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Special Supplement

Start up of the Kozienice 11 power plant highlights Poland's commitment to building modern, high efficiency coal fired generation.



Decarbonising Europe

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An energy storage system that will utilise disused mine shafts to store energy using a similar principle to pumped storage is gearing up to enter the demonstration phase.

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Sustainable Development Goals driven by gains in renewables

Adnan Z. Amin: renewables "expanding energy access"



An increasing number of the world's population is gaining access to electricity, partly driven by renewables. However, there is still a need for greater ambition in harnessing renewables to meet sustainable development and climate goals. **Junior Isles**

The world is not on track to meet the global energy targets for 2030 set as part of the Sustainable Development Goals, but real progress is being made in areas such as renewable energy, says a new report from five international agencies.

The report – which is the most comprehensive look available at the world's progress towards the global energy targets on access to electricity, clean cooking, renewable energy and energy efficiency – finds that while global trends are disappointing, recent national experiences around the

world offer encouraging signs.

'Tracking SDG7: The Energy Progress Report' is a joint effort of the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), United Nations Statistics Division (UNSD), the World Bank, and the World Health Organization (WHO).

The report's findings are based on official national-level data and measure global progress up to 2015 for renewable energy and energy efficiency, and 2016 for access to electricity and clean cooking.

According to the report, 1 billion people – 13 per cent of the world's population – still live without electricity. Sub-Saharan Africa, and Central and South Asia continue to be the areas of the world with the largest access deficits. Almost 87 per cent of the world's people without electricity live in rural areas.

The number of people gaining access to power has been accelerating since 2010, but needs to ramp up further to achieve universal access to electricity by 2030. If current trends continue, an estimated 674 million

people will still live without electricity in 2030, the report says.

Solar has played an important role in improving access to electricity, with "tens of millions of people" now having access to electricity through solar home systems or connecting to mini-grids.

Rapidly falling costs have allowed solar and wind to compete with conventional power generation sources in many regions, driving the growth in the share of renewables in electricity

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Emissions reduction supported by carbon pricing initiatives

A new report launched by the World Bank shows that carbon pricing continues to gain traction as governments at national and subnational levels around the world continue to prepare for, and implement, initiatives as a means to curb their emissions while raising revenues.

The annual 'State and Trends of Carbon Pricing 2018' report shows that 70 jurisdictions (45 national and 25 sub-national) have implemented, or are scheduled to implement, carbon pricing initiatives. These mechanisms helped governments raise about \$33 billion in 2017 in carbon pricing revenues from allowance auctions, direct payments to meet compliance obligations, and carbon tax receipts. This represents a 50 per cent increase compared to the US\$22 billion raised in 2016.

The report also finds that carbon prices are rising, with about half of emissions now covered by carbon

pricing initiatives priced at over \$10/tCO₂e, compared to one-quarter of emissions covered in 2017.

According to the World Bank, 2017 was "a very good year" for carbon pricing, noting that there are now 51 carbon pricing initiatives either implemented or scheduled to be implemented. This is roughly a 10 per cent increase on the previous year.

The Bank noted that once the Chinese emissions trading scheme (ETS) – which was officially launched in December – becomes operational, these initiatives will cover 11 gigatons of carbon dioxide equivalent (GtCO₂e), or about 20 per cent of global greenhouse gas emissions. This is up from 15 per cent the previous year.

"Governments at all levels are starting to see the effectiveness of carbon pricing in their efforts to cut harmful carbon pollution while also raising revenues for climate and

other policies, including environmental action," said John Roome, World Bank Senior Director for Climate Change. "As countries take stock of their Paris Agreement commitments and set a path towards increased ambition, carbon pricing mechanisms with robust pricing levels are proving to be essential elements of the toolkit."

He warned, however, that although 50 per cent of trading schemes are now operating at above \$10/t CO₂ (25 per cent more than a year ago), there is still a long way to go. Experts recommend a range of \$40-80/t in 2020 and \$50-100 by 2030.

"Although we have seen significant movement this year, it's still short of where prices need to be, so we have to see some further increase," said Roome. To get prices up, he says allocations could be tightened, as is being implemented in the EU, for example.

He noted, however, that there are concerns among some in the industry over whether higher carbon prices will affect competitiveness. "We have formed a forum looking at carbon pricing and competitiveness... it's very important to have clear communication on this and raise prices gradually," he said.

In late April, the London School of Economics found that all 197 countries, which signed the landmark Paris Agreement now have at least one law in place to fight climate change.

The new research is a 'snapshot' into global trends on climate legislation and shows the significant uptake in new laws and rules over the past 20 years.

According to the researchers, there are now more than 1500 climate laws and policies in place around the world. Of these, 106 were introduced since the Paris Agreement was signed in December 2015.

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to 22.8 per cent in 2015, the report states. It noted, however, that electricity accounted for only 20 per cent of total final energy consumption that year, highlighting the need to accelerate progress in transport and heating.

"Falling costs, technological improvements and enabling frameworks are fuelling an unprecedented growth of renewable energy, which is expanding energy access, improving health outcomes, and helping to tackle climate change, while also creating jobs and powering sustainable economic growth," said Adnan Z. Amin, Director-General, IRENA. "At the same time, this tracking report is an important signal that we must be more ambitious in harnessing the power of renewable energy to meet sustainable development and climate goals, and take more deliberate action to achieve a sustainable energy future."

According to the report, since 2010 China's progress in renewable energy alone accounted for nearly 30 per cent of absolute growth in renewable energy consumption globally in 2015.

China's position as leader in renewables was highlighted in the latest Renewable energy country attractiveness index (RECAI) published by EY. It finds that China is the most attractive destination for renewable energy for the third time consecutively, while the US and Germany overtakes India, which falls from second to fourth position amid rising protectionism.

Commenting on the publication, Ben Warren, EY Global Power & Utilities Corporate Finance Leader and RECAI Chief Editor, said: "Rising interest rates are likely to increase the cost of cheap capital that has underwritten the dramatic roll-out of renewable energy capacity over recent years. Government subsidies for clean power are being reduced around the world and financiers are anticipating tougher times ahead for project developers. However, movements in the Index suggest that these developments are just headwinds as the renewable energy sector continues to mature and markets expand."

In another report – 'Clean Energy Investment Trends 2018' – UK law firm TLT said that 2017 was a year of significant change for clean energy. The end of subsidies for on-shore wind and solar meant that the market needed to adapt but still remained buoyant. This was largely thanks to a highly active secondary M&A and project finance market.

Another major trend in 2017 was the diversification of portfolios, resulting in a 33 per cent increase in the number of offshore wind deals and increased take-up of alternative clean energy technologies such as energy storage. This, it says, is likely to continue into 2018, particularly as the market looks towards multi-technology projects as a way of making subsidy-free developments viable.

Maria Connolly, partner and head of energy and renewables at TLT, commented: "With the end of on-shore wind and solar subsidies, 2017 was a very significant year for clean energy technologies... With the changes brought about by the end of these subsidies, new clean energy investment trends have emerged, which give a good indication of the future direction of travel for the market. 2017 was marked by strong secondary market activity, but also a diversification of portfolios with less mature technologies such as energy storage attracting significant interest."

EC to massively increase spending on climate change and energy transition

- Additional €114 billion for climate change and adaptation
- EC proposes €8.65 billion for energy sector through CEF

Junior Isles

The European Commission has put forward its future budgetary plans, which include spending a quarter of its entire finances on tackling climate change.

Under the new proposals, covering the period between 2021 and 2027, a total of €320 billion will be spent on climate adaptation and mitigation, an increase of €114 billion.

Under the current budget, €206 billion is already being spent out to 2020 on combating climate change through investments in energy efficiency, renewable energy, environmental protection, and other carbon reduction schemes. This represents 20 per cent of the budget, and so the draft

proposal represents an overall increase of 5 per cent.

Earlier this year, French President Emmanuel Macron suggested that 40 per cent of the EU's budget should be spent on making the transition to a low-carbon economy, commenting that the amount "would allow for this transition to be ambitious rather than measured, as it is today".

The proposed budget will now go to the European Parliament and Council for final approval where revisions could be made to the level of climate ambition.

Environmental groups have pointed out that a bigger budget is needed to meet the goals of the Paris climate agreement, and Roland Joebstl, a policy officer at the European

Environmental Bureau, has said that the plan should also be more "Paris-compatible".

He commented: "An increase of climate spending does not fix a budget that, overall, still fails to be carbon neutral."

Notably, this latest proposal calls for €8.65 billion to be invested in the energy sector through the Connecting Europe Facility (CEF).

One of the key points of the plan is the promotion of Member States' co-operation in integrating cross-border renewable energy projects. The focus will be on completing priority sections of the energy networks essential for the internal market.

The plan also seeks to deliver smart and digitised energy grids, so as to

achieve interconnection targets and improve security of supply.

Following the announcement of the budget plans, a group of utilities, investors and non-government organisations sent a letter to the President of the European Commission, Jean-Claude Juncker, asking for more money to be invested in zero-emission mobility and power generation when allocating the EU budget after 2020.

The group said that the Commission's intention for future transport-related spending to be focused on "innovative infrastructure solutions" with a strong focus on e-mobility, smart grids and energy storage now needs to be translated into binding rules for all projects funded by the EU.

RWE may fight Netherlands coal plant ban

German utility RWE is contemplating legal action following the Netherlands' decision to ban coal fired power generation in the coming decade and shut down two of its five coal fired plants at the end of 2024 unless they switch fuels.

The law announced by Economy Minister Eric Wiebes last month applies to plants built in the 1990s, while newer ones will have to close by the end of 2029. It marks the first step towards the government's goal of shutting all coal fired plants by 2030.

Shutting the coal fired plants should help the government achieve its goal of reducing CO₂ emissions by 49 per cent relative to the 1990 level by 2030. Emissions last year were already 13 per cent lower than in 1990.

The first two plants are run by Germany's RWE and Sweden's Vattenfall in Geertruidenberg and Amsterdam, respectively, and have been in operation since 1994. The remaining three were built in 2015 and 2016.

Vattenfall subsidiary Nuon said it would abide to the law and would shut down its Hemweg-8 plant at the end of 2024.

RWE, which also operates one of the newer coal fired plants, however, said it was unhappy with the decisions. It stressed that they offer no compensation for the ban on coal and for the €3.2 billion (\$3.8 billion) it invested in its newest plant at the request of the government.

"We expect significant consequences for our activities", the company said in

a statement. "We will contemplate legal action if the law is implemented as currently proposed."

The news is a blow to the already hard-pressed company. In May it reported slumping revenues and profits as 2018 got under way.

Net profits at the group dropped 34.5 per cent year-on-year between January and March, to €620 million (\$739 million).

Revenue fell more than six per cent to €12.4 billion, while adjusted operating, or underlying profit fell to €1.9 billion, dragged down by "lower margins and wholesale prices" in conventional power generation, RWE said in a statement.

The company, however, remains confident of hitting targets for the full year

as a mega-deal with rival E.ON inches forward. Financial Director Markus Krebber insisted the group was "on track" with its operating business and would meet its full-year goals.

RWE said it would provide investors and analysts with updated forecasts later in the year, as a complex deal with German rival E.ON is set to reshape the business.

Earlier this year the two firms agreed on a series of asset swaps that will see RWE focus on energy generation with both renewables and traditional fossil fuel and nuclear plants, while E.ON specialises in retail customer relationships and managing energy networks.

Executives hope for approval from regulators and competition authorities by mid-2019.

Talks continue over government support for Wylfa nuclear power plant

Hitachi is to continue talks over the £20 billion (\$27 billion) Wylfa nuclear power plant project in Anglesey, Wales, after the British government made a financing offer, according to reports.

According to the *Japanese Times*, the UK government has agreed loans and loan guarantees covering over £13 billion, but not to take an equity stake in the remaining £7 billion investment needed.

It has been reported in the Japanese press that the struggling nuclear arm of Hitachi is proposing to postpone construction of the project by two years to 2027 due to difficulty in raising finance and the risk of spiralling costs, which the company is refusing

to absorb.

Financing the 2.7 GW project is proving a huge challenge despite support from the UK government. In recent weeks it doubled the offer of public support for the new reactor to £13.3 billion. The money will help cover the escalating cost of building the plant, which has risen from the initial £10 billion estimate.

Hitachi is also now asking for price guarantees for the electricity from the plant. Reports also suggested UK taxpayers could own a 33 per cent share of the project.

Commenting on the reports, a spokesperson for Hitachi's Horizon Nuclear Power only said: "While we understand the strong interest in progress,

we will not be commenting until they have reached a conclusion."

An official from the UK's Department for Business, Energy and Industrial Strategy (BEIS) added: "We don't recognise these reports. Nuclear power remains a crucial part of the UK's energy future but we have always been clear that this must be delivered at the right price for consumers and taxpayers."

UK ministers have insisted the plant must be cheaper than Hinkley Point in Somerset, which was given the go-ahead last year. Environmental campaigners, however, have slammed the plans.

Dr Doug Parr, Chief Scientist for Greenpeace UK said: "The financial

debacle that was the Hinkley deal is at risk of becoming just a starting point for new deals. Overseas nuclear companies want to build even more expensive plants than Hinkley in the UK, but with additional new demands for taxpayer support.

"It makes absolutely no sense to waste billions on expensive and outdated nuclear power stations when technologies like offshore wind can do a similar job faster and cheaper. Nuclear is an energy landline in the age of smartphones, chaining us to a slow, expensive, out-of-date technology while the world moves on to the interconnected, reliable, high tech system that will power our homes for generations to come."



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SMRs progress in USA

■ NuScale design milestone ■ FirstEnergy to close 4 GW

Siân Crampsie

The USA is looking to continue developing small modular nuclear reactors (SMRs) as operating nuclear plants in the country struggle with economic conditions.

NuScale Power said last month that its aim of becoming the first to market in the USA with its SMR came a step closer to reality when the Nuclear Regulatory Commission (NRC) announced it had completed phase one of its review of the company's design certification application.

The news came just after an announcement from the US Department of Energy that it had awarded NuScale a \$40 million grant to help with development costs. The firm, a subsidiary of Fluor Corp., hopes to construct a 12-module SMR plant by about 2026 at the Idaho National Laboratory. The facility would be owned and operated by Utah Associated Municipal Power Systems.

SMRs have the potential to be faster to construct, safer and less costly compared with traditional, large-scale nuclear designs. Several new nuclear

projects in Europe and North America have suffered from cost overruns and delays in recent years.

Last year Scana scrapped the VC Summer nuclear project in South Carolina after Westinghouse declared bankruptcy. More recently, FirstEnergy Solutions (FES) notified the NRC of its plans to permanently deactivate all its three nuclear power plants with a combined capacity of 4048 MW due to "severe economic challenges".

NuScale's Chairman and Chief Executive, John Hopkins, said the

company welcomed the rigorous review of its "revolutionary nuclear design" by the NRC and appreciated the government's recognition of "the importance of furthering NuScale's advancement".

Hopkins added: "Our technology means significant job and economic benefits for the country and it's positioned to revitalise the domestic nuclear industry by virtue of NuScale's affordable, flexible and safe solution to providing zero-carbon energy."

FES says it will retire the 908 MW Davis-Besse nuclear power station and

1268 MW Perry nuclear power plant, both in Ohio, and the 1872 MW Beaver Valley power station in Pennsylvania over the next three years.

FES chief nuclear officer Don Moul said: "We are actively seeking policy solutions at the state and federal level as an alternative to retiring these plants, which we believe still have a crucial role to play in the reliability and resilience of our regional grid."

"What also is at stake for the region is 4048 megawatts of zero-emission baseload generating capacity, an all but irreplaceable resource."

Iberdrola marks first 'green loan' in Mexico



Iberdrola has become the first company in Mexico to secure a so-called green loan.

The company's Mexican subsidiary, Iberdrola Mexico, has signed a \$400 million loan deal with 10 relationship banks on a five-year term to refinance the construction of wind farms in the country.

The loan has been certified as 'green' by Vigeo Eiris, a firm that provides environmental, social and governance guidance to investors, because the funds are being used for sustainable purposes in line with Green Loan Principles.

Iberdrola says that the funds will be used to refinance three wind farms in Mexico, where it is aiming to install more than 11 000 MW by 2022. The Spain-based utility was the biggest green voucher issuer at company level

in 2016 and 2017. The company has also made all its public offerings in 2018 in this format.

In January, Iberdrola signed the largest credit deal in the world under sustainability criteria, for €5.3 billion, with a spread associated with reducing the group's emissions.

In 2017 Iberdrola's fleet in Mexico included 5.55 GW of combined cycle gas plants, 294 MW of cogeneration plants, 367 MW of wind farms and 43 MW of solar parks.

■ Iberdrola is planning to invest \$833.1 million in new electricity distribution and wind projects in the northern Brazilian state of Rio Grande do Norte over the next five years. The new investment will double Iberdrola's current operating capacity in the state, where it currently operates 11 wind farms.

Bolivia borrows to boost wind

Bolivia is to borrow funds from Denmark to enable the construction of a portfolio of new wind power projects.

The country's government has signed a decree authorising borrowing \$1-3 million from the National Bank of Denmark to fund three new wind farms with a combined capacity of 108 MW.

All of the wind farms will be located

in Santa Cruz department. Bolivia's government will provide \$66 million of funding and says that the projects will help Bolivia to reduce carbon emissions and diversify energy resources in Santa Cruz.

The wind farms to be built are the 14 MW Warnes 1 project in Warnes, the 40 MW San Julian wind farm in Cotoca, and the 54 MW El Dorado wind farm in Cabezas.

PREPA mulls utility-scale storage

■ RfP planned for large-scale storage
■ Island prepares for new hurricane season

Puerto Rico has announced plans for a large-scale energy storage project in a bid to help the territory modernise its energy system.

The government said in May that it would issue a request for proposals (RfP) in June for a project that would help the island reduce dependence on energy imports and improve the stability of the grid.

The move follows the completion of a study into the need for energy storage commissioned by the Puerto Rico Public Private Partnerships Authority (PRPPA) and comes in the wake of hurricane Maria, which caused widespread damage to the island's grid in September 2017.

PRPPA's study concluded that "there is a need to revitalise and modernise [power utility] PREPA's assets and increase the efficiency and reliability of the current service."

The deployment of utility-scale energy storage systems at a variety of critical PREPA substations that can provide grid stability and peaking capacity is a critical component of this effort".

It added that energy storage capacity would reduce imports of fossil fuels and the associated exposure of PREPA to the risks associated with international shipping and fuel prices.

The government expects that PREPA would provide the site for one or more energy storage projects, and award contracts to private sector partners able to provide financing, design, engineering, construction and technology.

According to charity group Oxfam, thousands of citizens in Puerto Rico remain without power supplies more than seven months after the hurricane. It has also expressed doubts over the sustainability of the island's rebuild

efforts as hurricane season in the region looms once again.

"Honestly, while we welcome efforts to repair the grid, we're also worried that it is not being built back in a truly sustainable way," said Brenda Guzman, Oxfam programme officer in San Juan.

She added: "We're concerned that the work so far was just for the interim and patched back together – it won't be adequate to stand up to hurricane-force winds, which are just around the corner. We need to move quickly into the long-term rebuilding phase, as the short-term measures won't be sufficient."

Oxfam believes that the official figure of 29 000 people without power are a "drastic underestimate", and says that damage to submarine cables to outlying islands is so severe that it will take several years to fix them.

Acciona expands in Chile

Acciona is to add 400 MW to Chile's grid over the next three years to cover its supply commitments in the country.

The company is to build two solar photovoltaic (PV) plants as well as two wind farms in the country, with a total investment of \$600 million.

In early 2019 the company will start construction work on the 62 MW capacity Almeyda photovoltaic plant, which it expects to complete at the

end of the year. Consisting of solar modules with horizontal tracker technology, it will cover 150 hectares in the locality of Diego de Almagro in the region of Atacama.

A few months later, in the third trimester of 2019, Acciona will begin the construction of the 64 MWp Usya photovoltaic plant, with entry into service planned for mid-2020. With solar modules mounted on fixed structures, it will cover 105 hectares in Calama in

the region of Antofagasta.

Acciona will invest \$150 million in these two plants, which will enable it to meet its supply commitments under a recently signed power purchase agreement with the National Mining Company of Chile.

In Renaico municipality, Acciona is currently building the 183 MW San Gabriel wind farm, and is also preparing to start building the 87 MW Tolpn wind farm.



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Investors line up for Taiwan offshore wind projects

■ Seven developers secure offshore wind contracts ■ Further 2 GW planned under next auction

Syed Ali

A growing number of international investors are lining up to take advantage of Taiwan's budding offshore wind power sector.

At the end of April, Taiwan announced the results of its first major offshore wind farm auction, which aims to add 3.8 GW of capacity to its existing wind capacity of just 8 MW. The auction saw seven offshore wind farm developers secure government contracts to build 10 offshore wind farms along the western coast.

Notably, Taiwan did not consider bids from companies in China, the world's third-biggest offshore market and which claims Taiwan as Chinese

territory. Chung-Hsien Chen, director of the energy technology division at Taiwan's Bureau of Energy, said Chinese bids were excluded "due to concerns of national security".

The world's leading offshore wind developer Ørsted was one of the big winners in the auction, securing 900 MW of capacity. Now the company is looking to add to that total, announcing in May that it will join the end of May/June auction for constructing further large-scale Greater Changhua offshore wind farms.

Ørsted is currently developing four offshore wind farms off Changhua with a combined generating capacity of 2.4 GW. The upcoming process will add 2 GW more to Taiwan's offshore

wind pipeline, bringing the total to around 5.8 GW.

Ørsted's CEO Henrik Poulsen said: "As the Taiwanese government established an ambitious 20 per cent renewables target by 2025, offshore wind will play a significant role in contributing to Taiwan's green future... Ørsted is committed to build offshore wind farms off the Changhua coast on time to support the transition to clean energy in Taiwan."

The announcement came as Japanese trading house Mitsui and Co. Ltd said that it is buying a 50 per cent stake in Taiwanese wind farm developer Yushan Energy Co. in a move to secure a stake in one of Taiwan's major offshore wind farms.

Yushan Energy Co, which is part of Singapore's Enterprize Energy, owns 40 per cent of the Hai Long Offshore Wind development, situated in the Taiwan Strait, off the coast of Changhua. The development is still at the planning stage at the moment and is expected to cost around \$1.8 billion (NT\$53.8 billion) to develop.

Under another contract, signed at the end of April, Hitachi Ltd. and Belgium company Jan De Nul Group will design, manufacture and install the wind turbines as well as the off- and on-shore cables for a project offshore Chunghua County. The 21 offshore wind turbines each have a generating capacity of 5.2 MW.

Taiwan's offshore wind market is

expected to expand to 5.5 GW by 2025, and the government aims to invest \$23 billion in onshore and offshore wind projects by 2025, according to law firm Jones Day. This is the year when the island's last nuclear power plant is due to be shut down.

■ The Ministry of Economic Affairs (MOEA) has defended a controversial plan to build a coal fired power plant in New Taipei City, saying that an imbalance in the nation's regional power supply needs to be resolved. State-run Taiwan Power Co (Taipower) wants to build a coal fired plant on the site of the old Shenao Power Plant, which was near Rueifang District's Shenao Harbor and was demolished in 2011.

Vietnam continues to attract foreign investment

Vietnam's renewable energy sector and environmental projects are continuing to attract foreign capital, with a number of significant investments recently being confirmed.

In May, Envision confirmed it was planning to invest \$660 million in a 300 MW wind power project to be built in Soc Trang province.

The company also said it has established a specialised division for researching and investing in wind power projects in Vietnam, as there are many locations with good wind power potential.

Foreign investors already active in the Vietnamese power sector are looking to expand their footprints in the country, with an increased focus on renewable energy.

In early May, Malaysia's Jaks Resources Bhd. and China Power Engineering Consulting Group Co., Ltd., which are building a 1200 MW, \$1.87 billion coal fired power plant in the northern province of Hai Duong, said they are planning to build renewable projects in other provinces.

"Aligning with our strategy, we will grow our power portfolio in Vietnam with a view to participating in the

recent renewable energy drive in the country," said Elaine Tai, General Manager of Corporate Strategy at Jaks Resources.

In a recent visit to the southern province of Binh Phuoc, Haris F. Abdullah, a representative of Jaks Resources in Vietnam, said the firm plans to invest in a solar power project with a capacity of 200 MW and total investment capital of \$262.5 million. The project would be divided into two phases, with the first phase boasting a capacity of 50 MW and investment of \$87.5 million.

Early May also saw the Mekong Delta province of Bac Lieu sign a Memorandum of Understanding (MoU) on a liquefied natural gas-fuelled power project with Energy Capital Vietnam. The 3200 MW project will require an investment of about VND91.4 trillion (\$4 billion) funded by Energy Capital Vietnam.

The project will be implemented in three phases. The first 1000 MW phase will be launched this year and will start operations in late 2021. The second and third phases will be completed in 2024 and 2027, with capacities of 1000 and 1200 MW, respectively.

Chinese boost for Bangladesh power sector

Bangladesh's efforts to grow its installed power capacity received a boost last month with the signing of a joint venture (JV) agreement between the Bangladesh Power Development Board (BPDB) and China Huadian Hong Kong Company Ltd (CHDHK) to construct a 1320 MW coal fired power plant in Maheshkhali, Cox's Bazar.

The project is CHDHK's first investment in Bangladesh. The deal is expected to see the JV set up this month (June), according to BPDB Chairman Khaled Mahmood. The project, which will cost around \$2 billion, is scheduled for completion in 48 months from the start of construction.

Nasrul Hamid, State Minister for Power, Energy and Mineral Resources said the government was no longer focusing on short-term and mid-term projects but was instead putting its emphasis on base load projects.

Bangladesh has been steadily increasing its generating capacity and reportedly added 1000 MW to the grid in May.

In late April, Bangla Trac Power Unit-1 Ltd started supplying 200 MW to the national grid from its plant in Daudkandi, Comilla, according to Bangladesh Power Development Board. This brings the Bangla Trac

group's contribution to the national grid to 300 MW. Earlier that month, the company's plant in Noapara, Jessore, added 100 MW to the grid.

Meanwhile, renewable schemes are gaining traction in parts of the country that cannot access grid-connected base load power. In late April the World Bank approved a \$55 million loan to expand the use of clean renewable energy in rural areas.

The additional financing to the Second Rural Electrification and Renewable Energy Development (RERED II) project will help install solar irrigation pumps, solar mini-grids and improved cooking stoves.

The project has already built 10 solar mini-grids in remote areas, including islands and shoals to provide grid quality electricity. This additional financing will help construct another 30 solar mini-grids. These will provide about 28 000 connections to households and businesses, including small and medium-sized enterprises.

Since 2002, the World Bank has been helping the government expand renewable energy programmes. In the energy sector, the World Bank has ongoing support of over \$1.6 billion in Bangladesh covering generation, transmission, distribution, and renewable energy.

Japan back on nuclear path

Japan appears to have its sights clearly set on nuclear following what is turning out to be a temporary hiatus in its nuclear power programme. A subgroup of the Japan Advisory Committee for Natural Resources recently proposed an energy plan, which says that by fiscal 2030 nuclear energy should account for 20-22 per cent of total power generation. The Cabinet is expected to approve the plan within weeks.

The news comes against a background of anti-nuclear public sentiment that has prevailed since a meltdown at the Fukushima Daiichi plant following a tsunami caused by an earthquake in March 2011.

The Ministry of Economy, Trade and Industry has designated nuclear energy as an "important source of base load" generation. The draft stated that "necessary steps should be taken steadily" to increase nuclear generation, but stopped short of detailing specific measures. Neither new construction nor expansion was mentioned by the subgroup.

In order to meet the 20-22 per cent target an estimated 30 nuclear plants must be in operation. Up until 2011, Japan was generating some 30 per cent of its electricity from nuclear but following the Fukushima accident, the country shut down all of its 50 units for safety reviews. Since then only eight have resumed operation. As a result, nuclear energy now accounts for less than two per cent of the generating mix.

Japanese Prime Minister Shinzo Abe is in favour of restarting more of Japan's nuclear plants but continues to meet public opposition.

The government is under pressure to resume operation of the plants in order to meet carbon emission targets and halt rising energy costs driven by increased fuel imports.

Europe News



Plans for a 2 GW battery storage and EV network are a world first, according to Pivot Power.

Siân Crampsie

Energy company Pivot Power is planning to give UK system operator National Grid a “huge resource” of battery storage facilities to help it manage electricity supply and demand.

Pivot Power – a new venture backed by battery project developer Become Energy and investment firm Downing – has announced plans for a 2 GW network of grid-scale battery storage projects around the UK, as well as a string of electric vehicle (EV) rapid charging stations.

It says that the £1.6 billion programme is a “world first” that will provide infrastructure to support the rapid adoption of EVs, underpin clean air policies, and introduce valuable flexibility into the energy system.

Improved flexibility will support EV roll-out as well as increasing levels of intermittent renewable generation, it says.

Pivot’s initiative comes as new research shows that the UK’s generating mix is continuing to evolve and that the country is on track to phase out coal plants by 2025.

WWF and Sandbag said in May that renewables generation will surpass coal’s contribution to the energy mix by 2022 and that renewables, storage and other flexible technologies would provide the UK with enough capacity and stability to keep the lights on as coal is phased out.

Pivot’s move is the latest in a series of announcements indicating that energy storage in the UK is ramping up. Vattenfall has commissioned a 22 MW

battery facility at the Pen y Cmoedd wind farm in Wales, while Ørsted is building a 20 MW battery facility in Liverpool, England.

EDF has also recently announced a major investment programme in energy storage, pledging to spend €10 billion in the sector globally by 2035.

“The future energy system will be completely transformed from what it is today, with a smarter, more flexible grid, balancing supply and demand with new technology and cleaner energy generation,” said Ørsted UK’s Managing Director, Matthew Wright. “We want to continue to be at the forefront of this exciting shift towards a decarbonised energy system.”

Pivot Power plans to develop some 45 sites around the country, installing grid-scale 50 MW batteries at

electricity substations connected directly to the extra-high-voltage transmission system.

The battery network will be the world’s biggest, storing enough electricity to supply 235 000 average homes for a day and the ability to release or absorb two thirds the power of the planned Hinkley C nuclear power plant in response to grid balancing requirements, Pivot said. It added that it has chosen sites near towns and major roads so that they can also power EV charging stations.

Graeme Cooper, National Grid Project Director for Electric Vehicles, said: “We expect the use of electric vehicles to grow rapidly. This innovative solution will help accelerate adoption by providing a network of rapid charging stations across the country enabling

cars to charge quickly, efficiently and as cost-effectively as possible.

“It will also give the system operator more choice and flexibility for managing the demands in the day to day running of the network, and also help mass EV charging”.

Pivot Power aims to have operational batteries at ten sites within 18 months, with one on the south coast of England ready by mid-2019.

CEO Matt Allen said: “We want to future-proof the UK’s energy system and accelerate the electric vehicle revolution, helping the UK to clean up its air and meet climate targets. Big problems require big solutions, and we are moving fast to put in place a unique network to support a clean, affordable, secure energy system and embrace the low-carbon economy.”

Atlantis submits 1 GW French plan

Atlantis Resources says that the cost of tidal energy could be driven lower than that for offshore wind through the delivery of a 1 GW project in France.

The tidal energy firm says it has submitted plans to the French government for the installation of 1 GW of tidal energy capacity in the Raz Blanchard, Normandy, by 2025.

The move comes after Atlantis conducted a study showing that 2 GW of

tidal energy is immediately available to be harnessed in the Raz Blanchard. Developing this resource would help to drive down the levelised cost of energy (LCOE) for tidal “lower than any offshore wind farm currently under construction in France or in the UK”.

Atlantis believes the construction of a 2 GW project would attract €3.3 billion of investment, opening up an export market worth about €400 million

in turbine sales each year and the potential to create 10 000 jobs.

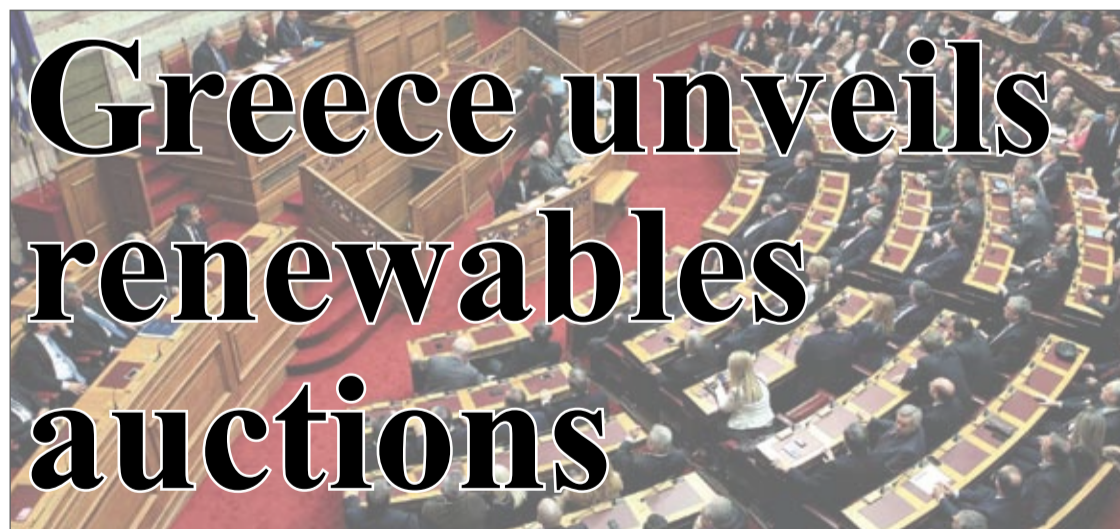
“France is sitting on a low cost renewable energy gold mine at Le Raz Blanchard,” said Tim Cornelius, Atlantis CEO. “Now that the tidal stream industry has been through the R&D phase and is now entering full scale commercialisation, France should be at the forefront of exploiting this environmentally benign, predictable

and inexhaustible source of renewable energy.”

“Our proposal, if implemented, could quickly create a new industry in France attracting investment in local companies to establish a supply chain capable of delivering more than one thousand 1.9 MW tidal turbines along with their associated foundations and the onshore infrastructure.”

France is developing tidal stream

experimentation sites and pilot projects in preparation for tidal commercial rounds recently announced by French environment secretary Sébastien Lecornu. Atlantis says it is pursuing an opportunity to develop a reference site in the Normandy area and is seeking assistance from the French government to create a local supply chain and invest in the maritime infrastructure in the Normandy area.



Greece’s government will auction 600 MW of wind and solar energy capacity in July as part of a move towards competitive renewable energy tenders.

The July tender will be the first competitive renewable energy auction in Greece, which has previously used a feed-in tariff system to support renewable energy development.

Overall it is planning to auction up to 2.6 GW of wind and solar capacity by 2020 and attract investments of \$3.6 billion to the sector.

The first tender will be held July 2 and will hand out permits to build 300 MW of wind power and 300 MW of solar photovoltaics (PV). Subsequent tenders will be held annually and follow a similar format, while two additional 400 MW auctions will be held pitting wind and solar against each other.

According to rules issued by Greece’s Regulatory Authority for Energy (RAE), bidders in the auctions must have environmental and grid connection permits for projects in place. For

wind, sites must be 3-50 MW in size. For the first auction, a ceiling price has been set at €90/MWh. The price secured in the auction will last for 20 years.

Greece has set a target of reaching 18 per cent of energy consumption to be met by renewables by 2020. The European Commission gave its approval to Greece’s new auction scheme earlier this year, calling it a “very good” scheme that will “facilitate Greece’s efforts to reach its 2020 climate goals”.

PGE queries nuclear role

Polish power group PGE Polska Grupa Energetyczna SA will abandon its role in Poland’s first nuclear power plant in favour of developing offshore wind capacity, according to reports.

The Reuters news agency says that the energy firm could not afford to finance both the nuclear and offshore wind farm projects, quoting sources.

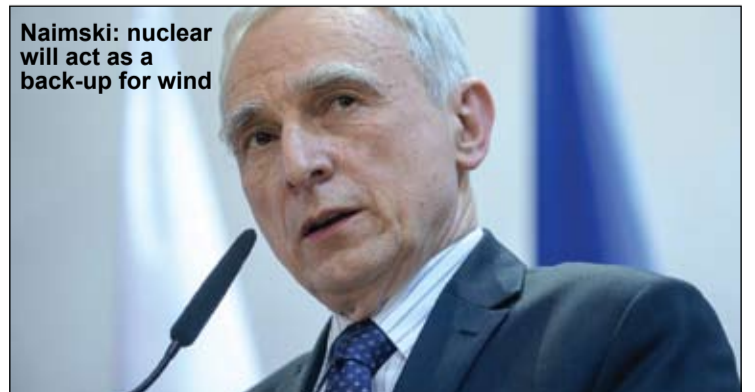
In March, PGE said it would build 1000 MW of offshore wind energy capacity in the Baltic Sea by 2025. It currently relies heavily on coal for its power generation needs.

In response to the media reports, a government official said that the

nuclear and offshore wind project were complementary. “We need both. Offshore wind-farms will be built in the mid 2020s ... We need them just as we need nuclear,” Piotr Naimski told Reuters, adding that the nuclear capacity would act as a back-up resource for wind energy.

Earlier this year a Polish think tank, the Foundation for Sustainable Energy (FNEZ) said that Poland could install up to 8 GW of offshore wind energy capacity in the Baltic Sea by 2035. It noted that a stable regulatory regime and market incentives would be needed to realise these projections.

Naimski: nuclear will act as a back-up for wind



Oman diversifies with coal and renewables

■ Duqm RfP expected in Q3 ■ 12 pre-qualify for Ibri solar

Siân Crampsie

Oman could buck the global downward trend in coal fired generation with the development of up to 3 GW of coal-fired power plant capacity in the next six years.

The country announced that it is preparing to issue a request for proposals (RfP) for the first phase of a large-scale coal fired plant at Duqm, where the government is developing one of the region's biggest Special Economic Zones (SEZ).

The RfP is expected to be issued in

the third quarter of 2018 and follows on from a Request for Qualifications (RFQ) for a 1200 MW project issued earlier this year.

The Oman Power and Water Procurement Company (OPWP) will be the sole off-taker of electricity from the project, which is expected to attract a large number of international power plant developers. A second phase of the project will add up to 1800 MW.

The Duqm coal fired power plant will help Oman to diversify its energy resources and improve security of

supply. Alongside coal fired power generation, the country is also developing a renewable energy sector.

According to OPWP, Oman will install six wind and solar energy projects with a combined generating capacity of 2.65 GW by 2024.

The renewable energy plants will be developed by independent power producers and include three solar photovoltaic (PV) parks of 500 MW each, to be commissioned in 2022-2024. They will be located in Ibri, Manah and Adam.

Some 12 international consortiums

have been prequalified to participate in a competitive international tender for the first of these solar projects, at Ibri.

Some 28 international developers originally registered their interest to participate in the Ibri bid when a RfQ was floated by OPWP late last year. A formal contract for the project is expected to be announced in the third quarter of 2018, OPWP said, adding that the plant could be on-line as early as 2021.

The qualified bidders include Masdar, Lightsource BP, EDF Energies

Nouvelles, ACWA Power, Hanwha Q Cells, and Marubeni.

Three independent power producer (IPP) wind projects will also be developed between 2018 and 2024. These are the 150 MW Dhofar II wind farm slated for commissioning in 2023, and two parks of 200 MW each are expected to be installed in Dhofar and Duqm.

Oman relies on natural gas for 97 per cent of its electricity generation needs. It has set a target for renewables to meet ten per cent of electricity generation by 2025.

Eskom explores energy storage

South African utility Eskom is exploring energy storage as a means to help it integrate large quantities of renewable energy into the electricity grid.

Eskom has launched a request for information (RfI) to identify energy storage technologies for multi-purpose applications. It says that energy storage will be essential to South Africa's plans to build several GW of renewable energy in the next few years.

The RfI will help Eskom to identify all industry role players and stakeholders as well as different available technology and solution options. It will use the information when making decisions on how to apply suitable storage technologies throughout its network.

Energy storage technologies could help Eskom to alleviate grid constraints, manage peak demand and facilitate the integration of independent power producers (IPPs) that are building renewable energy capacity.

In April Eskom finally signed 27 renewable power purchase agreements (PPAs) representing about 2300 MW of generating capacity, after the process was delayed several times since.

It had been due to sign the PPA contracts in 2016 but refused to do so due to cost issues and excess power generation capacity. Plans to sign the contracts in March 2018 were also delayed by a legal challenge brought by the National Union of Metalworkers of South Africa (MUNSA), which argued that the renewable energy projects would result in the closure of coal fired power plants in South Africa and an increase in electricity prices.

The 27 projects include solar photovoltaic (PV), wind and concentrated solar power (CSP) projects and were selected under bid windows 3.5, 4 and 4.5 of the country's Renewable Energy Independent Power Producer Procurement Programme (REIPPP).

World Bank boosts KenGen books

The World Bank is helping to strengthen the finances of the Kenya Electricity Generation Company (KenGen) with a \$180 million loan guarantee.

The guarantee is designed to help the state-owned company to procure long-term commercial financing of up to \$300 million to refinance some existing commercial loans.

It will also help KenGen to enhance its credit status, as well as continue with plans to invest in Kenya's power sector, where electricity demand is

growing at around eight per cent per year.

Kenya relies heavily on hydropower and geothermal energy but is investing in renewable energy and in its grid to keep pace with economic growth and reduce the frequency of blackouts.

Kenya has an installed generating capacity of 2370 MW and peak demand of about 1770 MW.

KenGen, which is 70 per cent owned by the government, has an installed capacity of 1631 MW.

Egypt launches ambitious grid plan

■ AFESD providing finance
■ Links with Saudi Arabia and Sudan planned

Egypt has developed an ambitious national plan to invest in the country's grid infrastructure to help overcome energy shortages and meet growing electricity demand.

The country in April signed a \$200 million financing deal with the Kuwait-based Arab Fund for Economic and Social Development (AFESD) to help fund the grid project, which aims to develop and expand the electricity network, especially in areas with increasing electricity loads.

A spokesman for Egypt's presidency told local media that three new substations would be commissioned in May, June and July this year. Outages had reached a peak in 2014 and the government says that the problems causing the energy shortages have been resolved.

Egypt's government is also expecting to sign a memorandum of understanding with Sudan covering the terms of an electricity interconnection project.

The capacity of the project is

expected to be 200-300 MW and it is likely to cost \$56 million. The link would be the starting point for Egypt to connect its grid to other parts of Africa.

The country is also planning a 3000 MW grid interconnection with Saudi Arabia, according to the Ministry of Energy.

Contracts for that transmission project are expected to be signed in June, and the link would start operating in 2021.

World's largest solar-diesel plant takes shape

The world's largest solar-diesel hybrid power plant has started supplying energy to an off-grid gold mine in Burkina Faso.

According to developer Wartsilä, the hybrid facility will provide a reliable and sustainable round-the-clock supply of energy to the mine and demonstrates "the enormous potential of integrating renewables as the baseload

electricity".

Wartsilä was selected by the global renewable energy independent power producer Total Eren SA and African Energy Management Platform (AEMP) to build the 15 MWp solar photovoltaic (PV) plant to deliver energy to Iamgold Essakane SA at its gold mine in Burkina Faso, 350 km north-east of the capital, Ouagadougou.

By hybridizing an existing 57 MW diesel power plant with the new solar PV plant and related hybrid plant controls, the plant's performance has been significantly enhanced, Wartsilä said.

The company estimates that the addition of the PV plant will reduce fuel consumption by some 6 million litres per year, while reducing annual CO₂ emissions by as much as 18 500 tons.

Kozienice 11 marks a new era in coal fired generation

Kozienice 11 is Poland's most modern and efficient coal fired station. Its start up highlights the country's commitment to building coal fired power plants that can operate at efficiencies of higher than 45 per cent while meeting the EU's latest environmental standards.

Junior Isles

A site on the banks of the Wistula River, 60-70 km southeast of Warsaw, is now home to the largest, most efficient, coal fired power plant in Poland and among the most efficient in the world.

Kozienice 11, located in Swierze Górne near Kozienice, was officially handed over to Polish state-controlled energy company, Enea, on December 19, 2017, marking the culmination of four years of a huge collaborative effort between its constructors – Mitsubishi Hitachi Power Systems Europe (MHPSE), its Polish consortium partner Polimex-Mostostal S.A. and several Polish authorities.

While coal fired plants might be a dying breed in Europe and the US, some argue that the project shows that coal can still play a role in some parts of the world and can provide affordable, reliable electricity, while keeping emissions well below strict environmental limits.

Poland has long been an ardent supporter of coal fired generation. It has the largest reserves of coal in the EU and uses the fuel for about 90 per cent of its electricity. It currently has 3.2 GW under construction – all scheduled to come online throughout the next decade – part of a 10 GW build-out of new coal fired power generating capacity in the country.

The new Kozienice 11 power unit will strengthen Poland's coal-based electricity production, which is in line with its policy of "focusing on one's own resources", promoted by Poland in the EU. According to the government, this strategy significantly raises Poland's energy security, which it sees as a part of its national and economic security.

With the construction of Kozienice 11, MHPSE played an important role in the extension of the Polish power generation system and in ensuring a dependable supply of electricity in an expanding economy.

Construction of the new unit itself also provided a boost to the local economy. While MHPSE was responsible for delivering all the major equipment, the entire balance-of-plant, HV electricals, civil works and construction was handled by Polimex-Mostostal.

At a total cost of zlotys 6.3 billion (€1.5 billion), Kozienice 11 is one of the biggest energy investments in Poland. About half of the contract value was handled by the domestic consortium partner – fulfilling a legal requirement that local partners must be involved in such projects.

According to MHPSE, the proviso had its advantages, noting that there are issues such as Polish civil law for

construction that are typically better handled by local companies. Also, with the contract being paid in Polish zlotys, it was advantageous to have a significant portion of the supply in zlotys.

The most important components for the new unit were either supplied by companies within the corporate group or from parent company Mitsubishi Hitachi Power Systems, Ltd. (MHPS). These include the steam generator, coal bunkers, coal mills, firing equipment, flue gas cleaning, and some balance-of-plant. MHPS supplied the steam turbine, generator, auxiliary equipment and the flue gas desulphurisation (FGD) plant.

The new unit is part of an existing site, where there were already 10 units with a generating capacity of 2905 MW. It is an important facility – it is the second largest in the country, after Belchatow, and represents

Four mills are located at the bottom of the boiler, which MHPSE says is quite unusual for a boiler of this size. There are typically 6-8 mills for a boiler this size but Kozienice 11 uses four large mills.

The boiler, which has a gross maximum power output of 1075 MW, measures 104 m at its highest point. Unlike a two-pass boiler, which is more common in places like the UK or US, Kozienice 11 features a tower-type boiler where the convective heat section is above the radiant section of the boiler. The convective heating surface is above of the evaporator.

The boiler features 32 wall-fired, internally-staged low NOx burners – eight burners situated on four levels inside the boiler.

Supercritical steam conditions within the boiler are the main contributor to the plant's high efficiency.

The new Kozienice 11 power unit will strengthen Poland's coal-based electricity production, which is in line with its policy of "focusing on one's own resources"

8 per cent of the country's installed capacity. Notably, it is the first coal fired power station in Poland designed to have an efficiency of nearly 46 per cent and follows a list of supercritical coal fired plants, like those seen in Germany and the Netherlands.

Kozienice 11 has a net generating capacity of 1000 MW and is hooked into both the 110 kV and 400 kV grids, and controlled remotely from a control centre in Warsaw some 70-80 km away.

Using an existing site for the new highly efficient Unit 11 was an obvious choice. In addition to the infrastructure, the site is next to the Wistula River, which provides the cooling water to feed the huge cooling tower.

The plant receives bituminous coal by rail from all over the country. Although it is designed to burn Polish coal, it can run on coal from elsewhere if necessary.

Coal arriving at the plant is typically high volatile bituminous coal with a calorific value of about 20 000 - 24 000 kJ/kg, ash content of 16-25 per cent and sulphur content of around 0.8 - 1.3 per cent.

Coal is fed by conveyor belt to the plant where it is first crushed to a fine powder by a series of mills before being fed into the boiler at a rate of 101.9 kg/s (guarantee coal).

The once-through Benson design steam generator produces 2894 t/h steam with a superheated steam reheat temperature of 603°C at 250 bar and reheat steam at 621°C/55 bar.

According to MHPSE, the 603°C/250 bar is quite unique for Europe. Although the temperatures are similar to other supercritical projects in Europe, the pressures are usually 20-30 bar higher.

Supercritical steam conditions represent a physical point just above the triple point of water. When the boiler pressure reaches above the critical pressure of 221.2 bar and temperature of 374°C, two-phase mixtures of water and steam cease to exist, and are replaced by a single supercritical fluid. These steam conditions allow a once-through boiler design where the high steam temperature and pressure results in greatly increased efficiency compared to a drum-type boiler.

Supercritical steam is fed to an advanced four-casing steam turbine of dual shell design. There is a high-pressure (HP) turbine, a double-flow intermediate-pressure (IP) turbine and two double-flow low-pressure (LP) turbines. The LP end of the turbine is connected to a hydrogen-cooled generator.

Steam pressure at the turbine inlet is 242 bar with main steam temperature of 600°C and reheat temperature

of 620°C.

The steam turbine is state-of-the-art, combining advanced 3-D blading and improved blade tip seal technology for high steam turbine efficiency. The steam turbine and generator are manufactured in Japan. Notably, only ferritic steel made in Japan is used, as opposed to austenitic steel. Japanese manufacturers have the longest experience with this steel.

MHPSE says this has some key advantages. Combining a ferritic steel rotor with austenitic steel blades can cause problems in the long term due to the different rates of thermal expansion. MHPSE says it can handle the 600°C temperature with just ferritic steel.

The development of high-temperature resistant steels in Japan was an essential key to building this new generation of highly efficient ultra-supercritical power plants. The economy of ultra-supercritical (USC) power plants depends on reliable evidence of their long-term strength. Japan has a great deal of experience in operating USC steam power plants, with references that demonstrate high reliability since 1998 with live steam temperatures of 600°C and reheat temperatures of 610°C to 620°C.

The low-pressure section is where the steam turbine has its greatest innovation.

It is the first time in Europe that a 60-inch last stage blade is used in the low-pressure turbine. The largest is currently 49 inches. With this new last-stage blade, the cooling water temperature of 17°C and a vacuum of 40 mbar can be utilised in the steam turbine at quite moderate steam turbine exhaust velocities, which results in higher plant efficiency.

The large cooling tower also helps to maximise efficiency at the site. Because the plant is located next to a river in the middle of the country, the cooling water conditions are not as favourable as if the plant was located next to the sea with direct seawater cooling. Consequently, not only is the cooling water warmer than if it came directly from the sea but also there is a constraint on the amount of available cooling water.

At 185 m high, the cooling tower is one of the tallest in Europe. This has a direct positive impact on the efficiency of the plant. The cooling is a closed circuit where the water in the cooling tower can reach 33°C. The cooling water from the tower is used to cool the condensate in the condensers.

The plant's design not only limits

Special Project Supplement

the effect on the local marine environment but also uses best available technology to limit impacts on air quality.

Kozienice 11 has a sophisticated environmental protection system so that emissions are guaranteed to be either equal to or lower than EU environmental limits. There are three systems: a selective catalytic converter (SCR) reduce NO_x emissions from the combustion process; an electrostatic precipitator (ESP) to capture dust; and a FGD system to capture SO_x.

The SCR, located behind the boiler, receives gas directly after the convective heating surfaces at a temperature of about 350-360°C. Ammonia is injected into the SCR reactor, where it reacts with the NO_x to form water and nitrogen.

Flue gases leaving the SCR flow through an air heater before entering the ESP to capture dust.

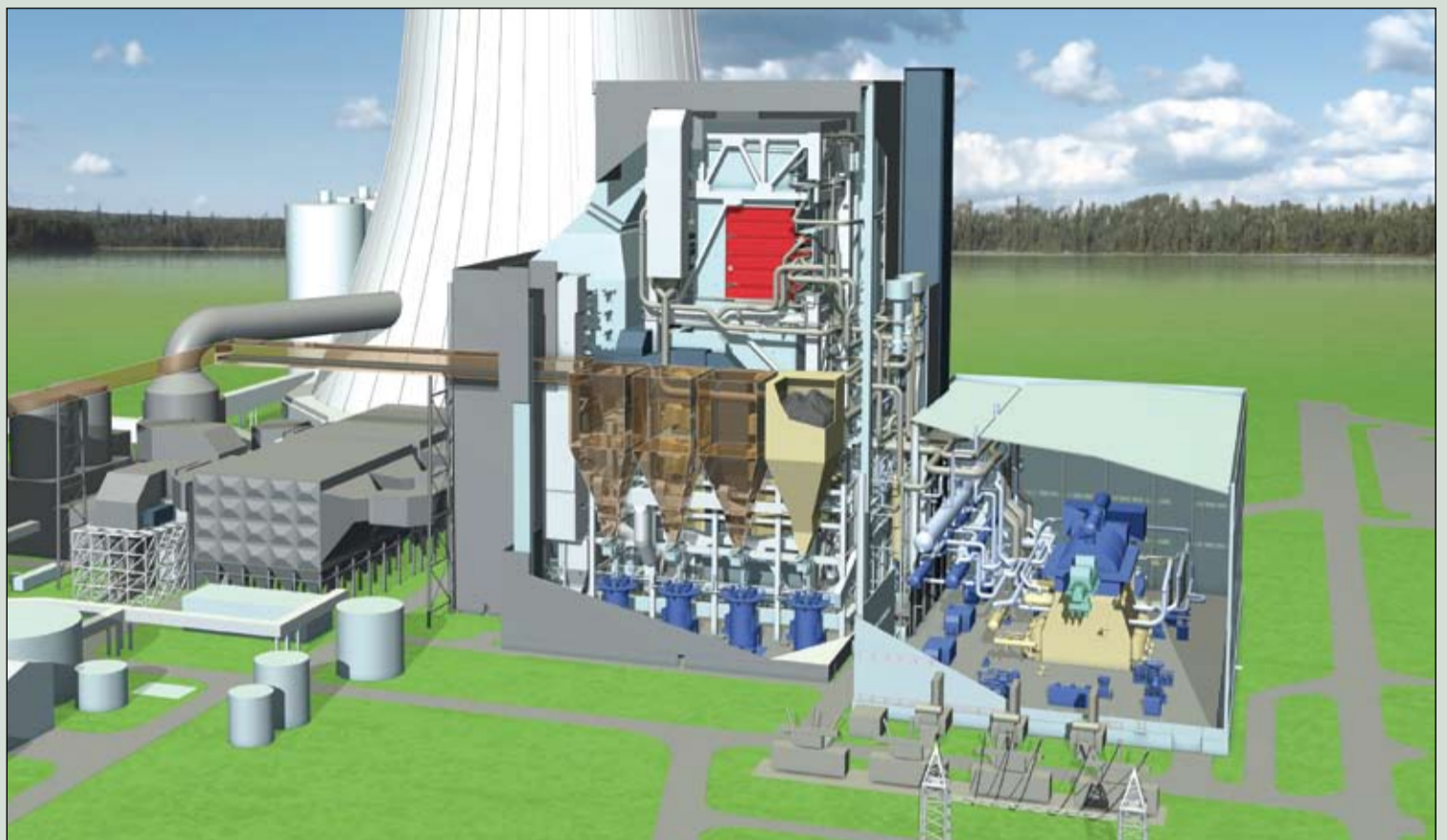
Desulphurisation is achieved through the use of the limestone gypsum process, where gypsum can be recovered as the end product for further industrial use. This process involves sulphur dioxide (SO₂), hydrogen chloride (HCl) and hydrogen fluoride (HF) being precipitated in an alkaline scrubbing liquid.

The flue gas enters the lower part of the MHPS absorber and ascends through the absorption section. Intelligent technology ensures that the number of nozzle levels of the contact zone and positioning of their nozzles are designed to the desired absorber collecting efficiency. Up-to-the-minute computations of flue gas entry angle and speed make it possible for turbulence to be kept well down inside the absorber. A large and a fine droplet separator retain the fine droplets in the flue gas before the cleaned gas leaves the absorber. The actual transition from pollutant gas to liquid occurs in an intensively intermixed gas/liquid contact zone.

The limestone-induced absorption gives rise to a high-grade gypsum product.

Flue gases leaving the plant do not go through the stack but instead are vented into the cooling tower. The dust emitted at the end is a combination of what is caught by the FGD and the ESP but at the cooling tower is 10 mg/Nm³. This is much lower than the 20 mg/Nm³ specified EU standard.

Dr. Frank Wilkendorf, MHPSE's Project Manager said: "All the emission values are well below the guarantee values of 100 mg/m³ for NO_x



and 100 mg/m³ for SO₂."

Certainly Kozienice 11 is a technically impressive project that has been long in the making. Discussions on the project opened in 2010 but it was some time before the contract was awarded.

Following the contract award on September 21, 2012, site access was granted on October 2nd. Demolition of some existing facilities began immediately, with preparation of underground networks etc., and the official ground breaking took place on November 26, 2012.

To meet the scheduled construction dates, a significant amount of assembly work had to be done on the ground at the site and the assembled components lifted into place. This helped to speed-up construction allowing the boiler steel structure to be finalised in June 2014.

Much of the required pre-manufactured material had to come from various parts of Poland, Europe and even Japan which was a logistical challenge but went according to plan.

All the boiler parts were more or less fabricated and pre-assembled at

site before placement in the boiler house. Several of the key erection milestones were reached in 2015.

With regards to the boiler, the first section of the feed water tank (one of four) was transported from port to site by trailer in February 2015 and HP heater No. 8 was transported from port to site by rail in March 2015. Mill classifiers were transported to site by trailer in June 2015.

The other main large pieces of plant equipment, i.e. the generator stator and LP turbine rotor were shipped from Japan and transported from the port to the site by rail wagon in July 2015 and October 2015, respectively.

Installations then took place throughout 2016 to allow first firing of the boiler on March 18, 2017. First steam was fed to the steam turbine four months later and the steam turbine was synchronised to the grid on September 1, 2017. Following a three-month period of tuning and testing, the unit was handed over for commercial operation on December 19, 2017.

Since then the plant has operated

for over 3200 hours (as of mid-May). Dr Wilkendorf noted: "The plant has been running well with an efficiency that's been even better than expected. During the trial run we were safely above the predicted efficiency. The official test for the guarantee values, however, is still to be done. This will be performed during the first year of operation by a third party contracted by the client."

In his speech during the PAC signing ceremony at the power plant Satoshi Uchida, CEO of MHPSE Europe said: "Construction of Kozienice 11 was MHPSE's first step in accessing the Polish power market. Poland is clearly a key market for our company and the very good collaboration with Polish partners under the lead of the customer, ENEA, is an important reference for us."

MHPSE noted that the collaboration was particularly successful when considering the "extremely complicated" Polish procurement law. "Tendering is a really complicated process in Poland," said Helge Schulz, Head of Corporate Communications, MHPSE, "but the cooperation was very good at the

CAD drawing of the new unit showing a cutaway of the boiler house and turbine hall

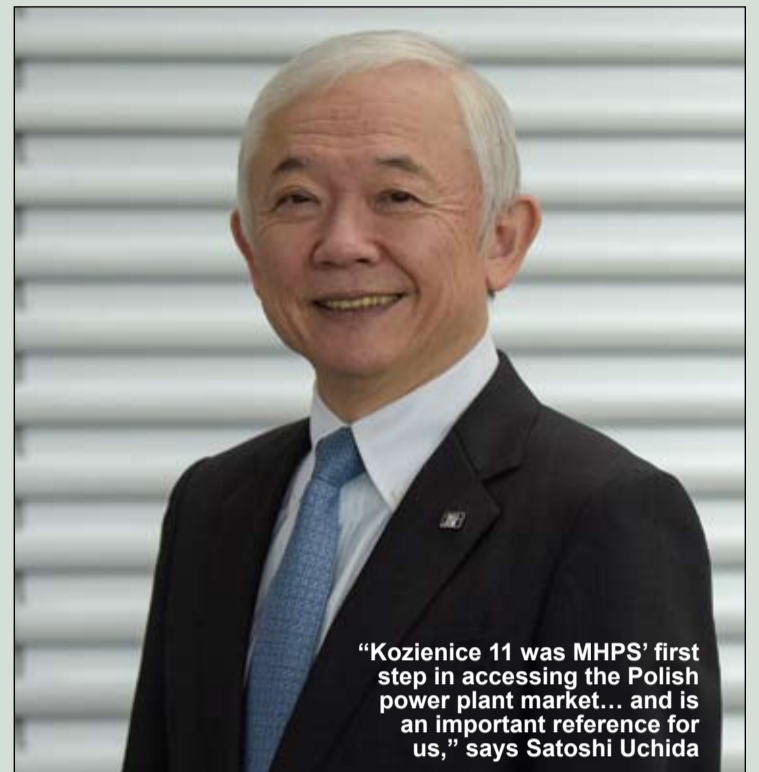


The new unit (seen here during construction) is part of an existing site, where there were already 10 units with a generating capacity of 2905 MW

Special Project Supplement



Inside the turbine hall. Following a three-month period of tuning and testing, the unit was handed over for commercial operation on December 19, 2017



"Kozienice 11 was MHPSE's first step in accessing the Polish power plant market... and is an important reference for us," says Satoshi Uchida

operational level and went without complication."

Rainer Klockow, MHPSE's Project Director, added: "There were many interfaces between several internal departments – with our Japanese colleagues, the turbine team, the FGD part and a number of sub-contractors. Polimex also had sub-contractors for engineering as well as for supply and erection. All of these interfaces had to be coordinated."

"We all had a common interest – between us, the client and our consortium partner – in achieving the PAC target and obtaining all the permits from the various authorities and the grid company, PSE. This is the biggest and most modern coal fired unit in Poland and close cooperation with PSE is needed to coordinate any rapid change in load to maintain grid

stability," Klockow emphasised.

With Poland's continued interest in coal, Kozienice 11 is an important project for both the country and MHPSE. Poland has expressed an interest in coal gasification, which could present other opportunities for MHPSE.

In the meantime, the company is continuing to build and bid on projects that will further improve the efficiency and lower the environmental impact of the installed base.

Construction of the Turow 11 lignite fired power station is ongoing, and in June last year it signed a contract to build the Żerań gas fired combined cycle CHP plant. According to MHPSE, this plant will be the most modern combined cycle power plant in the country. It will be equipped with a F-class gas turbine with a

HRSB and a steam turbine.

Following the construction, the exhausted coal fired boilers will be taken out of service. The new generating unit will increase the facility's electricity generation by about 80 per cent, while ensuring heat supply to the Warsaw district heat system and keeping heat prices competitiveness for the inhabitants of Warsaw.

Although Poland's interest in coal runs counter to the direction of its EU neighbours, MHPSE believes that the large installed generating base there will also continue to offer opportunities.

"It is still a very promising market because most of the older coal fired power plants must be updated to meet the new BREF regulations on emissions," said Schulz.

MHPSE also sees good opportunities

for new build, and is already having discussions with potential Polish clients with regard to next-generation clean coal technologies such as integrated coal gasification combined cycle (IGCC). The company is currently constructing two 540 MW IGCC in Japan, and it says the same design can be applied in Poland.

MHPSE's IGCC technology utilises an air-blown coal gasifier and desulphurisation system linked to a gas turbine combined cycle to deliver much higher efficiency and environmental performance than a conventional coal plant.

Uchida concluded: "We want to contribute environmentally friendly power systems to the Polish market, even when utilising coal. This way, Poland can again be a technological front-runner in Europe."

The Żerań gas fired combined cycle CHP plant will be the most modern in the country





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Companies News

Organisations recognising value of “energy leadership”

- Companies moving away from “commoditised attitude” to energy
- Centrica transformation “working well” despite fall in profits

Junior Isles

The role of energy is increasingly being considered an integral part of business objectives and boardroom strategies, according to UK-based energy company Centrica.

Research by Centrica Business Solutions has found that companies that have invested in advanced energy solutions are reporting a wide range of benefits, and those with an energy strategy are more than twice as likely to be ahead in their market.

In a survey of 1007 companies across Britain, Ireland, Germany, Italy, the US and Canada in organisations with 100+ employees and technical and/or financial decision makers for energy matters, the survey revealed that 41 per

cent have seen significantly reduced energy costs, whilst 35 per cent report greater control and visibility. Organisations have also experienced improvements to their company reputation (24 per cent) and realised additional revenue (23 per cent).

Energy leaders – defined as businesses which have a sophisticated attitude to energy, invest in advanced energy solutions, and measure and control energy efficiency – are twice as likely to outperform competitors on customer-centricity and brand leadership, and almost seven times on business sustainability.

Tim Wynn-Jones, UK Head of Distributed Energy Solutions Sales at Centrica Business Solutions said: “Businesses are increasingly moving

away from a commoditised attitude to energy. Instead, they’re looking at how investing in energy delivers benefits beyond cost savings alone. They know their relationship with energy can have a far-reaching impact that helps power performance and drive their business forward.

“For these reasons, companies are starting on what we call an energy journey – the move towards energy leadership, where the role of energy is considered an integral part of business objectives and boardroom strategies.

“Progress towards different aspects of energy leadership varies from business to business but, importantly, each company on an energy journey combines vision and execution. This means they’re in a strong position to improve

their competitiveness.”

Centrica itself has been going through a transformation. The company has been shifting its resources to become more customer-facing, with a greater focus on energy supply and services. At the same time it has been repositioning its asset portfolio, disposing of large centralised facilities and replacing them with smaller, more flexible decentralised generating assets.

Financial performance for the second half of 2017, however, was weak, with operating profit down 17 per cent. According to Group Chief Executive, Iain Conn, this primarily reflected poor performance in Business energy supply and particularly in its North America Business unit.

Wynn-Jones, however, maintains

that the strategic transformation is yielding positive results.

Speaking on the sidelines of the All Energy conference in May, he said: “It has been working out very well. We’re investing significantly in this part of the business and have had some very big successes such as the Cornwall Local Energy Market. We are also working with a large number of industrial customers on combined heat and power to help make their processes more efficient so they can be more cost effective.

“Distributed generation is a significant growth area for us... we’ve already made a number of strategic acquisitions, so at the moment it’s certainly performing in line with expectations.”

Oil firms under pressure on climate

Energy firms are coming under increasing pressure to make sure their business activities are pursuing a low-carbon trajectory and are aligned with international climate change goals.

Last month a group of oil and gas company shareholders called for the industry to take responsibility for its emissions and take action on climate change.

The group, which includes HSBC Global Asset Management, PKA, Rabobank Pension Fund and Schroders, published an open letter in the *Financial Times* in which it warned that the oil and gas industry and its products account for 50 per cent of global carbon emissions, and that the sector would face additional risks and costs associated with its carbon-intensive activities.

“We strongly encourage all companies in this sector to clarify how they see their future in a low-carbon world,” said the signatories in the letter. “This should involve making concrete commitments to substantially reduce carbon emissions, assessing the impact of emissions from the use of their products and explaining how the

investments they make are compatible with a pathway towards the Paris goal.”

The companies noted that several large oil and gas groups would hold planned annual general meetings in the coming weeks, and would face shareholder votes on climate change.

These include Royal Dutch Shell, which faces a resolution compelling it to align its business with the goal of the Paris climate agreement.

The company’s board urged shareholders to reject the resolution, which has the support of investors with £28 billion of assets under management.

In April, German insurance giant Allianz said it would stop insuring coal-fired power plants and mines extracting the fuel.

Allianz said it aims to divest from the coal sector completely by 2040 as part of a push to integrate the Paris Climate Agreement into its operations. It has also set other climate targets, including reducing the carbon footprint of its business operations, and joining the Science Based Target Initiative as a commitment to the long term development of a carbon-free economy.

sPower and Array Technologies team up

Two of the largest players in the US solar energy market are planning to do “multi-gigawatts” of business in the coming years after sealing a new partnership deal.

sPower and Array Technologies have signed a three-year contract to collaborate on the development and construction of solar photovoltaic (PV) projects in the USA.

The deal extends a previous four-year partnership between the two firms. Array is a provider of solar tracker technology, while sPower is the largest private owner of operating solar assets in the USA.

“The newly created partnership between Array Technologies and sPower

is a testament to the strength and success of a matured US solar market,” said Jeff Krantz, Senior Vice President at Array Technologies, “This deal represents a significant milestone for our company’s continued robust growth throughout the nation.”

The adoption of solar trackers for utility-scale solar projects has grown significantly in recent years, with more than 70 per cent of ground-mounted PV systems in the USA utilising the technology. In regions with high solar irradiance, trackers can produce a 20 to 30 per cent increase in energy output over fixed-tilt systems. The continued adoption of solar trackers comes down to economics and reliability.



- CTG targets EDP’s global assets
- Market regulator waives takeover rules

Siân Crampsie

Energias de Portugal (EDP) says that a takeover bid launched by China Three Gorges Corporation (CTG) is priced too low.

CTG has made a €9.1 billion offer for the Portuguese energy company, in which it already owns a 23.4 per cent stake.

EDP’s board in mid-May rejected the €3.26-per share cash offer because the price offered “does not adequately reflect the value of EDP”. It also said that the offer premium – just over 5 per cent above EDP’s closing share price the day before the offer – was too low “considering what is customary for European utilities where the offeror has acquired control”.

EDP’s stance raises the possibility

of an increased offer from CTG, or a rival bid from another suitor. CTG’s prospects were improved in the wake of its offer after Portugal’s market regulator, CMVM, said it would waive a rule in its takeover regulations that would normally prevent CTG from raising its offer.

CTG’s offer values EDP at €11.8 billion, or about €25.6 billion including net debt. If successful, it would give CTG control of energy infrastructure in southern Europe and add to the wave of Chinese capital that has entered the region in the wake of the financial crisis.

EDP is also active in the Americas, including major markets such as Brazil, the USA, Canada and Mexico. At the end of 2017, EDP had 26 753 MW of installed capacity globally.

On May 23, CMVM said that CTG would be allowed to drop a 50 per cent plus one share clause in the takeover rules as long as its bid process runs to its legal conclusion.

The move would effectively enable CTG to raise its stake in EDP even if it does not hold 50 per cent plus one share of the company. It could therefore quickly raise its share in EDP to 33 per cent, the level needed to block any potential rival bidders.

According to analysts, other utilities, including Gas Natural and Engie, have been looking at EDP.

If the deal succeeds, CTG would be obliged to launch a mandatory offer for the 17 per cent of shares in EDP Renováveis, the Portuguese company’s listed renewables subsidiary, not controlled by EDP.

E.On builds on Vortex

E.On has moved to boost its onshore wind energy activities in Germany.

The German-based utility, says that its recent acquisition of Vortex complements its existing activities in the German wind farm sector and would add a 300 MW project pipeline to its portfolio. Kassel-based Vortex also has a “large number” of onshore wind farm projects at an early stage of development, E.On added.

“We see strong growth potential for

wind energy in Germany. Vortex’s outstanding expertise and regional networking are a key factor for us to exploit this potential and compete for the best locations,” said Anja-Isabel Dotzenrath, CEO of E.On Climate & Renewables.

The move comes just weeks after E.On launched a voluntary public takeover offer for innogy stock.

The offer for innogy follows the agreement sealed by E.On and RWE

in March in which E.On will acquire RWE’s 76.8 per cent stake in innogy via a far-reaching and complex exchange of assets and businesses.

The deal would bring together the renewables businesses of E.On and RWE in a single RWE-controlled group that would operate around 8 GW of renewable energy capacity. It would enable E.On to focus on networks and retail while RWE will be focused on energy generation.

10 | Tenders, Bids & Contracts

Americas

Vestas bags Pampa order

Danish turbine maker Vestas Wind Systems A/S has received an order to equip two 53 MW wind farms in Buenos Aires province, Argentina, for Pampa Energía SA.

Vestas will supply and install 28 of its V136-3.45 MW turbines, delivered in 3.8 MW Power Optimised Mode, at the Pampa and De La Bahia wind project near Bahia Blanca city. Delivery is to take place in the fourth quarter of 2018, while commissioning is targeted for early 2019.

The contract also includes a 20-year service agreement.

Seabased scores in Caribbean deal

Swedish wave energy company Seabased has signed an agreement with Bermuda General Agency (BGA) to deliver two 20 MW wave energy parks in the Caribbean.

Feasibility studies for the projects will begin on several islands this summer, and phase one is expected to be operational by the fall of 2019, Seabased said.

Phase one of the first 20 MW plant will consist of a 5 MW pilot in the Bahamas. According to the agreement, Seabased will design, manufacture, install and manage the maintenance of the wave parks.

Siemens wins first Panama order

Siemens has received its first order from Panama for six SGT-800 gas turbines.

The German firm will supply the six industrial gas turbines along with a steam turbine for a new combined cycle power plant being built by Shanghai Electric Group Co. Ltd. for Martano, an independent power producer (IPP).

The scope of supply from Siemens includes a power block in a multi-shaft configuration, consisting of six SGT-800 industrial gas turbines of single-lift package design, six gas turbine generators, one SST-600 industrial steam turbine, an SGen6-100A-2P steam turbine generator, six VOTSG heat recovery steam generators, as well as Simatic PCS7 control system for the gas turbines and a SPPA-T3000 control system for the steam turbine.

The new plant will be built near the seaport of Colón on the Caribbean coast and be operated with liquefied natural gas (LNG) as a fuel.

Commissioning is scheduled for late 2020.

Asia-Pacific

Thermax inks deal with Amonix

Thermax Ltd has clinched a deal with Amonix Inc of California, US, to offer their new concentrated photovoltaic (CPV) technology for the Indian solar power market.

Under the collaboration, Amonix will supply the solar modules and technology for building power plants, while Thermax will serve as the engineering, procurement and construction (EPC) provider to clients. Amonix will initially make the CPV modules at the Flextronics Technologies facility in Chennai, India.

Jan De Nul signs Formosa 1 Phase 2 contract

Jan De Nul Group has signed a deal with Formosa Wind Power Co. for the design, procurement and installation of the wind turbine foundations

for the Formosa 1 (Phase 2) offshore wind farm in Taiwan.

Phase 2 of Formosa 1 will add 20 wind turbines with a total capacity of 120 MW to the wind farm's existing 8 MW capacity. Jan De Nul's scope also includes scour protection and cable installation.

Formosa 1, located off the coast of Chunan Town, Miaoli County, in northwest Taiwan, will be the first commercial scale offshore wind farm in Taiwan before 2020.

Siemens Gamesa secures Japan order

Siemens Gamesa has sealed its first agreement with Tokyu Land Corporation for the supply of wind turbines for two projects in Hokkaido, Japan.

Siemens Gamesa will supply 22 of its SWT-3.4-108 wind turbines, with delivery expected in 2018-2019. Gamesa will also handle the operations and maintenance services at the wind farms for the next 20 years.

PLN orders GIS

Indonesian power firm PLN has placed an order with ABB for the supply of gas insulated switchgear (GIS) for ten substation projects.

Under the order, ABB will design, supply and commission 150 kV GIS for ten substations in the greater Jakarta area, Western Java, East Java and Sulawesi. The substations will facilitate the reliable supply of energy in these urban areas and are part of wider plans by the Indonesian government to connect all households to the grid by 2025.

BHEL wins Nepal hydro order

India's Bharat Heavy Electricals (BHEL) has secured a contract from Nepalese firm SJVN Arun 3 Power Development (SAPDC) to implement the 900 MW Arun 3 hydropower project.

Located in the Sankhuwasabha district, the Arun 3 project will add to Nepal's installed power capacity and support its vision of utilising its vast hydropower potential for accelerated economic development.

Under the Rs5.36 billion (\$80 million) deal, BHEL will be responsible for designing, engineering, manufacturing, supply, erection and commissioning of electromechanical equipment, which includes four vertical 225 MW Francis turbines and generator sets.

Europe

New GIS for Berlin

ABB has sealed a deal with Stromnetz Berlin GmbH to supply gas insulated switchgear (GIS) for the new Wuhletal substation in Berlin.

The substation will strengthen the distribution network in the Berlin-Kaulsdorf neighbourhood in Berlin's eastern Marzahn district. Stromnetz Berlin chose GIS technology because of its compact footprint, ABB said.

ABB will design and supply a 110 kV GIS for the project.

Burns & McDonnell selected for SEND

Burns & McDonnell has been selected by Keele University in a competitive process as the main technical advisor for the delivery of its ground-breaking UK-based Smart Energy Network Demonstrator (SEND).

A £15 million investment, SEND will be one of the first of its kind in Europe – a living laboratory where new energy-efficient technologies can be researched, developed and

tested in a real-world environment. It will be delivered by Siemens, with Burns & McDonnell overseeing the technical design and project execution.

CPower Energy scoops EA1 prize

CPower Energy is gearing up to commission one of the world's largest offshore wind farms after winning a preferred supplier contract for East Anglia One from ScottishPower Renewables.

Under the contract, CPower will supply commissioning managers and engineers, as well as engineers for the offshore and onshore substations, wind turbine generators, logistics and supervisory control and data acquisition (SCADA) systems.

When fully operational in 2020, East Anglia One will have 102 wind turbines generating 714 MW, capable supplying clean energy to almost 600 000 British homes.

Unielectrica to build 50 MW solar park

Spanish power trader Unielectrica is to develop a 50 MWp solar photovoltaic (PV) project in the autonomous community of Murcia.

The €40 million (\$47.4 million) plant will be located in the municipality of La Pedrera and will start operating in January 2020. It be able to generate around 100 GW per year. The output will be for own use.

Unielectrica says it is also studying other opportunities for building more PV projects in the region.

Eolica San Lupo orders WTGs

Eolica San Lupo Srl has placed an order with Vestas for the supply and installation of wind turbine generators for a 48 MW wind farm in Benevento, southwestern Italy.

The San Lupo wind farm is being developed by German firm BayWa and will include Vestas' V117-3.45 MW turbines operating in load optimised mode with a nominal rating of 3.0 MW. Turbine delivery is expected by the end of 2018 whilst commissioning is scheduled for the first quarter of 2019.

BayWa won the rights to develop the San Lupo project in a renewable energy auction held in Italy in 2017.

MHI Vestas selected for Northwester 2

Belgian offshore wind company Parkwind has selected MHI Vestas Offshore Wind's V164-9.5 MW turbine for the 224 MW Northwester 2 project off the coast of Belgium.

The 370 MW wind farm is likely to be 2 the world's first offshore wind farm to feature the 9.5 MW turbine, the most powerful currently available on the market. Installation of its 23 turbines, which are expected to deliver enough electricity to power 220 000 Belgian homes, is scheduled to start in late 2019.

The conditional order includes a service agreement, MHI Vestas said.

Senvion supplies turbines to Witherwick II

Senvion has signed a contract with German based developer Energiekontor, to supply four MM92 turbines to its Witherwick II extension project, a UK wind farm to be built without government subsidies.

Witherwick II reached financial close today and has been fully funded solely with revenues from a Power Purchase Agreement (PPA)

with one of the UK's leading consumer goods brands.

Witherwick II extends the original 18.45MW Witherwick Wind farm constructed back in 2016, by a further 8.2MW, taking the site to a total of 26.65MW.

International

RR gensets head for Slovakia

Rolls-Royce has signed a contract with EPC contractor Energyco for the supply of four gensets to a cogeneration plant in Kosice, Slovakia.

Based on the medium speed gas engine B35:40V20AG2, the plant will generate a total of 37 MWe heat and power for the district heating company Teplaren Kosice a.s (TEKO).

"We have been working closely with Rolls-Royce for this project for more than a year," said Lubomir Fejko, Energyco Project & Site Manager. "One of the critical parameters required by TEKO was 3 minutes start to full load to comply with Slovakian grid support service. This was new for us and we appreciate that Bergen Engines could commit to these requirements."

The medium speed engines are flexibly designed for different operating modes, and can be used to generate base-load, peak power or operate in combined cycle.

The contract will also include a service agreement for five years.

Orano signs Ukraine contract

Orano and the Ukrainian utility EnergoAtom have signed a contract for assessing the feasibility of reprocessing services for spent fuel assemblies from Ukrainian VVER-1000 nuclear reactors in Orano's la Hague facility in France.

The contract marks an important step for Orano and paves the way for treatment of Ukrainian used fuel by the French recycling sector, Orano said.

Used fuel consists of 96 per cent recyclable materials and four per cent final waste. The process implemented at Orano's la Hague plant consists of separating the reusable materials, which will once again be used to produce energy, from the final waste, which undergoes safe and stable conditioning and packaging.

Qatar plans solar boost

Qatar General Electricity and Water Corporation (Kahramaa) has launched a call for prequalification of bidders in a 500 MW solar tender.

The prequalification round has a deadline of June 24, 2018, and is the first stage in the process to select a company to design, build, own, finance, operate and transfer a 500 MW solar photovoltaic (PV) plant near Al Kharsaa. Kahramaa will buy the output under a 25-year power purchase agreement (PPA).

The project has an expected commercial operation date (COD) of December 2020.

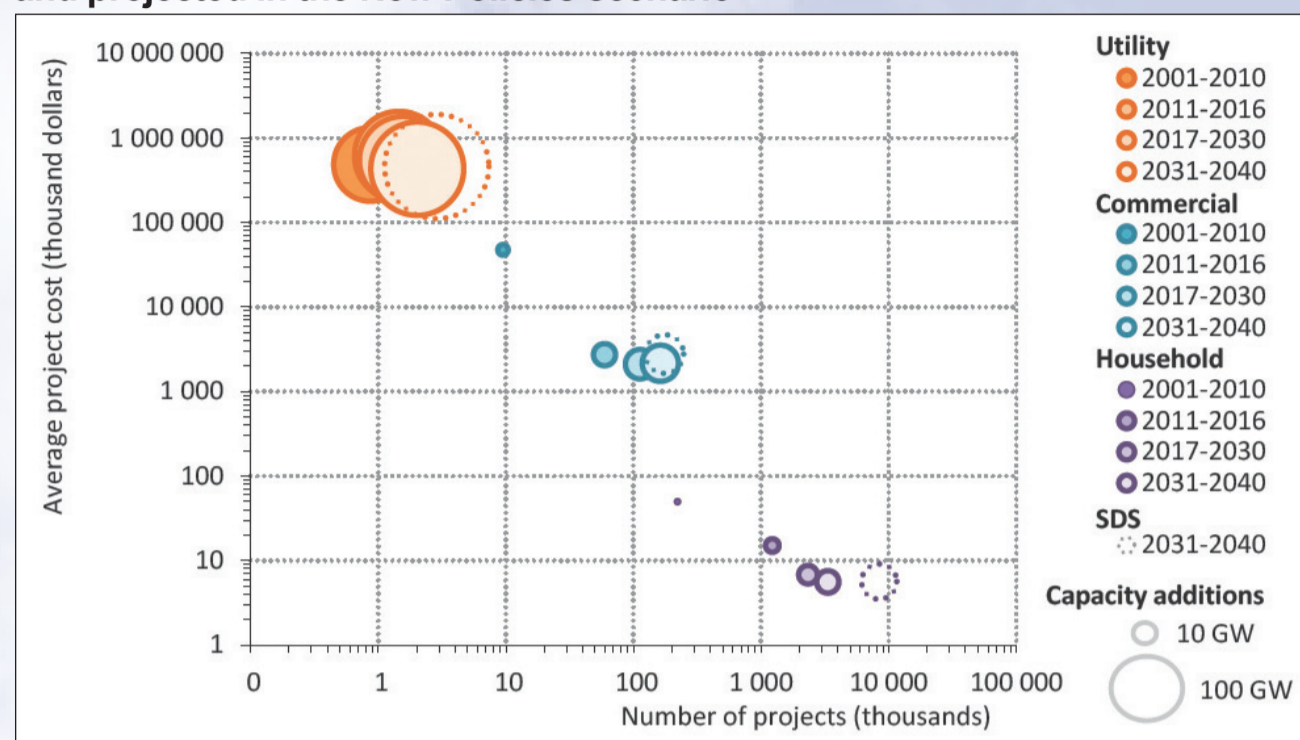
Ansaldo scores in Tunisia

Ansaldo Energia has signed a turnkey engineering, procurement and construction (EPC) contract with Société Tunisienne de l'Électricité et du Gaz (STEG) to build a 625 MW gas fired open cycle power station near Tunis, Tunisia.

The plant will be located in Mornaguia and be equipped with two AE94.3A model gas turbines. It will take 22 months to build, said Ansaldo. The firm's contract also includes a long-term service agreement.



Average project cost, number of projects and capacity additions historically and projected in the New Policies scenario



For more information, please contact:

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World Energy Outlook 2017, © IEA/OECD, Figure 6.11, page 253

World electricity generation by source and scenario (TWh)

	New Policies		Current Policies		Sustainable Development			
	2000	2016	2025	2040	2025	2040	2025	2040
Total	15 477	24 765	29 657	39 290	30 724	42 321	28 226	35 981
Fossil fuels	10 017	16 136	17 124	19 758	18 666	25 336	14 071	7 971
Coal	6 005	9 282	9 675	10 086	10 897	14 386	6 575	2 195
Gas	2 753	5 850	6 730	9 181	7 033	10 428	6 903	5 585
Oil	1 259	1 004	719	491	736	523	593	192
Nuclear	2 591	2 611	3 217	3 844	3 218	3 825	3 531	5 345
Renewables	2 869	6 018	9 316	15 688	8 840	13 160	10 625	22 664
Hydro	2 619	4 070	4 804	6 193	4 755	5 964	4 986	6 928
Bioenergy	164	566	867	1 424	833	1 211	952	1 807
Wind	31	981	2 192	4 270	1 983	3 358	2 785	6 950
Solar PV	1	303	1 264	3 162	1 096	2 192	1 629	5 265
Other renewables	53	98	188	638	173	436	274	1 715
Fossil fuels	65%	65%	58%	50%	61%	60%	50%	22%
Coal	39%	37%	33%	26%	35%	34%	23%	6%
Gas	18%	24%	23%	23%	23%	25%	24%	16%
Oil	8%	4%	2%	1%	2%	1%	2%	1%
Nuclear	17%	11%	11%	10%	10%	9%	13%	15%
Renewables	19%	24%	31%	40%	29%	31%	38%	63%
Hydro	17%	16%	16%	16%	15%	14%	18%	19%
Bioenergy	1%	2%	3%	4%	3%	3%	3%	5%
Wind	0%	4%	7%	11%	6%	8%	10%	19%
Solar PV	0%	1%	4%	8%	4%	5%	6%	15%
Other renewables	0%	0%	1%	2%	1%	1%	1%	5%

World Energy Outlook 2017, © IEA/OECD, Table 6.6, page 257

ABB

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Oil

Iran, Venezuela and next Opec move leaves oil market uncertain

- Political crisis in Venezuela accelerating decline in oil production
- Geopolitics beginning to determine prices

David Gregory

Could this be the nightmare scenario that consumers everywhere are dreading – oil back at \$90/b or higher?

New shipping regulations to be imposed by the International Maritime Organization (IMO) on 1 January 2020 that are designed to enforce new emission standards and thus reduce pollution created by ships could push the price of crude to more than \$90/b, according to oil analyst Amrita Sen, speaking on *CNBC* in late May.

The new regulations will force vessels to stop using high-sulphur fuel oil. This could create an oversupply of the fuel, which is abundant in the Middle East, and spur greater demand for lighter crudes. So the price for the right kind of oil could go up.

But that is 18 months away. The current question is whether the decision by the US to withdraw from the Joint Comprehensive Plan of Action (JCPOA), which was designed to

check Iran's nuclear programme in return for the lifting of economic sanctions, will force Iranian crude out of the market as buyers consider consequences that the US might impose for doing business with Iran.

Iran is now producing about 3.6 million b/d of oil and exporting some 2.4 million b/d. When sanctions were in place before JCPOA, Iran was exporting 1.2 million b/d. If more than 1 million b/d of Iranian oil were to disappear from the market, prices would rise and there would be questions over how the crude would be replaced.

Would Saudi Arabia, which has led Opec and non-Opec producers in an 18-month long quest to remove surplus oil from the market and reduce OECD stocks, step in to fill the supply gap left by its arch-nemesis? Are US producers, who are now pumping some 10 million b/d, capable of meeting demand?

Furthermore, the long-running political crisis in Venezuela is resulting in an accelerating decline in oil

production. In its most recent monthly *Oil Market Report*, the International Energy Agency (IEA) reported that Venezuelan output fell 50 000 b/d in April, down to 1.42 million b/d a decline of 640 000 b/d from a year ago.

Upgraders operated by foreign joint venture partners in the vast Orinoco heavy oil belt are running below capacity as the multiple challenges of sourcing diluents, payment woes, corruption issues, equipment breakdowns and staff security grow tougher. Output from Venezuela's ageing conventional oil fields is also fast declining," the IEA said.

On top of this, the IEA reports, there exists the potential for more US sanctions on Venezuela's state-owned oil company PDVSA. The agency points out that the US "has already enforced economic measures that impair Venezuela's ability to finance projects and pay back debt. With the oil sector spiralling deeper into crisis, it is possible that capacity could fall by several

hundred thousand barrels a day by the end of the year."

And then there is Opec, which has yet to make its position clear on what course it will take now that the price from Brent crude is flirting with \$80/b. It is always boom or bust in the oil market, and Opec has learned the hard way that high oil prices for too long a period do not work in its favour.

Eventually economies that pay high transportation costs, which trickle down into all areas of commerce, reach a point where they can no longer pay the price. Economies suffer, demand declines, prices go down and oil producers are back whining about a fair price.

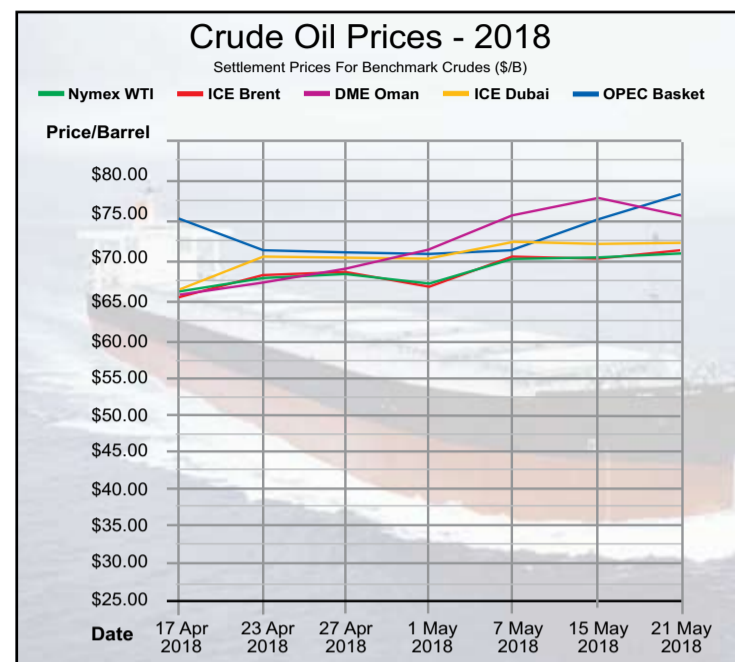
Unfortunately for many oil producers, their budgets require a price that is near \$100/b if not higher.

The tighter oil market, the Iranian and Venezuelan conundrums, and the possibility of pushing the price over the edge, has caused the Opec/non-Opec partnership to question whether it would be wise to keep the production

cuts that began in January 2017 in place for much longer. With the market in balance, geopolitics is beginning to determine prices, and unless there is a genuine crisis that interferes with supply and demand, geopolitics can throw the market for a loop.

Following the St. Petersburg International Economic Forum in late May, Russian Energy Minister Alexander Novak suggested that restrictions on oil production could be eased "softly" if Opec and non-Opec acknowledge a balance in the oil market in June, Russian energy news agency *Interfax* reported. Bear in mind that it has been the determination of Saudi Arabia and Russia that has brought about the success of balancing the market and there will be little risk-taking as both need oil prices to go as high as the market will allow.

Novak said geopolitics and the US withdrawal from the Iranian deal were adding \$5-\$7 to the oil price, which signals that oil at about \$75/b would be acceptable.



Gas

Rising gas production in Oman to move economy forward

Oman is hoping that increased natural gas production from the Khazzan gas project, while diversifying away from direct oil and gas sales, will boost its economy.

Mark Goetz

Natural gas production in Oman is rising as output from the BP-led Khazzan gas project nears its Phase 1 target of 1 billion cubic feet per day (bn cfd). Furthermore, as development at Khazzan moves into Phase 2 and expands into the adjacent Ghazeer field, increasing gas production is expected to provide additional support to downstream projects that Oman will use to diversify its economy away from direct oil and gas sales.

Also, Oman last month signed a new agreement with Shell and Total that covers upstream work and downstream gas-to-liquid (GTL) and LNG bunkering projects.

The collapse in oil prices since 2014, and subsequently gas prices, hit Oman hard, but as oil and gas prices have recovered over the last year, Muscat has seen its economic situation improve. Gas production has been

squeezed by rising domestic demand, forcing the country to import gas from the UAE and resulting in a decline in gas supply to the Oman LNG liquefaction facility for export.

BP, partnered 60/40 with Oman Oil Company (OOC) in the Khazzan gas project, announced in April that it will proceed with Phase 2 of the project after having sanctioned a final investment decision (FID) to start development of the Ghazeer gas field. Besides the 1 bn cfd of natural gas, Khazzan is also producing some 35 000 b/d of natural gas liquids.

Both Khazzan and Ghazeer are located in Oman's Block 61 in central Oman. The two fields cover 2550 km² and transporting the gas will require 400 km of pipeline over the life of the project.

Yousuf Al Ojaili, President of BP Oman, said in a statement that further development of the Khazzan/Ghazeer project "is expected to support Oman's

energy needs for many decades to come".

Ghazeer is scheduled to come on-stream in 2021 and produce an additional 0.5 bn cfd and a further 15 000 bpd of condensates. BP has drilled 200 wells in Khazzan for Phase 1 and drilling in Ghazeer will see another 100 wells.

Gas produced in Khazzan is channeled through a two-train processing plant, a third train and related infrastructure has already started production. Throughout the course of the project's operations to 2043, the two fields are expected to produce 10.5 trillion cubic feet of gas and 350 million barrels of liquids.

Much of that gas will be used to generate electricity and to supply energy intensive projects such as water desalination and the Duqm refinery and petrochemical project that OOC plans to build in partnership with Kuwait Petroleum Corporation (KPC). A

foundation stone for the \$7 billion complex was laid in April and initial start-up is to begin in 2022.

Oman's quest for natural gas supply has led it to enter a gas pipeline project with Iran that would supply Iranian gas for domestic use and for export as LNG. Oman announced in April that it will soon tender for bids for construction of the pipeline, the route of which has been redrawn to avoid the UAE's offshore territory.

The pipeline will be small in comparison to others in the region with a capacity of 1 bn cfd. However, the decision by the US to withdraw from the Iran nuclear deal and the probable re-introduction of sanctions against Iran could impact this project.

Meanwhile, in mid-May, Shell and Total signed memoranda of understanding (MOUs) with the government of Oman to develop upstream gas resources and downstream gas projects. With Shell as operator in

several gas fields located in Block 6, the two majors will hold shares of 75 per cent and 25 per cent, respectively, in the Greater Barik onshore area. The plan calls for initial production to start at 500 million cubic feet per day and later rise to 1 bn cfd. The gas will go towards GTL and LNG projects.

Maarten Wetselaar, Director of Shell Integrated Gas & New Energies, said Shell hoped to use its resources to accelerate Oman's diversification and industrialisation agenda, adding that the proposals contained in the MOUs could create value and jobs in Oman's economy. The Greater Barik is located near the Khazzan/Ghazeer gas fields.

Total said it would use its equity gas entitlement from Greater Barik as feedstock for a new small-scale modular liquefaction plant it would build in Sohar port, which would serve as a regional hub for a LNG bunkering service for marine vessels.



US plots course for wind power breakthrough

Despite a rollercoaster ride in terms of policy support, hard-won reductions in the lifetime cost of energy is making the case for wind power increasingly compelling in the US.
David Appleyard

At face value, President Donald J Trump's withdrawal from the Paris Climate Accord, his apparent bullishness on fossil fuels, and his plans to rescind environmental protection and clean energy policies introduced by the previous administration, paint a gloomy picture for renewables like wind. However, evident latent opposition to renewables has not been translated into aggressive policy action. Indeed, the energy policies that have been announced broadly benefit the energy sector in general and have generally therefore been perceived as neutral for the renewable energy industry.

Indeed, despite initial post-election pessimism the US recently reached second spot on the Renewable Energy Attractiveness Index from EY. Naturally China tops the list, but that the US has now succeeded in overtaking India and Germany points to the resilience of the US market.

The positive analysis from EY is reflected in the latest industry figures too, with strong demand in the first quarter of 2018. Power Purchase Agreement (PPA) contracts for 3500 MW of new US wind capacity were signed onto the books over the first quarter – a recent high water mark.

The latest figures from the American Wind Energy Association (AWEA) also reveal another 5523 MW of first quarter wind either launching construction or entering into advanced development, adding to a total of 33 449 MW of wind power capacity in the combined US construction and advanced development pipeline. This is a 40 per cent increase on the equivalent quarter last year.

US operating wind power capacity grew by 9 per cent in 2017 with the installation of more than 7 GW and it generated a record 6.3 per cent of total US electricity over the year. Meanwhile Iowa, Kansas, Oklahoma, and South Dakota all generated more than 30 per cent of their electricity using wind. Nationally, 14 states generate more than 10 per cent of their power from wind alone. There are now 89 379 MW of installed wind capacity and the country's wind sector is buoyant.

As ever with the Trump White House, there are mixed messages and energy policy is no exception. For example, the latest budget request sets out plans for a massive cut in the Department of Energy (DoE) budget for renewables research. The proposed budget, which is typically significantly modified before legislative approval, earmarks just \$696 million for energy

efficiency and renewable energy. This is \$1.3 billion less than the FY 2017 plan as enacted. For comparison, \$502 million has been earmarked for Fossil Energy R&D, \$81 million more than 2017.

Trump is also calling on Congress to enact his \$100 billion infrastructure plan, which is expected to stimulate at least \$1.5 trillion in new investment over the next 10 years. Under this programme, states and localities would receive incentives in the form of grants.

Other Trump policy initiatives, such as solar import tariffs imposed in January, are also likely to have only a limited impact on solar energy development in the country, but are likely to tip the scales toward wind projects at the utility scale, according to EY's analysis.

Most significantly, the current administration has not repealed the crucial tax breaks for the renewables industry that are expected to provide more than \$12 billion in support by 2020. The Tax Cuts and Jobs Act that passed late last year preserved the renewable energy Production Tax Credit (PTC) and Investment Tax Credit (ITC) structure with a tapered phase-out of the tax credit through 2019. The final extension of the PTC and ITC had originally occurred in 2015 and included a five-year extension and phase-down of the PTC, as well as the option to elect the investment tax credit for wind energy. Leaving that in place means that for the PTC, wind projects that started construction in 2015 and 2016 receive a full value PTC of \$2.4 cents/kWh for the first 10 years of operation. The tax credits are now being phased out, falling by 20 per cent each year beginning in 2017 and ending after 2019 so that for projects that begin construction in 2017, the credit is at 80 per cent of full value and so on. Similarly for the ITC, wind projects that started construction in 2015 and 2016 are eligible for a full 30 per cent ITC, falling to 12 per cent by 2019.

As before, the rules will allow wind projects to qualify as long as they start construction before the end of the period, which can mean placing orders to the value of 5 per cent of the construction costs. Wind facilities commencing construction by the end of December 2019 can qualify for this credit.

After much delay and still with much promise to be delivered, US offshore wind is finally taking off. With AWEA estimating an offshore wind potential of 2000 GW in state and federal waters, the country's first offshore wind farm, Block Island

Wind Farm off the coast of Rhode Island, only began operations 2016. Now projects are under development off the East and west coasts and in the Great Lakes.

For example, Dominion Energy Virginia is moving ahead with its 12 MW project 27 miles (48 km) off the coast of Virginia Beach, the mid-Atlantic's first offshore wind project on a 2135-acre (863 Ha) site. In partnership with Ørsted (formerly DONG Energy) the first phase of the project will feature two 6 MW machines due for installation by the end of 2020. An adjacent 112 800-acre (50 000 Ha) site is also leased by Dominion Energy with full deployment expected to see some 2 GW installed.

The US is also expected to benefit from major technical breakthroughs that have seen offshore wind costs plunge in Europe with prices as low as £57/MWh (\$76/MWh) for the latest generation of projects.

This is a point noted by Tom Kieran, CEO of AWEA who said: "Some of the world's most powerful wind turbines will now flow from new investments in America's port and manufacturing infrastructure."

For example, Siemens-Gamesa is expected to up-rate its 8 MW direct drive wind turbine that is set for its first commercial deployment at the 1.3 GW Horns Rev 2 project off the UK. Simultaneously, GE (formerly Alstom) is going ahead with its 12 MW Haliade offshore machine.

Thomas Broström, President for Ørsted North America, picked up on this point saying: "The US is in a prime position to take advantage of the positive developments in the offshore wind industry, including rapid cost declines and innovative technologies."

Some states are aggressively pushing for offshore wind development. For instance, this year New Jersey governor Phil Murphy said the state will move ahead with 3500 MW of offshore wind by 2030.

New York has also issued its Offshore Wind Master Plan, set to engender 2400 MW of offshore wind in the state with construction beginning around 2023.

Indeed, a recent study by New York, Massachusetts and Rhode Island states with the Clean Energy States alliance found that 8 GW of offshore wind is achievable by 2028 off the east coast.

Alongside individual state efforts, the federal government is also backing offshore wind – despite declared opposition to some renewable energy sectors. For example, writing in the *Boston Globe* recently, Ryan Zinke, Secretary of the Interior – responsible

for areas like offshore wind development – put the current administration squarely behind wind, in particular offshore. Zinke said: "As we look to the future, wind energy will play a greater role in sustaining American energy dominance. Ramping up wind development and building new power grid systems also coincides well with Trump's goal of enhancing and modernising our American infrastructure."

He highlights measures such as the release of draft guidelines on a "design envelope" approach, to allow for more flexibility in planning.

There are now some 8 GW of firm commitments for offshore wind in six northeastern states and a total offshore wind project pipeline of some 25 GW across the US.

A major boost to US renewables has been a shift in investor profile from traditional project finance lenders to utilities and corporate entities such as insurance companies and pension funds looking for the long-term financial stability such investment products offer.

With utilities and Fortune 500 brands scaling up investments in wind energy, AWEA reports that six companies including Adobe, AT&T and Nestle have signed PPAs for wind power for the first time this quarter. High profile brands like Bloomberg, Facebook, Nike and T-Mobile became repeat customers for wind, according to the AWEA analysis and utility buyers including PacificCorp and DTE Energy announced plans for large-scale wind power development.

Ben Warren, EY Global Power & Utilities Corporate Finance Leader, explained: "Rising interest rates are likely to increase the cost of cheap capital that has underwritten the dramatic roll-out of renewable energy capacity over recent years. Government subsidies for clean power are being reduced around the world and financiers are anticipating tougher times ahead for project developers. However, movements in the Index suggest that these developments are just headwinds as the renewable energy sector continues to mature and markets expand."

Appropriate and supportive energy policy has long been the key challenge for renewable energy – the on/off nature of the PTC is a good example – but with the US set to capitalise on the hard-won reductions in the lifetime cost of energy for wind, as wind becomes truly competitive with other resources, its future will be based instead on demand for energy and associated infrastructure costs. For the US, that is becoming increasingly compelling.

Decarbonising Europe

Fully decarbonising Europe's transport, heat and electricity sectors by 2050 will require significant investments. A recent study by Pöyry assesses the economics of two potential pathways. **Richard Sarsfield-Hall**

A recent study by Pöyry highlights the scale of the challenge to fully decarbonise Europe's transport, heat and power systems by 2050 as part of meeting the ambition within the Paris climate change agreement for limiting the global temperature increase to 1.5°C.

The Paris ambition is particularly challenging for some sectors, e.g. industry, where its CO₂ emissions in 2014 are already over three times the economy wide limit for 2050, a 95 per cent reduction compared to 1990 levels. Such an ambitious reduction requires full decarbonisation of the energy sector (transport, heat and power), alongside a significant reduction in other sectors (shipping, aviation, agriculture, food, other land use and waste) – a process likely to cost many billions of euros over the next 30 years.

The study evaluated two potential pathways to a decarbonised Europe: a 'Zero Carbon Gas' pathway, where biomethane, hydrogen and CCS are part of the technology options allowed to economically compete; and an 'All-Electric' future, where only electrification of all transport and heat is permitted. Although other pathways may be possible, the comparison of these two is instructive for understanding the risks and challenges.

The 'Zero Carbon Gas' pathway represents a future where economics determine which technologies are deployed to fully decarbonise the energy sector. The gas industry is allowed to adapt to the requirements of a decarbonised system and provides zero carbon energy in all sectors.

In the non-process heating sector a combination of natural gas district heating (with CCS), hybrid heat pumps and stand-alone hydrogen boilers are required to meet the decarbonisation targets. This transition relies on a number of new technologies such as hybrid heat pumps and new fuels (e.g. hydrogen and biomethane) becoming commercially available.

As hybrid heat pumps utilise electricity in warmer conditions and biomethane and hydrogen during periods of colder temperatures, hydrogen appears in small quantities by 2030 and then expands as the supply chain develops.

Decarbonisation in the transport sector is achieved through a mixture of hydrogen vehicles, mostly in the freight sector, and electric vehicles, primarily in the passenger sector. Nearly 100 million hydrogen-powered vehicles are deployed alongside 330 million electric vehicles.

The expansion of electricity use in transport and heat means that total European electricity demand will increase by 60 per cent in 2050. Solar and onshore wind are the main drivers of the required 150 per cent capacity increase across Europe. Interconnector capacity grows strongly, but nuclear capacity falls over time as there are cheaper options available. The resulting generation mix is therefore dominated by renewables as the cheapest form of zero carbon

electricity generation.

An 'All-Electric' pathway builds upon the assumption that only electrification can achieve decarbonisation, and policies are put in place to prevent the development of 'Zero Carbon Gas' alternatives, resulting in new nuclear and biomass build.

Heat pumps become the dominant technology in non-process heating, with air-source heat pumps in urban environments and ground-source heat pumps in rural areas. In many Northern European countries, air-source heat pumps are deployed alongside an electric resistive backup system to cover time periods when the ambient outside temperature falls below working limits for stand-alone heat pumps (assumed to be -15°C). The remaining demand – currently met with coal, oil and gas – switches to biomass as the only practical zero carbon alternative that can support high temperature load needs, leading to large biomass requirements in this pathway. Heat from combined heat and power, which converts from fossil fuels to biomass, is also used.

In the transport sector, decarbonisation is achieved by fully electrifying all road vehicles and trains. This includes heavy goods vehicles, which assumes that there is successful development of very large battery systems and supercharging facilities to ensure range requirements are met. This pathway estimates that 432 million electric vehicles will be on the road in 2050 across Europe.

The electrification of transport and heat means total European electricity demand increases by approximately 180 per cent from 2020 to 2050, whilst total renewable generation in 2050 is around 80 per cent. More than five times the amount of nuclear generation required in the 'Zero Carbon Gas' pathway is needed to help balance intermittency alongside smart demand side response. Since many countries do not allow nuclear power, those countries that do, especially France, the UK, Poland and Czech Republic, are expected to build the bulk of the new 190 GW. European-wide electricity interconnection approximately doubles to more than 300 GW by 2050 to enable sharing of all generation sources.

In order for the envisaged pathways to be feasible, several prerequisites need to be met:

Any decarbonisation pathway can only be achieved if:

- Insulation is sufficient for heat pumps to be viable. Since heat pumps provide a lower amount of heat compared to boilers, it is important that buildings are sufficiently insulated for heat pumps to be viable. In order to deploy heat pumps on the envisaged scale, significant expansion is required in the supply chain
- Countries co-operate on electricity interconnection. Better interconnection between countries is needed to avoid overbuilding generation capacity and maximise the value of intermittent renewables
- Customers embrace the flexible energy economy. Frameworks need to be

put in place to allow smart and flexible services. Consumers need the right incentives so that they embrace flexibility and contribute actively to the energy economy, including smart appliances, heating and EV charging

■ Smart grids enable flexibility and 'EV-to-grid'. Technical fundamentals need to be in place to allow smart operation of grids and appliances. This includes improved batteries that deteriorate less quickly when operated as required (two-way charging).

A 'Zero Carbon Gas' pathway can be achieved if:

■ CCS is available and accepted. CCS allows gas to be used in a wide range of sectors (power generation, heat production, hydrogen production and industrial process output). Pipeline infrastructure needs to be built and adapted to transport the CO₂ to the storage sites.

■ Hydrogen is produced on a large scale for heat and transport. For hydrogen to be competitive, large quantities of methane reformers need to be deployed.

■ Hybrid heat pumps are deployed. Reflecting poorer performance of air-source heat pumps in colder weather hybrid heat pumps are deployed in homes alongside boilers using biomethane or hydrogen. Such systems need to be available and ready for large scale deployment.

■ Gas networks are adapted for decarbonisation. In most countries, the use of gases in heating remains high across the modelled period. These networks need to be adapted for decarbonisation (e.g. different usage patterns, conversion to hydrogen).

An 'All-Electric' pathway can be achieved if:

■ Nuclear power is supported and flexible. A zero-carbon system based on electrification requires a significant contribution from nuclear power. This will be challenging from several perspectives: politically – acceptance is problematical across Europe; from a supply chain perspective – the amount of new build required is as high as its historical peak; and technically – plants will be operated much more flexibly than today

■ HGVs can be electrified. The pathway focus leads to an electric heavy transport sector, with a supported infrastructure

■ Biomass is considered sustainable and is available. The absence of CCS or any other alternatives leaves sustainable biomass as the only option to decarbonise heat for industrial processes that cannot be provided by electric solutions

■ Industry can be decarbonised without CCS. While this study only considers decarbonisation of the energy sector, not allowing CCS has wide-ranging consequences for the industrial sector. Without CCS, other more expensive solutions in industrial processes need to be found to avoid emissions – or operations need to scale down or relocate away from Europe.

Combining the analysis from all sector models with calculations of networks, supply and other costs produces the total system costs for

each pathway. There are significant extra costs of €1.15 trillion associated with the 'All-Electric' pathway, which precludes CCS, biomethane and hydrogen. The largest differences occur in the heating sector, where both electricity and biomass fuel prices contribute to very high costs, and in residual power costs, which are mainly associated with the extra costs of power generation, especially nuclear, in the 'All-Electric' pathway.

The outcome of a fully decarbonised 'All-Electric' solution is €94 billion costlier per annum in 2050 than the 'Zero Carbon Gas' alternative. This is especially the case for the transport and heat sector costs which amount to €113 billion of additional costs p.a. in 2050.

The key messages and risk mitigation factors that all stakeholders should consider based on the analysis in this study are the following:

■ Keeping options open is critical to managing risks, costs and security of supply. A pathway that precludes options, e.g. CCS, could lead to higher investment costs than necessary (e.g. in power generation or networks) and increased risks. Accordingly, it is prudent to keep as much flexibility in the technology options available

■ Utilising Zero Carbon Gas options as part of the energy mix, especially in transforming heat, comes at a saving of over €1150 billion compared to an 'All-Electric' world only

■ The future for small vehicles is electric, but for larger vehicles hydrogen is a better option

■ CCS deployment allows industry to decarbonise not only energy but also process emissions

■ Power generation will be dominated by renewable technologies – especially solar PV and onshore wind – with some support from flexible zero carbon technologies, which comes from nuclear in an 'All-Electric' world or from hydrogen and CCS in a 'Zero Carbon Gas' world. It makes economic sense to deploy these where the natural resource is most prevalent.

Interestingly the findings also predict a major shift in the future, where demand balances intermittent supply by utilising flexible EVs and electric heat. This mass deployment of smart-grid connected and flexible EVs will largely displace other flexibility providers like batteries and power-to-gas, by removing many periods of excess renewable electricity generation.

The good news for all stakeholders is that this study has shown that it is feasible to fully decarbonise Europe's transport, heat and electricity sectors by 2050. However, achieving this will require significant investments and requires a major transformation across all three sectors regardless of which particular pathways stakeholders chose to follow.

Richard Sarsfield-Hall is a Director at Pöyry Energy Consulting and lead author on the study 'Fully decarbonising European Energy system by 2050'.

Sarsfield-Hall: mass deployment of smart-grid connected and flexible EVs will largely displace other flexibility providers like batteries and power-to-gas



Technology

Gravity-based energy storage: a weighty prospect

The system uses a heavy weight suspended in a deep shaft. When there is excess electricity, the weight is winched to the top of the shaft. This weight can then be released when required to produce electricity

An energy storage system that will utilise disused mine shafts to store energy using a similar principle to pumped storage is gearing up to enter the demonstration phase. **Junior Isles** reports.

Who would have thought that an idea from the 17th century could play an important role in today's energy sector? It may sound unlikely, but the same principle behind winding and lowering the weight in a pendulum or 'grandfather' clock is now behind the development of an energy storage system conceived by Edinburgh start-up, Gravitricity.

The system uses a heavy weight suspended in a deep shaft. When there is excess electricity, for example on a windy day, the weight is winched to the top of the shaft. This weight can then be released when required to produce electricity.

Charlie Blair, Managing Director of the company commented: "Our Technical Director, Peter Fraenkel came up with the idea. He was a good enough intuitive engineer with the vision to see that you could use the same idea for electricity storage in power grids. It was his idea to use an old Victorian technology for a very modern purpose."

The idea of using gravity to store energy is not new. There are many pumped storage hydro schemes operating around the world, where water is pumped uphill to be released when required. But while the physics is like pumped hydro – without the restrictions of geography – Blair says the commercial characteristics are more like lithium batteries.

"We have some of the good aspects of pumped hydro – it is mechanical with a very long lifetime and we can cycle as much as we want but don't need a convenient mountain sitting there. In due course we can sink a new shaft exactly where the storage is required as a piece of grid infrastructure.

"Yet we also have valuable flexibility characteristics; we can respond very fast, which means we can provide more value to electricity grids."

The system consists of a huge weight (up to 2000 t) suspended by

several cables, which are attached to the winding gear, or winch, at the top of a vertical shaft. There are multiple winch modules, each with a cable attached to the weight.

According to Blair, there would be a minimum of four cables but there could be eight or as many as 16 in a large system. The winches are driven by electric motors when the weight is being lifted. When power is being discharged back to the grid during lowering, the motors are driven as generators. This is much the same way that a pumped hydro plant has a turbine running as a generator in one direction and a pump in the other.

Gravitricity says its first (several tens of) projects will be in existing mine shafts. "We're interested in any mine shaft that is over, say, 300 m deep. But our first ones, and there are thousands of these around the world, will be 500 or 600 m deep. The shaft also has to be reasonably wide, around 7 m, and in good condition."

Gravitricity is also developing the processes it needs to sink new shafts in the areas they are needed, for example, in locations where the grid is constrained. These shafts will be shallower but much wider. These will probably be 100 m deep and up to 10-15 m in diameter.

There will no doubt be civil engineering challenges to getting a mine shaft that has not been designed for handling and supporting a 500 t weight. Tailored structures will therefore be needed at the top of every mine shaft.

"While our winch system can be modular, onsite civil engineering and the challenges around getting a 500 t weight slowly up and down a shaft is not simple," noted Blair. "It's difficult to know what condition a mine shaft is in if it hasn't been used for 10 years. We might have to reinforce the surface structures."

At full power output, the fastest the weight would be expected to travel down a 500 m shaft is 15 minutes.

Alternatively it could take 4 hours with a reduced power output.

Blair explained: "It is accelerating under gravity but we slow it down by extracting energy, which is why we have a fast speed of response of less than one second... so gearing is also a challenge."

He added that there are some specific challenges around the dynamics of what happens in the first second of operation when changing direction. "Control systems for controlling the dynamic and mechanical behaviour of the system is also a big part of our work... it's about making sure the movement of the weight in the shaft, and therefore the winches and gearboxes and generator, all correspond to the right form of electricity output."

Blair believes the technology will have its place among the various other energy storage technologies such as batteries, flywheels and liquid air.

"There is space for all of the technologies. We are quite close to lithium batteries in terms of characteristics but we have a very much longer lifetime – 10 if not 100 times longer. And we don't have any degradation issues or depth of discharge limits.

"For power applications we will be much cheaper than liquid air, which is potentially good at doing bulk energy storage. We do faster reacting, higher power storage applications, which is where the value is at the moment. On a cycle lifetime basis, we are cheaper than lithium batteries and a lot cheaper than flywheels."

His claims on the economics are supported by Imperial College London. In an independent report, analysts predict that Gravitricity's system may offer a better long-term cost of energy storage than batteries or other alternatives.

The report suggests that the technology will be particularly well suited to providing grid balancing and rapid frequency response services to grid operators – where the requirement for multiple short cycles and high power availability play to its strengths. Blair noted that applications could also include providing backup power, peak shaving and other ancillary services to the grid such as black start.

Imperial College studied factors in all relevant cost and performance factors including capex, operating costs, discount rate, depth of discharge and degradation over a 25-year lifespan to arrive at an annualised power levelised cost of energy storage (LCOS) quoted in \$/kWyear.

In a frequency response scenario – requiring 700 cycles per year and a duration of 15 minutes at a power output of 4 MW – Gravitricity has a predicted LCOS of \$141/kWyear, outperforming all alternatives.

Blair said: "Our economics are based on multiple value streams. We can access the very high value services where we may only be required for say, two hours in the evening in

the winter; but the rest of the time, unlike batteries, we can access other value propositions."

Another key finding of the report was that the higher initial opex is offset by very long lifespan (up to 50 years), high power availability, 100 per cent depth of discharge and zero per cent degradation.

Gravitricity has an R&D plan that will see it first develop a concept demonstrator, which it is planning to build this year. This will be built on a rig using a 50 t weight. The demo, which will incorporate a 250 kW motor, will be used to understand the dynamic behaviour of the system.

"Blair explained: "It doesn't store a lot of energy but provides a surge of power because we need to understand the system as it changes direction. It takes less than a second to change direction so it doesn't need a lot of vertical drop."

The next step will be to build a commercial prototype, for which it received a £650 000 grant from Innovate UK, the UK government's innovation agency in February this year. Since receiving the grant, the company has signed a R&D agreement with Dutch lifting multi-national Huisman to develop and test it in the Netherlands and Scotland.

"The full-scale prototype will be designed and funded next year and deployed in early 2020," said Blair. "That system will use a 500 t weight and will be a 4 MW system."

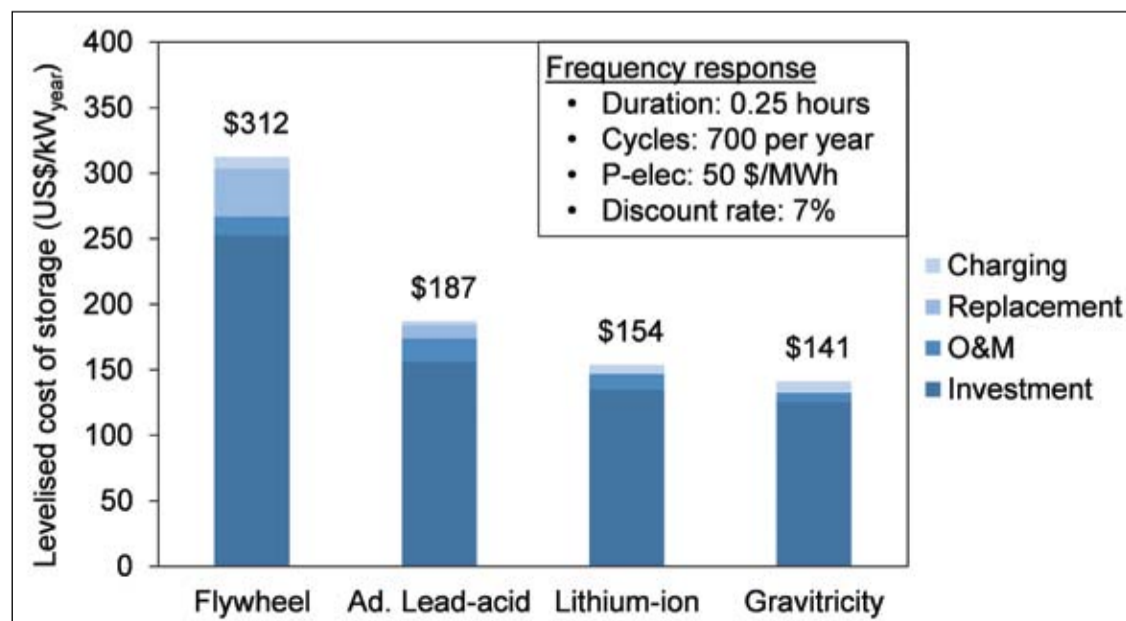
The exact location of where the prototype will be installed is still to be confirmed but Blair says it will most likely be in a UK mine shaft. "There are 50 000-plus mine shafts in the UK. Most have been filled in or are not suitable but there are many hundreds that are the right diameters and depths. Of those, many have been filled but we have identified several that are suitable for us in England and we would like to do more work on them."

He says this project will provide ancillary services to the national grid, such as frequency services. If this prototype is successful, Gravitricity then plans to build commercial projects firstly in mine shafts. These will be in countries such as the UK, Germany and South Africa, i.e. countries where there are a lot of vertical mine shafts.

Certainly, the path appears clear from a technical perspective. Yet, the imminent challenge to commercial projects is policy.

As Blair summed up: "The challenge at the moment is having long term clarity that there will be revenues from these projects. The contracts, generally speaking, are not long term. Convincing investors that there will be a long term return is difficult for us at the moment; for us and other energy storage projects. It's frustrating because we have a long lifetime. People are coming round to the importance of lifetime, though, especially in power companies. I think we'll do well."

Levelised cost of storage for various technologies



One size doesn't fit all



Junior Isles

When it comes to generating revenue in the energy market of the not too distant future, there is no one size fits all in terms of business models. But as the new energy landscape continues to take shape, there is a clear trend that energy suppliers are increasingly shifting their focus downstream to the end consumer.

Certainly, different suppliers in different markets are further along their chosen path than others but the direction of travel is clear.

The UK, for example, is quite advanced in terms of the vast number of retail suppliers in the market, some of which are investing heavily in home solutions. Centrica is a case in point. The British multinational energy and services company has reformed its business, centring its customer-focused strategy on digital in-home through its Hive business. But the sheer number of retail suppliers in the market has not only brought in competition for retail customers, it is also driving innovation and the adoption of technologies such as demand side management.

Delta Energy & Environment (EE) is a UK-based information and consulting firm for distributed energy markets, specialising in helping organisations to exploit opportunities in the changing energy market. Charmaine Coutinho is Principal Lead for New Energy Business Models at the company.

She said: "Even in markets such as France where there aren't as many players, the threat of losing customers to new potential entrants from other industries such as technology, product manufacturers or the likes of Google

and Amazon, is really driving [business model] innovation."

It is a view which Michael Dodd, Market Area Manager, UK & Ireland at DNV GL agrees with. "One of the fundamental things that will change over the next five years on the domestic side is how we buy electricity and gas. We will buy these via an energy service to the home, and at some point will flip over control of our energy supply to someone that can do it much more efficiently. That's when people will start to bring new technologies into service, e.g. home energy management systems, storage, smart appliances, etc."

In its research, Delta EE says it has seen evolution in six categories of business models, which it believes are shaping the future. These are: time-of-use optimisation (models that leverage value from flexibility, whether through demand shifting, storage or use of distributed generation); efficient consumption (models that use a primarily data-driven approach to improve customer consumption); lifestyle products (focused on improving customer quality of life); marketplace operations (a business model that transforms the way in which stakeholders are connected and transactions occur); bundling (offering a combination of services package together into a single proposition); and energy as a service (providing the use of a product as a continued service, rather than a one-off commodity purchase).

Many of these business models seem to be underpinned by flexibility. Using 'lifestyle products' as an example, Coutinho said: "Quite often companies start off with offering their

customers a gadget such as a smart phone, for example. Part of the reason they do this is to garner some data. With more data they can build a better picture of what the customer wants. They could potentially use that gadget and the home energy hub to know when or how much energy a household consumes to decide when they can buy or sell that demand into the market. This gives them a much better understanding of how much value they can place around flexibility."

Coutinho explains that this could evolve into them adopting other business models such as time-of-use optimisation. Here, they could use information gathered about the home or energy demand in a building to sell other products or services such as, for example, a flat rate energy tariff.

Technologies such as storage and even electric vehicles will play an important role for those interested in targeting prosumer models.

"Storage has an important role as a sort of arbitrator because it fundamentally changes the way you forecast energy usage patterns," said Coutinho. "If you think you can predict a customer's supply or demand and you can put a battery in there, it means you can change that. You then enter the realm of it being much more of a hedging, optimisation, gaming, perspective. You wouldn't be able to use machine learning and artificial intelligence in the same way if you didn't have the ability to store energy."

Sonnen is one example of a business that is using batteries plus storage to create a successful business model. The German solar-energy-storage maker, created the SonnenCommunity, which allows peer-to-peer selling

of electricity.

Members pay Sonnen a monthly subscription charge (membership fee) to use a SonnenBatterie and solar PV to meet their own energy needs and feed into a 'virtual energy pool' that serves other members. This disruptive community, which bypasses the traditional utility, is thriving. In one year, it offered up over 14.7 million kWh, more than half of which was purchased.

Although important, not every business model is predicated on storage. Not everyone will want to be a prosumer but might only want to know they are receiving a good deal on their energy tariff. There will be a number of propositions as different technologies and business models are brought to market. It will not be a case of one size fits all.

Delta EE says it is doing a lot of work with energy suppliers and product manufacturers to look at where they best play in the new downstream, decentralised, low-carbon world. One of the questions Coutinho says she often gets is whether there is value in downstream.

"I think it really depends on where you play and who you are," she said. "One of the key things we are seeing, is companies trying to understand what their inherent strengths are."

But much could be scuppered by a lack of policy, which will play an important role in the success of some of the business models.

Coutinho said: "For flexibility, policy is a real challenge. Having consistent and predictable revenue streams is essential. It's a real challenge when people don't know how much each of the different value streams they are thinking about in their models will be over the course of an investor's timeframe." She added that discussions are ongoing between governments and industry in the UK and other countries across Europe, as well as in Japan, in terms of setting the market structure and value of flexibility.

While energy companies can only have a limited effect on policy, what they can do is ensure they have the right skills for their chosen path. Going forward into the new energy world, energy companies will have to draw on their expertise in areas such as energy trading and origination to help with energy optimisation. Or perhaps build on their knowledge of the customer to ensure whatever service or product they supply is the best thing for them.

"We really put an emphasis on knowing your customer and knowing yourself as an organisation. One of the key things we are seeing, is companies trying to understand what their inherent strengths are," said Coutinho.

How customers will incorporate technologies such as storage and EVs into their lives will be very important and it is an area to which the industry has to give some serious thought. It is easy to get caught up in discussions around technologies and their costs but neglect the customer.

Coutinho noted: "There are pros and cons for different chemical compositions for batteries but actually, the most important thing is to start with the customer and the business model and work out how you can make money from it."

If the experts are correct, success in the new energy world all starts and ends with the customers. All energy companies now need to figure out, is which business model best aligns their own expertise with their customers' needs.

