy security

South Australia[110]

- In March 2017, South Australian government announced plans to invest more than A$550 million over the long term to secure the state's electricity supply, including building, owning and operating a A$360 million, 250-MWh plant to provide power grid stability and for emergency power needs
- The major grid-scale battery storage facility is expected to be completed by 2017

Victoria[111]

- Following the announcement by South Australian government, Victoria also announced its A$20 million tender process for procurement of two 20MW battery systems to be built in western Victoria, at a site with a weak network and expanding renewable energy capacity
- The two projects are expected to have a combined storage capacity of 100MWh with installation to be completed by January 2018
- Applicants were also encouraged to seek funding from ARENA for the Victorian initiative, to drive even further investment in this new energy technology[112]
- Victoria's battery storage tender attracted approx.110 proposals, surpassing even the extraordinary response to the rival tender in South Australia[113]

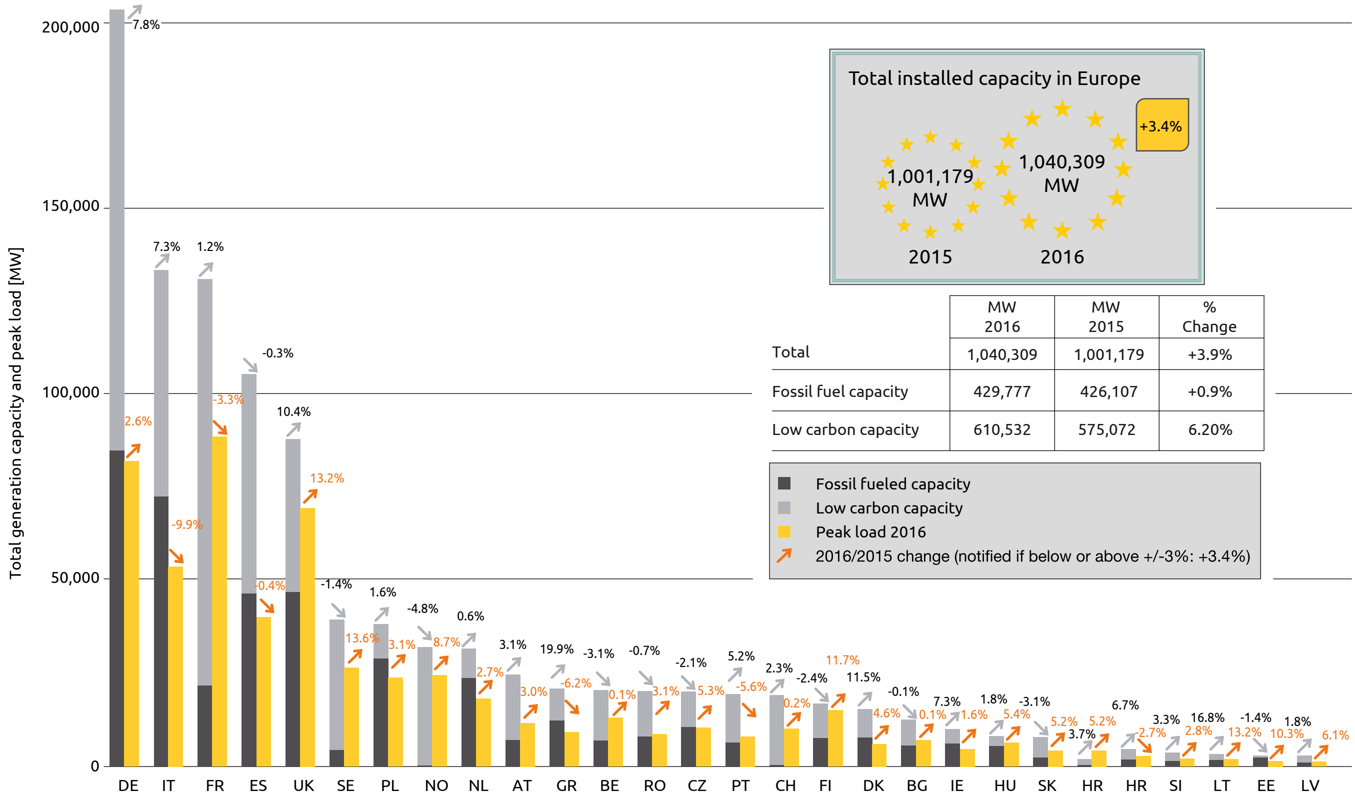
Queensland[114]

- Ergon Energy is conducting a solar and battery storage pilot program in 33 homes across Townsville, Cannonvale and Toowoomba
- The trial which uses new technology, batteries and solar PV to benefit Ergon's network and potentially lower customers' power bills has now entered its third stage
- In addition to advanced technologies, a new tariff system - Tariff 14, is also being trialed for the first time – the demand driven tariff together with the combination of the new batteries, solar and home energy management system, is expected to provide customers with better price signals and help them avoid high cost impacts and therefore high bills

110 http://www.abc.net.au/news/2017-03-14/sa-power-energy-minister-electricity-market-plan-jay-weatherill/8351450
111 http://reneweconomy.com.au/victoria-seeks-100mw-energy-storage-in-20m-tender-41073/
112 http://www.premier.vic.gov.au/storage-to-strengthen-victorias-energy-system/
113 http://reneweconomy.com.au/storage-boom-victoria-outstrips-south-australia-tender-with-100-proposals-70072/
114 http://statements.qld.gov.au/Statement/2017/5/2/townsville-innovative-battery-trial-extended

Appendix Figures

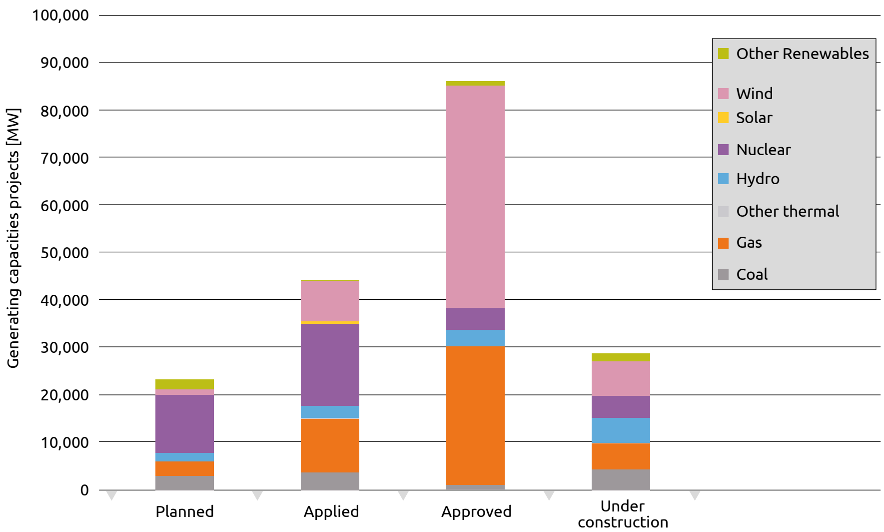
Figure A.1 Peak load, generation capacity and electricity mix (2016)



	MW 2016	MW 2015	% Change
Total	1,040,309	1,001,179	+3.9%
Fossil fuel capacity	429,777	426,107	+0.9%
Low carbon capacity	610,532	575,072	6.20%

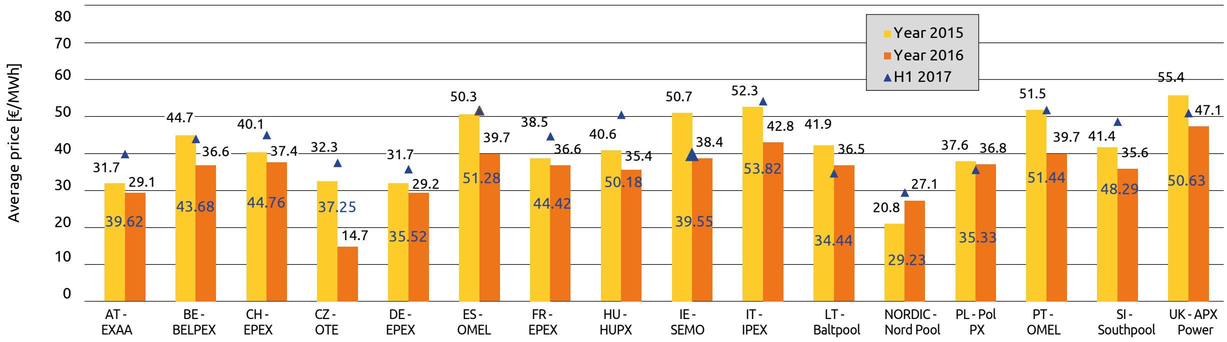
Source: ENTSO-E database – Capgemini analysis, WEMO2017

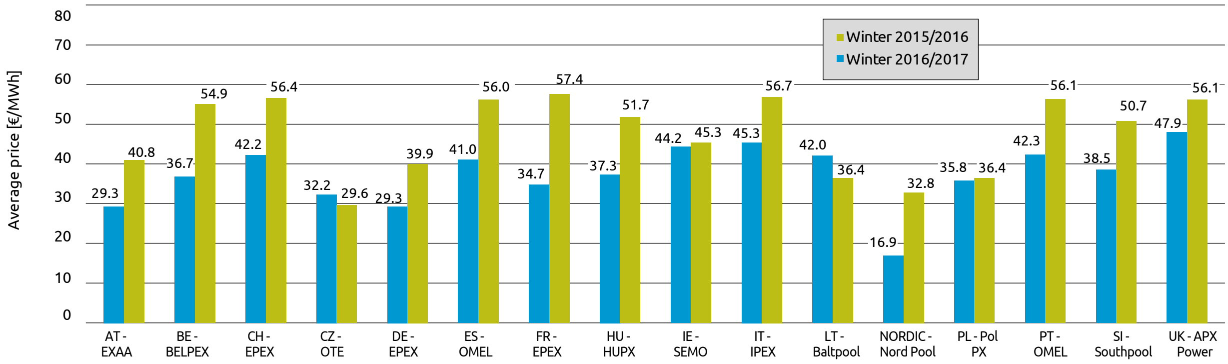
Figure A.2 Generating capacities projects (as of June 2017)



Note: Data available for projects > 100 MW
Status definitions: Planned=Announcement of intent; Applied=Main permits applied for; Approved: Contracts and financial go-ahead pending; Under construction=Ground has been broken
Source: Platts – Capgemini analysis, WEMO2017

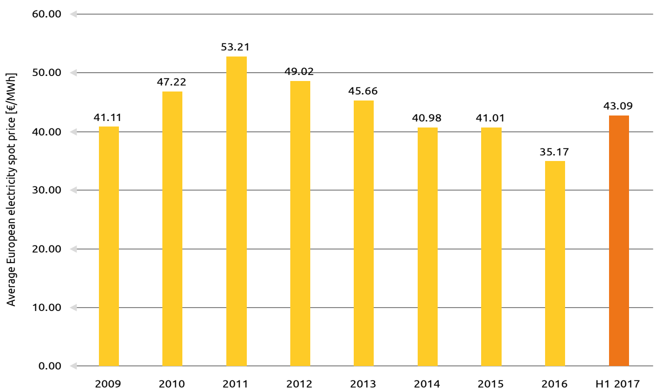
Figure A.3 Yearly (2016 and 2017) and winter (2015/2016 and 2016/2017) average electricity spot prices





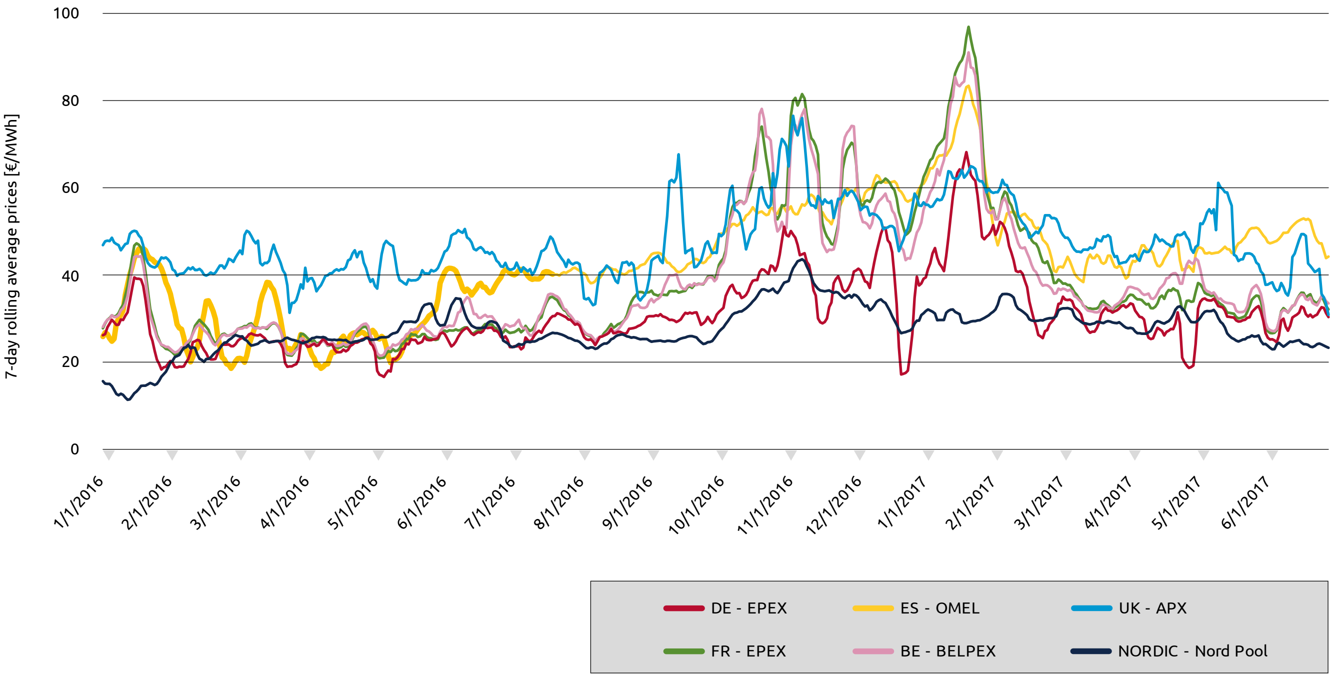
Source: Power Exchange websites – Capgemini analysis, WEMO2017

Figure A.4 Average European electricity spot price (2009 to H1 2017)



Source: Power Exchange websites – Capgemini analysis, WEMO2017

Figure A.5 Electricity spot prices on the main European markets (2016 and H1 2017)



Source: Power Exchange websites – Capgemini analysis, WEMO2017

Figure A.6 Status of electricity price regimes (2016)

Country	Existence of regulated prices (year of price control removal)	
	Households	Non-households
AT	No (2001)	No
BE	Yes	No
BG	Yes	Yes
CZ	No (2006)	No
DK	Yes	Yes
EE	No (2013)	Yes
FI	No	No
FR	Yes	No
DE	No (2007)	No
GR	No (2013)	No
HR	Yes	Yes
HU	Yes	Yes
IE	No (2011)	No
IT	Yes	No
LV	Yes	No
LT	Yes	Yes
LU	No (2007)	No
NL	Yes	No
PL	Yes	No
PT	Yes	Yes
RO	Yes	No
SK	Yes	Yes
SI	No (2007)	No
ES	No (2014)	No
SE	No	No
UK	No	No

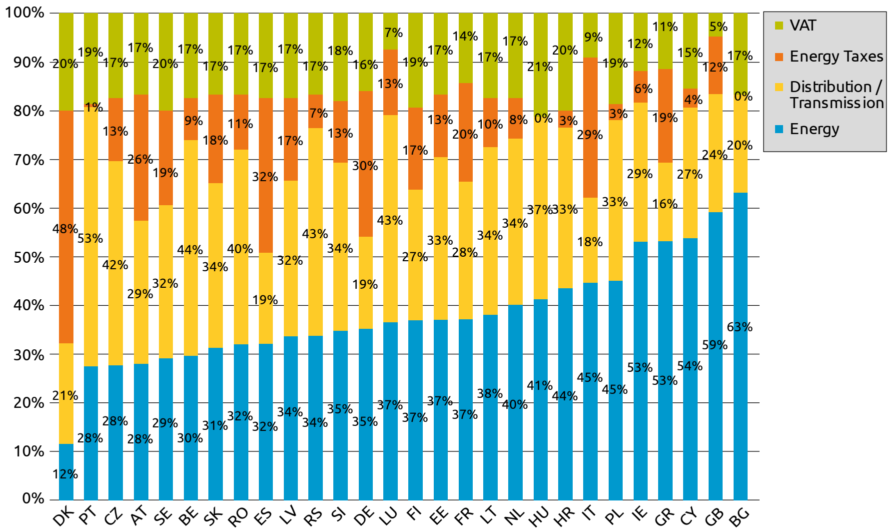
Source: CEER-ACER, National regulators – Capgemini analysis, WEMO2017

Figure A.7 Electricity retail market size (2016)

Country	Number of electricity customers (in thousands)
AT	6,008
BE	5,127
BG	4,839
CZ	5,899
DE	50,077
DK	2,750
EE	561
ES	28,825
FI	3,600
FR	36,476
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 2017

Figure A.8 Residential electricity price breakdown (as of June 2017)



Source: HEPI by E-Control Austria, MEKH and VaasaETT, 2017; AER; EA, analysis by VaasaETT - WEMO2017

Figure A.9 Status of gas price regimes (2016)

Country	Existence of regulated prices (year of price control removal)	
	Households	Non-households
AT	No (2002)	No
BE	Yes	No
BG	Yes	Yes
CZ	No (2007)	No
DK	Yes	Yes
EE	No	No
FI	No	No
FR	Yes	Yes
DE	No (2007)	No
GR	Yes	Yes
HR	Yes	Yes
HU	Yes	Yes
IE	Yes	No
IT	Yes	No
LV	Yes	Yes
LT	Yes	No
LU	No (2007)	No
NL	Yes	No
PL	Yes	Yes
PT	Yes	Yes
RO	Yes	Yes
SK	Yes	No
SI	No (2007)	No
ES	No (2014)	No
SE	No (2007)	No
UK	No	No

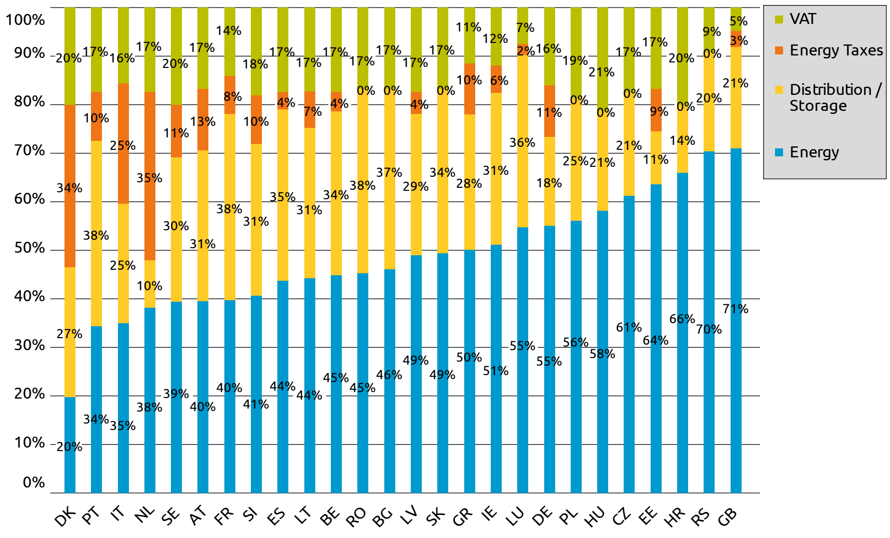
Source: CEER-ACER, National regulators – Capgemini analysis, WEMO2017

Table A.10 Gas retail market size (2016)

Country	Number of gas customers (in thousands)
AT	1,349
BE	3,226
BG	74
CH	647
CZ	2,849
DE	21,179
DK	420
EE	52
ES	7,556
FI	31
FR	11,268
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	1,352
RO	3,282
SE	37
SI	136
SK	1,506
UK	2,302
EU-28	100,665

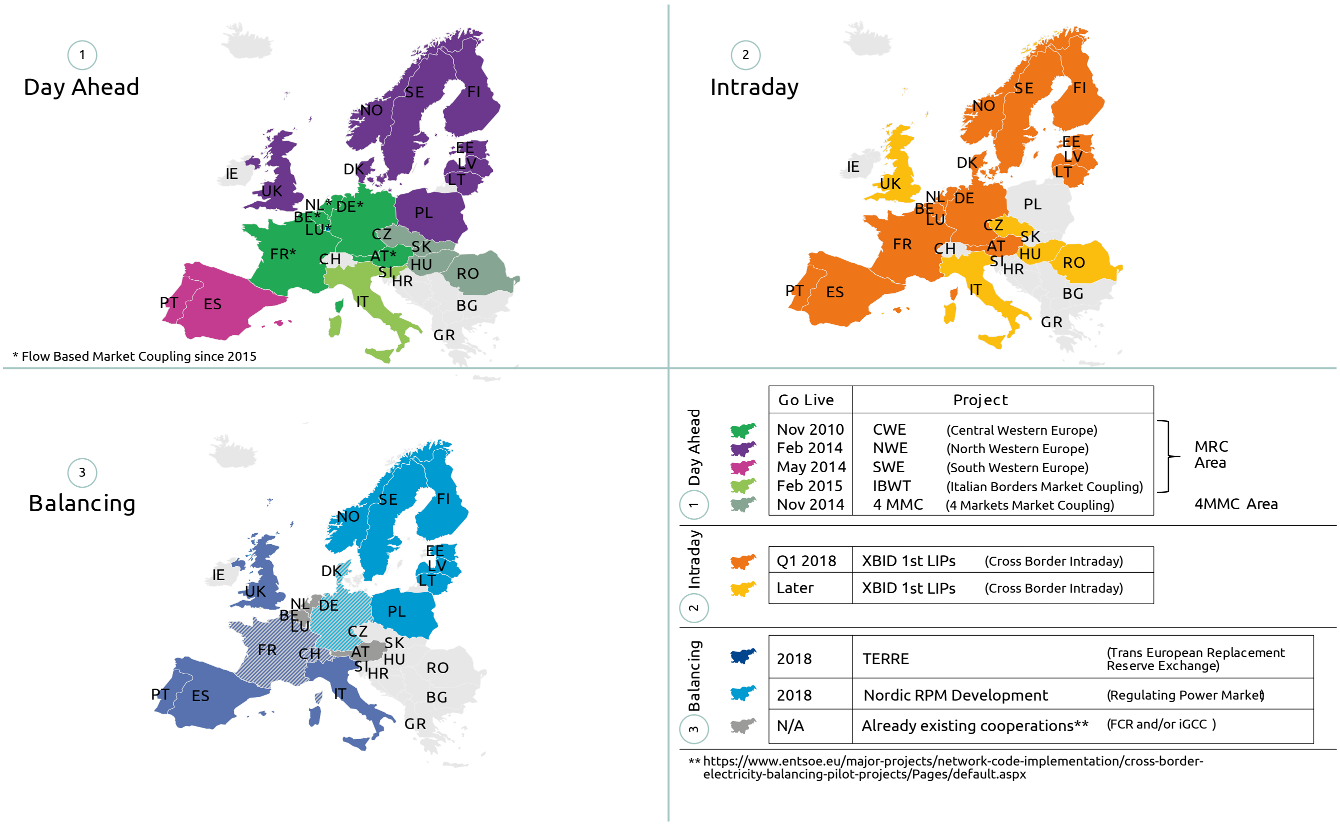
Source: Eurogas – Capgemini analysis, WEMO 2017

Figure A.11 Residential gas price breakdown (as of June 2017)



Source : HEPI by E-Control Austria, MEKH and VaasaETT, 2017; AER, EA, analysis by VaasaETT - WEMO2017

Figure A.12 Market Integration mechanisms progress (2017)



Note: The European Council requires each country to have a minimum import capacity level equivalent to 10% of its installed capacity
Source: European Commission, ENTSOG – TYNDP, various sources – Capgemini analysis, 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. ACT: Australian Capital Territory
3. ADIT: Accumulated Deferred Income Tax
4. AEMC: Australian Energy Market Commission
5. AER: Australian Energy Regulator
6. AGA: Advanced Grid Analytics
7. AMI: Advanced Metering Infrastructure
8. APEC: Asia-Pacific Economic Cooperation
9. APGCC: ASEAN Power Grid Consultative Committee
10. ARENA: Australian Renewable Energy Agency
11. ARFVTP: Alternative and Renewable Fuel and Vehicle Technology Program
12. ARRA: American Recovery and Reinvestment Act
13. ASEAN: Association of Southeast Asian Nations
14. BAU: Business-as-usual
15. Bcm: Billion cubic meters
16. BNEF: Bloomberg New Energy Finance
17. CAFÉ: Corporate Average Fuel Economy
18. CapEx: Capital Expenditure
19. CC: Contestable Consumers
20. CCA: Climate Council Authority
21. CCC: Climate Change Commission
22. CEVS: Carbon Emissions-Based Vehicle Scheme
23. CO_2: Carbon dioxide
24. CO_2e: Carbon dioxide Equivalent
25. COAG: Council of Australian Governments
26. COP22: 22nd Conference of the Parties
27. CPP: Clean Power Plan
28. CREZ: Competitive Renewable Energy Zones
29. CRI: Climate Risk Index
30. CRM: Customer relationship management
31. CSI: California Solar Initiative
32. CSIRO: Commonwealth Scientific and Industrial Research Organization
33. DER: Distributed Energy Resource
34. DES: Distributed Electricity and Storage
35. DfE: Design for Efficiency
36. DOE: Department of Energy
37. DSO: Distribution System Operator
38. DSM: Demand-side Management
39. EASe: Energy Efficiency Improvement Assistance Scheme
40. EBITA: Earnings before Interest, Taxes, and Amortization
41. EBITDA: Earnings before Interest, Tax, Depreciation and Amortization
42. EC: Energy Commission
43. ECF: Equity Crowd Funding
44. EE: Energy Efficiency
45. EERS: Energy Efficiency Resource Standards
46. EIA: Energy Information Administration
47. EMA: Electricity Market Authority
48. EPA: Environmental Protection Agency
49. EPS: Earnings per Share
50. ERCOT: The Electric Reliability Council of Texas
51. ETS: Emissions Trading Scheme
52. EV: Electric Vehicle
53. FERC: The Federal Energy Regulatory Commission
54. FFO: Funds from Operation
55. FFR: Fast Frequency Response
56. FPSS: Future Power System Security
57. FPA: Federal Power Act
58. FRC: Full Retail Contestability
59. GCF: Green Climate Fund
60. GDP: Gross Domestic Product
61. GHG: Greenhouse Gas
62. GIS: Geographic Information System
63. GJ: Gigajoules
64. GMI: Grid Modernization Initiative
65. GMLC: Grid Modernization Lab Consortium
66. GREET: Grant for Energy Efficient Technologies
67. GTFS: Green Technology Financing Scheme
68. GW: Gigawatt
69. HEV: Hybrid Electric Vehicle
70. IA: Investment Allowance
71. IBR: Incentive Based Regulation
72. ICT: Information and Communication Technologies
73. IEA: International Energy Agency
74. IEC: International Energy Consultants
75. IFC: The International Finance Corp
76. INDC: Intended Nationally Determined Contribution
77. IoT: Internet of Things
78. IPP: Independent Power Producer
79. IPv6: Internet Protocol version 6
80. ISO: International Organization for Standardization
81. IVR: Interactive Voice Response
82. KW: Kilowatt
83. KWh: Kilowatt-hours
84. LCOE: Levelized Cost of Energy
85. LNG: Liquefied Natural Gas
86. LPG: Liquefied Petroleum Gas
87. LRET: Large-scale Renewable Energy Target
88. LSS: Large Solar Scale
89. M2M: Machine to Machine
90. MDM: Meter Data Management
91. MIDA: Malaysian Investment Development Authority
92. MMBTU: Million Metric British Thermal Units
93. MMT: Million Metric Tonnes
94. MMTPA: Million Metric Tonnes Per Annum
95. MNCAA: The Mayors National Climate Action Agenda
96. MOU: Memorandum of Understanding
97. MSCI: Morgan Stanley Capital International
98. Mtoe: Million Tonnes of Oil Equivalent
99. MW: Megawatts
100. MWh: Megawatt-hours
101. NAFTA: North American Free Trade Agreement
102. NDC: Nationally Determined Contributions
103. NEA: National Environment Agency

104. NEB: National Energy Board
105. NECF: National Energy Customer Framework
106. NEPA: National Environmental Policy Act
107. NEM: National Electricity Market
108. NEMS: National Energy Modeling System
109. NGV: Natural Gas Vehicle
110. NIA: National Irrigation Administration
111. NIC: Network Interface Card
112. NOL: Net Operating Loss
113. NREP: National Renewable Energy Program
114. NSPS: New Source Performance Standards
115. NSW: New South Wales
116. OECD: Organization for Economic Co-operation and Development
117. PACE: Property Assessed Clean Energy
118. PHEV: Plug-in Hybrid Electric Vehicle
119. PEV: Plug-in Electric Vehicle
120. PBR: Performance-Based Ratemaking
121. PPAs: Power Purchasing Agreements
122. PPP: Public Private Partnership
123. PV: Photovoltaic
124. RGGI: Regional Greenhouse Gas Initiative
125. RE: Renewable Energy
126. REP: Retail Electric Provider
127. RET: The Renewable Energy Target
128. RIT-T: Regulatory Investment Test for Transmission
129. RPS: Renewable Portfolio Standards
130. RRO: Regional Reliability Organizations
131. RTO: Regional Transmission Organization
132. SCA: Scheme of Control Agreement
133. SCC: Social Cost of Carbon
134. SCEM: Singapore Certified Energy Manager
135. SEA: Southeast Asia
136. SGER: Specified Gas Emitters Regulation
137. SMOC: Streaming Media Online Charging System
138. SoC: Scheme of Control
139. SRES: Small-scale Renewable Energy Scheme
140. SSR: Summer Saver Rebate
141. S&P: Standard & Poor's
142. TCF: Trillion cubic feet
143. ToU: Time-of-Use
144. TWH: Terawatt Hours
145. T&D: Transmission and Distribution
146. UNCED: United Nations' Conference on Environment and Development
147. UNFCCC: United Nations Framework Convention on Climate Change
148. USTDA: United States Trade and Development Agency
149. UTP: Uniform Tariff Policy
150. VES: Vehicular Emissions Scheme
151. VPP: Virtual Power Plant
152. VRE: Variable Renewable Electricity
153. VWEM: Vietnam Competitive Wholesale Electricity Market
154. WSD: Water Supplies Department
155. WTE: Waste-to-Energy
156. WTO: The World Trade Organization
157. YTD: Year to date
158. 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 Environment: www.magrama.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

Team and Authors

Report Sponsor

Philippe Vié
+33 1 49 67 42 47
philippe.vie@capgemini.com

Project Manager

Alexandra Bonanni
+33 1 49 67 42 60
alexandra.bonanni@capgemini.com

Editorials

Colette Lewiner
colette.lewiner.externe@capgemini.com

Perry Stoneman
perry.stoneman@capgemini.com

Gaurav Modi
gaurav.modi@capgemini.com

Jan Lindhaus
+61 3 9613 3377
jan.lindhaus@capgemini.com

NORTH AMERICA

Bart Thielbar
bart.thielbar@capgemini.com

Sabyasachi Roy
+91 90511 75666
sabyasachi.roy@capgemini.com

EUROPE

Our partners

Climate Change Challenges insights
Institute for Climate Economics -I4CE-

Emilie Alberola
+33 6 30 90 93 73
emilie.alberola@ i4ce.org

Charlotte Vailles
+33 7 84 42 12 75
charlotte.vailles@i4ce.org

Switching and pricing insights-VaasaETT-

Christophe Dromacque
+358 (0)4 4906 68 22
christophe.dromacque@vaasaett.com

Hanna Launonen
+358 (0)4 4906 68 20
hanna.launonen@vaasaett.com

Brexit and Self-consumption -Depardieu Brocas Maffei-

Christine Le Bihan Graff
+ 33 (0) 1 53 57 71 95

Paul Courtade
+ 33 (0) 1 72 69 70 28

Elisabeth Creux
+ 33 (0) 1 72 69 70 72

Energy Transition

Alain Chardon
alain.chardon@capgemini.com

Marianne Boust
Marianne.boust@capgemini.com

Guillaume Bourseau
guillaume.bourseau@capgemini.com

Michaela Buriankova
michaela.buriankova@capgemini.com

Justine Roure
justine.roure@capgemini.com

Fernando Maria Ginestal Vela
fernando-maria.ginestal-vela@capgemini.com

Guillermo Amor Alonso
guillermo.amor-alonso@capgemini.com

Charles-Gabriel Raux
charles-gabriel.raux@capgemini.com

Security of Supply and Energy Market Integration

Florent Andrillon
florent.andrillon@capgemini.com

Electricity

Yann de Saint Germain
Yann.de-saint-germain@capgemini.com

Colette Talbot
Colette.talbot@capgemini.com

Lamya Lasfar
Lamya.lasfar@capgemini.com

Madeleine Alliez
Madeleine.alliez@capgemini.com

Gas

Bakr Naciri
bakr.naciri@capgemini.com

Akram Al Ganad
akram.al-ganad@capgemini.com

Hubert Clément
hubert.clement@capgemini.com

Emmanuel Ragon
emmanuel.ragon@capgemini.com

François Comby
francois.comby@capgemini.com

Customer Perspective

Aurelia Valot
aurelia.valot@capgemini.com

Alexandre Autheman
alexandre.autheman@capgemini.com

Dat Dinh
dat.dinh@capgemini.com

Omar Ait Idder
omar.ait-idder@capgemini.com

Innovation & Transformation in Energy Companies

Alain Chardon
alain.chardon@capgemini.com

Paul Faraggi
paul.faraggi@capgemini.com

Arthur Arrighi de Casanova
arthur.arrighi-de-casanova@capgemini.com

Thierry Batut
Thierry.batut@capgemini.com

Louise de Brémond d'Ars
louise.de-bremond-d-ars@capgemini.com

Benjamin Vergnhes-Henniaux
benjamin.henniaux-vergnhes@capgemini.com

Marine Watremez
marine.watremez@capgemini.com

Salma Zouari
salma.zouari@capgemini.com

Financials

Matthieu Peterschmitt
matthieu.peterschmitt@capgemini.com

Bénédicte Martin
Benedicte.martin@capgemini.com

Badr Labraiki
badr.labraiki@capgemini.com

Gabrielle Desarnaud
gabrielle.desarnaud@capgemini.com

Sébastien Le Quoy
sebastien.le-quoy@capgemini.com

SOUTHEAST ASIA

Anastasios Kyriakopoulos
anastasios.kyriakopoulos@capgemini.com
+852 3512 3825

Sandra Lork
sandra.lork@capgemini.com

Kiran Keshav
kiran.keshav@capgemini.com

Rajesh Kottul
rajesh.kottul@capgemini.com

Francois-Xavier Reodo
francois-xavier.reodo@capgemini.com
+33147545031

Rajarshi Goswami
rajarshi.goswami@capgemini.com

Introduction, Climate Change, Supply & Final Customer, Market Transitions & Innovation, and Financials

Sabyasachi Roy
+91 9051175666
sabyasachi.roy@capgemini.com

Energy Transition, Infrastructure & Adequacy of Supply

Vandana Chaudhary
+91 97690 18813
vandana.chaudhary@capgemini.com

AUSTRALIA

Anastasia Klingberg
anastasia.klingberg@capgemini.com
+61 3 9613 3619

Sabyasachi Roy
+91 90511 75666
sabyasachi.roy@capgemini.com

Tanvi Goel
tanvi.goel@capgemini.com

Climate Change

Brinta De
brinta.de@capgemini.com
+91 72599 75900

Energy Transition, Infrastructure & Adequacy of Supply, and Supply & Final Customer

Vandana Chaudhary
+91 97690 18813
vandana.chaudhary@capgemini.com

Market Transitions & Innovation

Sreeja Dutta
+91 98369 44968
sreeja.dutta@capgemini.com

Marketing & Communication

Acknowledgements to :

Arvind Lakshmiratan
arvind.lakshmiratan@capgemini.com

Camilla Carlsson
camilla.carlsson@capgemini.com
+46 853685836

Florence Lièvre
florence.lievre@capgemini.com
+33 1 47 54 50 00

Stéphane Tchirieff
stephane.tchirieff@capgemini.com
+33 147545108

Dawnell Larsen
dawnell.larsen@capgemini.com

Coordinators

Victor Falières
victor.falieres@capgemini.com

Yassine Mansouri
yassine.mansouri@capgemini.com

DE PARDIEU BROCAS MAFFEI

AVOCATS

De Pardieu Brocas Maffei is one of France's leading independent business law firms and currently has 33 partners.

Founded in 1993, the Firm has become a key player in French business law and also has a highly regarded international practice. The firm's lawyers regularly advise on both domestic and international matters, and clients primarily include large French and overseas corporations.

In addition, the Firm works with an extensive network of referral law firms in the main financial centers in different parts of the world.

I4CE INSTITUTE FOR CLIMATE ECONOMICS

About I4CE

"I4CE – Institute for Climate Economics" is an initiative of **Caisse des Dépôts and Agence Française de Développement.** The think tank provides independent expertise and analysis on economic issues linked to climate & energy policies in France and throughout the world. I4CE aims at helping public and private decision-makers to improve the way in which they **understand, anticipate, and encourage the use of economic and financial** resources to promote the transition to a low-carbon resilient economy. I4CE works with a large and established network of partners.

I4CE focuses on three research areas, addressing the issues faced by actors involved in the energy and climate transition:

- Industry, Energy and Climate: understanding policies for the low-carbon transition in the industry and energy sectors
- Territories and Climate: identifying and analyzing courses of action in the fight against climate change in the agriculture and forestry sectors as well as urban areas.
- Finance, Investment and Climate: analyzing the mainstreaming of climate change into financial decision-making by public and private entities.

How we work

- Providing research and expertise
  - Research projects and expert reports
  - Publications
- Building capacity
  - Disseminate knowledge and research results
  - Conduct applied research projects
  - Design and organization of training sessions
- Contributing to public debates
  - Organize events (conferences, workshops, breakfast meetings)
  - Respond to public consultations
  - Participate in expert working groups

More information at www.i4ce.org

vaasa ETT

About VaasaETT

VaasaETT is a research and advisory consultancy dedicated to customer related issues in the energy industry. VaasaETT advises its clients based on empirical evidence brought about from extensive research in the area of customer behavior, competitive market behavior and consumer-centric dynamics (including smart energy offerings, demand response, energy efficiency, smart home, smart grid). VaasaETT's unique collaborative approach enables it to draw on an extensive network of several thousand energy practitioners around the world who can contribute to its research activities or take part in industry events it organizes allowing VaasaETT to integrate global knowledge and global best practice into its areas of expertise.

VaasaETT's truly global focus is reflected by research and strategic support having been provided to a diverse array of organizations on 5 continents including for instance large industry players, the European Commission, Government and public research bodies in Europe, Japan, the UAE, the Middle East and Australia.

More information at www.vaasaett.com

About Capgemini Consulting

Capgemini Consulting is the global strategy and transformation consulting organization of the Capgemini Group, specializing in advising and supporting enterprises in significant transformation, from innovative strategy to execution and with an unstinting focus on results. With the new digital economy creating significant disruptions and opportunities, our global team of over 3,600 talented individuals work with leading companies and governments to master Digital Transformation, drawing on our understanding of the digital economy and our leadership in business transformation and organizational change.

Our Expertise and Unique Approach in the Utilities and Energy Sector

Capgemini Consulting helps clients formulate operational strategies, implement wide business transformations and optimize organizations and processes through dedicated operational management initiatives.

Our areas of expertise in the Utilities and energy sector include:
Digital Utilities Transformation
Smart Energy (including implementation of smart infrastructures)
Power generation
Power & gas infrastructures and regulated activities
Energy retail including energy services
Clean technologies
Water distribution, collection and treatment
Upstream and downstream Oil & Gas
- Digital Asset Lifecycle Management

Our 800+ professionals operating in 12 major geographies include consulting professionals and experts in specific value chain segments and industry issues. We deliver consulting services to 60% of the leading Utilities companies, and to 50% of the leading Oil and Gas companies worldwide.

We are recognized for our professional commitment and leadership, our intellectual curiosity, and our ability to innovate.

Find out more at:

www.capgemini-consulting.com

Capgemini

About Capgemini

With more than 190,000 people, Capgemini is present in over 40 countries and celebrates its 50th Anniversary year in 2017. A global leader in consulting, technology and outsourcing services, the Group reported 2016 global revenues of EUR 12.5 billion. Together with its clients, Capgemini creates and delivers business and technology solutions that fit their needs and drive the results they want. A deeply multicultural organization, Capgemini has developed its own way of working, the Collaborative Business Experience™, and draws on Rightshore®, its worldwide delivery model.

Capgemini Consulting is the global strategy and transformation consulting organization of the Capgemini Group, specializing in advising and supporting enterprises in significant transformation, from innovative strategy to execution and with an unstinting focus on results. With the new digital economy creating significant disruptions and opportunities, the global team of over 3,600 talented individuals work with leading companies and governments to master Digital Transformation, drawing on their understanding of the digital economy and leadership in business transformation and organizational change.

Learn more about us at

www.capgemini.com/utilities

flashcode

web

PEFC 10-31-1238

IMPRIM'VERT