# THE ENERGY INDUSTRY TIMES

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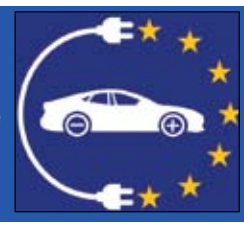
**Special Supplement**

The Hanhikivi 1 nuclear power plant in Finland is hoping to buck the trend when it comes to constructing large nuclear plants on time and to budget.

**Decarbonising transport**



Decarbonising transport is essential if the EU is to meet its climate change targets. The electricity sector has a crucial role to play in these efforts. ***Page 13***

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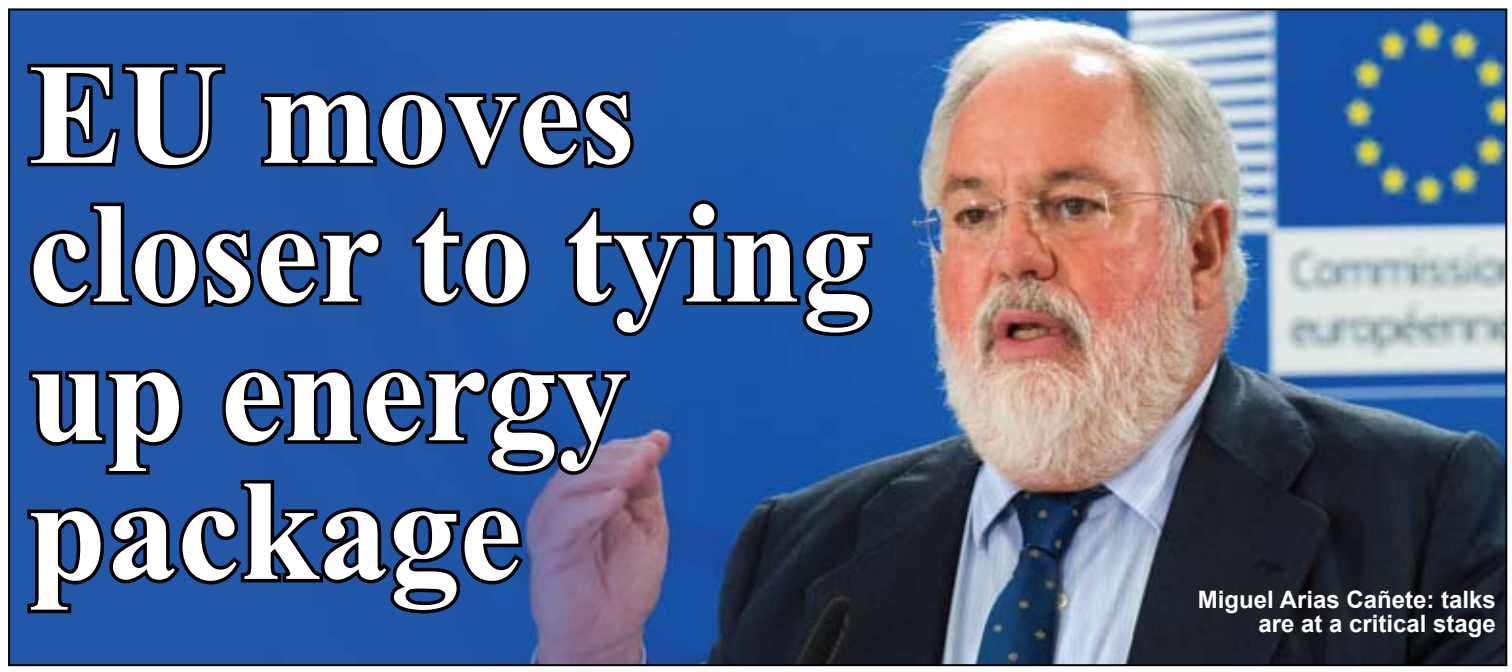
# EU moves closer to tying up energy package



Miguel Arias Cañete: talks are at a critical stage

With renewables on the rise, the European Commission hopes that the full package will be adopted by the end of the year. **Vic Wyman** in Brussels and **Junior Isles** in London.

Political talks on the European Union's energy and environment future up to 2030 have reached a critical stage, claimed Miguel Arias Cañete, the bloc's climate action and energy Commissioner.

The EU institutions – the European Parliament, the European Council and the European Commission – are edging towards agreements on new energy efficiency and renewable energy targets and on energy governance, he told an informal EU energy ministers meeting in Bulgaria in April.

At the meeting, Cañete called the energy package vital for stabilisation, energy security and economic growth in the Balkans, which is a political priority for the EU.

Those deals would follow an expected final agreement within weeks by the EU's Council of Ministers on rules on the energy performance of buildings, after receiving the final thumbs up from the Parliament on April 17, 2018.

The building energy rules would be the first of eight parts of the Commission's 2016 energy package to be adopted. The other four parts cover electricity market design (the Electricity Regulation, the Electricity Directive, and the Risk-Preparedness Regulation) and rules for the EU agency of electricity regulators, Acer.

The Commission hopes to unveil its market design proposals before July 2018. At the recent EU Energy Summit conference in Brussels, Belgium, Pawel Wróbel, of the Polish Electricity Association, said: "We really count on having effective instruments and financial instruments."

The Commission hopes that the full package will be adopted by the end of the year.

Its 2030 targets include a 40 per cent cut in greenhouse gas emissions on 1990 levels, a 27 per cent renewables share of energy consumption and 30 per cent efficiency savings compared with business-as-usual. The 27 per cent is higher than a 2014 target because of the rapid falls in the costs of renewables.

Although original criticism of the targets as unambitious has become muted, the Parliament, for example,

*Continued on Page 2*

# EDF ramps up focus on renewables and storage

France's state-backed energy group EDF is taking steps to develop its energy storage footprint as it moved to bolster its renewables credentials.

In April, its wholly-owned subsidiary EDF Energies Nouvelles said it is rebranding its international subsidiaries to EDF Renewables to support the company's expansion in the international renewable energy market.

"With the worldwide priority to tackle global warming, it seems crucial for us to raise the visibility of our international business by establishing a strong brand name consistent with the EDF Group's strategic goal of being a major player in the energy transition," said Antoine Cahuzac, Group Executive Director in charge of Renewable Energies and Chairman-Chief Executive of EDF Energies Nouvelles.

"By switching to an harmonised international brand, we reinforce our corporate culture and our common commitment across all our subsidiaries," he said.

The company has already developed and operated wind, solar and energy storage projects in around 20 countries.

In French-speaking countries where EDF Energies Nouvelles is established, such as Morocco, and Quebec province in Canada, the brand name is changing to EDF Renouvelables. The German operations and maintenance subsidiary will change its name to REETEC EDF Renewables.

The brand identity will remain EDF Energies Nouvelles in France and for the name of the EDF Group subsidiary dedicated to wind and solar energy, the company said.

The news follows an announcement in late March that EDF plans to invest €8 billion by 2035 to develop 10 GW of additional storage around the world by 2035, in addition to the 5 GW it currently operates. According to the *Reuters* news agency, the additional capacity includes 6 GW of large, industrial sized storage such as pumped storage and batteries. It also said 4 GW will be for use by retail customers and companies.

The company is also putting €70 million into power storage research and development up to 2020.

EDF's Chief Executive Jean-Bernard Levy said: "With storage we can smooth out the intermittence of renewable energy and guarantee the performance and balance of the grids.

In December, EDF announced a massive push into solar power that will cost up to €25 billion with many suggesting the move was due to increasing pressure from the government to increase its use of renewable energy.

The French government will outline its energy plans for the next ten years by the end of 2018, including how it intends to reduce the proportion of nuclear power in its energy mix. France relies on nuclear plants for 70 per cent of its energy.

"The goal of reducing nuclear power is irrevocable," said left-leaning Environment Minister Nicholas Hulot in a recent interview.

He noted, however, that it would "be difficult to maintain the target of reducing the share of nuclear to 50 per cent by 2025" as to do so would risk power shortages and could, counter-productively, push up carbon emissions. Last November he therefore suggested a new target of closer to 2035.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still wants a 35 per cent efficiency increase and a 35 per cent renewables target.

Simone Mori, Executive Vice-President of the Italian energy company Enel, told the Brussels conference: "We believe that 35 per cent is a proper target for renewables. It is achievable." Mori was more concerned about heating and cooling, which represent a large part of energy consumption: "We should try to be more ambitious."

Jonathan Cole, offshore managing director of Iberdrola Renewables, claimed that renewables were now mainstream, and that 35 per cent is "achievable, affordable and realistic".

According to figures published by AIB (Association of Issuing Bodies), the total market demand for renewable electricity documented with Guarantees of Origin increased from 367 TWh in 2016 to 471 TWh in 2017, an increase of 28.3 per cent.

Meanwhile, in its spring forum in March, UK analytics firm Aurora Energy Research claimed there is potential for more than 60 GW of subsidy-free renewables across northwest Europe by 2030.

The investment opportunity in renewables in the region – Great Britain, Germany, France, Ireland, the Netherlands and Belgium – by 2030 is estimated at around €180 billion ($222 billion). More than a third of that, €64 billion, could be in subsidy-free projects.

These figures indicate that the energy transition is well under way and gaining momentum.

**Cole said the 35 per cent is "achievable, affordable and realistic"**

Cañete, who was also in Brussels told delegates that geopolitical and other uncertainties within and outside the EU meant an urgent need to unify around an ambitious energy transition. On energy security, for example, he cited energy imports, which provided 72 per cent of EU primary energy consumption in 2016: 40 per cent of solid fuels such as coal; 70 per cent or €1 billion a day of gas; and 88 per cent of oil.

"The main challenge for the EU is in the gas supply," he added. In 2016, 76 per cent of gas was from Russia and Norway, 13 per cent was liquified natural gas (LNG) and 11 per cent from Algeria. Russia would remain a major supplier, he said, but should face competition, typically by more pipelines and an expanded EU LNG network.

In late March, the European Commission's latest reports on gas and electricity markets showed that, despite a slight year-on-year decrease in the last quarter of the year, in 2017 EU gas consumption was 491 bcm (billion cubic metres), 6 per cent more than in 2016 and the highest level since 2010.

Although high prices in Asia driven by surging Chinese demand made Europe a less attractive destination for LNG supplies, EU LNG imports increased by 16 per cent year-on-year in the last quarter of 2017.

# Cyber security breaches on the rise

- Attack takes Ukraine energy ministry website offline
- Report shows breaches in Middle East region most severe

**Simonovich: systematic effects are most concerning**

Junior Isles

Cyber security breaches in the energy industry are on the rise, with several incidents being reported in recent weeks.

On April 24th, hackers used ransomware to take the website of Ukraine's energy ministry offline and encrypt its files. Following the hack, the website displayed a message written in English, demanding a ransom of 0.1 bitcoin – worth $927.86 (£664.98).

Ukranian cyber-police spokeswoman Yulia Kvitko said the attack was an "isolated incident" and no other government websites had been affected. She added that the energy ministry's email system was still up and running.

A week earlier the US Department of Homeland Security (DHS) issued a warning that Russian hackers are targeting millions of devices around the world to build networks for potentially devastating future cyber attacks.

Andrea Carcano, Co-Founder and Chief Product Officer, Nozomi Networks commented on the DHS warning: "The alert reminds us that our nation's critical infrastructure is only as strong as our weakest links. Despite the benefits of connectivity, wireless devices, including industrial routers, access points and gateways, as well as smartphones and tablets used by engineers and operators for remote access, remain especially vulnerable to cyber attacks.

Meanwhile, in mid-April gas and power company E.On Romania and the National Computer Security Incident Response Team (CERT-RO) signed a cooperation protocol aimed mainly at exchanging cyber security intelligence. The protocol also provides for support for cyber security risk awareness campaigns and the facilitation of expert information exchanges.

Frank Hajdinjak, CEO, E.On Romania, said in a release: "We take risks related to incidents or cyber attacks very seriously. The digital systems in our power transmission grids can be targeted by such attacks with highly serious potential consequences on the security of supplies and substantial losses to the company. At the same time, we are aware of the obligations incumbent on us regarding the protection of key energy systems and of collected and managed data."

The electricity and oil and gas sectors are among the most highly targeted verticals across all industry sectors. In early April, news broke that a supply chain cyber attack disrupted a chain of natural gas companies. According to *Bloomberg News*, it affected a software platform developed by a company named Energy Services Group LLC that is used to process customer transactions.

Commenting on the threat to the energy sector Leo Simonovich, Siemens Vice President and Global Head, Industrial Cyber and Digital Security said: "You only have to open a newspaper to look at the recent spate of news about attackers getting into refineries and production facilities with the intent of shutting them down. The Saudi refinery was recently one step way from a major safety event and losing production."

A new study by Siemens and Ponemon Institute found that cyber security breaches in the Middle East are widespread and frequently undetected, with 30 per cent of the region's attacks targeting operational technology (OT).

"What we found with the report, is that not only is the oil and gas sector the most targeted vertical, but energy as a whole," said Simonovich. "Fifty per cent of all attacks target the oil and gas sector, in particular the OT environment. The potency and sophistication of the attacks is probably the most severe of any other region that we have seen."

According to Siemens, 15 per cent of organisations surveyed in the report said they were experiencing 10 or more attacks per year.

The study, which largely focuses around the readiness of the sector to identify and protect against cyber threats, outlines six key principles that underlie the most effective OT cyber programmes, beginning with assigning and empowering dedicated ownership for OT cyber security.

While the study did not look at the electricity sector, Simonovich believes that, globally, it is experiencing a similar wave of attacks and challenges. "With the power sector, the systematic effects are what's most concerning. Getting into one part of the grid could lead to rolling blackouts across the whole system."

The study is one of a series being undertaken by Siemens and Ponemon. Having published one for the US, there are plans for a study on Europe. This report, which would primarily look at oil and gas but may also cover power, could be published this year.

"We want to go deeper on the regions where we know there are a lot of questions. We want to put some data behind what the risks look like, but more importantly, what can companies do to address the challenge," said Simonovich. "We recognise that the industry has to come together to address the challenge."

Noting that cyber security erodes trust, earlier this year Siemens and eight partners from industry signed the first joint charter for greater cyber security.

Initiated by Siemens, the 'Charter of Trust' calls for binding rules and standards to build trust in cyber security and further advance digitalisation.

# Nuclear still a priority despite challenges

- Poland hopes to take decision this year
- Flamanville issues raise concerns for Hinkley

Building new nuclear generating capacity is still a priority for Poland despite challenges facing the industry in other parts of Europe.

At a conference in Gdansk last month, Poland's Energy Minister, Krzysztof Tchórzewski, told journalists that a nuclear power station is a priority for the country, stressing that it represented the country's "credibility with the European Commission".

Asked when a decision could be expected on starting construction of a nuclear power station, Tchorzewski replied: "This year or never."

Investment and Development Minister Jerzy Kwiecinski said that Poland is ready to finance a nuclear power plant from its own resources, if such a decision is taken.

"We must take a decision on building a nuclear power plant very prudently, based on the best possible analytical research. Such research is already being finalised at the Ministry of Energy. Considering the very long investment process, characterised by high expenditures and a long project life cycle, capital and debt financing will have to be implemented."

Poland remains determined to build a new nuclear plant regardless of the fact that some countries are either moving away from nuclear or struggling to construct plants on time and to budget.

Following the 2011 accident at Fukushima in Japan, Germany took the decision to close all of its nuclear capacity, while Italy voted against reviving the country's programme. Last year, Switzerland also voted to follow Germany and start exiting nuclear power as part of a revised energy strategy, which will also cut consumption and increase wind and solar power generation.

At the end of March Belgium became the latest country in Europe to announce its withdrawal from nuclear.

According to a document published by the Cabinet, Belgium aims to "withdraw from nuclear energy by 2025". Brussels also plans to ensure a sufficient and stable power grid, and invest in new energy sources and energy management. The government will authorise the construction of new wind farms along the coast starting in 2020 to fill the gap in the energy production.

The bill on the closures is to be submitted to the Council of Ministers by May 31st. Belgium currently has seven nuclear reactors, generating about half of its electricity.

The news comes as France announced that its project at Flamanville is facing further delays.

In April EDF Energy warned that the project could run further behind schedule and over budget, after it detected faults at the €10.5 billion ($12.8 billion) plant. The French state-owned firm said inspections in March had uncovered problems with welding on pipes at the plant in northwest France.

EDF said it was performing further checks to see what works would be needed to satisfy the safety requirements of the French nuclear regulator, ASN, and would report back in May.

Flamanville's new EPR unit is the same reactor design as the one being used at the delayed Olkiluoto 3 plant in Finland and at Hinkley Point C in Somerset, where EDF is preparing to build the UK's first new nuclear power station in decades.

The findings at Flamanville have raised concerns over the plans for Hinkley. Paul Dorfman, of the Energy Institute at University College London, said the problems did not bode well for Hinkley Point C, which is due to come online in 2025.

"If they can't build their own reactor in France, where can they build it? This seems counter to their claims that they are learning from their mistakes and Hinkley won't be a repeat."

In late March, official documents from the UK nuclear regulator raised concerns with EDF Energy over management failings that it warns could affect safety at Hinkley Point C if left unaddressed. Britain's chief nuclear inspector identified several shortcomings in the way the French firm is managing the supply chain for the £19.6 billion ($27 billion) plant.

Projects with more proven designs still appear to be progressing in other parts of the world, however.

The United Arab Emirates recently completed one of the four Korean-built nuclear reactors at its Barakah plant.

Last month Rosatom announced that construction work at Egypt's al-Dabaa nuclear power plant can provisionally start in 2020. According to the Egyptian Energy Minister, Mohamed Shaker, the plant is due to be completed by 2026-2027.

# US energy companies realise value in storage

■ BP takes the plunge with Tesla ■ Energy storage more viable, says Moody's

Siân Crampsie

Energy companies in the USA are seeing growing value in large-scale energy storage systems as a tool to boost grid reliability in the face of growing renewable energy deployment.

BP last month announced that it was planning to work with Tesla on a new pilot battery storage project at a Texas wind farm, while Bay State Wind said it has agreed to work with NEC Energy Solutions to develop a 55 MW energy storage system for an 800 MW offshore wind farm in Massachusetts.

Earlier this year E.On commissioned two 9.9 MW energy storage projects, known as Texas Waves, while Fluence, a newly-created venture between AES and Siemens, has announced plans for a massive 100 MW/400 MWh battery storage project in Long Beach, California.

According to analysts, regulatory support in some parts of the USA, coupled with declining prices for certain storage technologies, is helping to drive market growth. A recent report from Moody's said that energy storage mandates in several states, including California, Massachusetts, New York and Hawaii would help to drive a nine-fold growth in energy storage from 2017 to 2022.

According to Moody's, the growth of renewable energy from solar and wind technology has led to a proliferation of intermittent generation entering the grid. Emerging battery storage technology is credit positive for grid operators, as it will become a key element in managing stability.

Battery storage can help integrate renewables into the grid, and can also support natural gas peaking facilities, which take longer to power up fully. Lithium ion technology has become the technology of choice for storage developers, largely thanks to their scalability and cost reductions, Moody's notes.

According to Moody's, energy storage is increasingly emerging as a viable project finance opportunity, although different revenue models pose different risks for battery storage projects.

"While the developing technology presents some unique challenges, especially regarding operating risks, we view the financing approach of a battery storage project to be broadly akin to many of the risks associated with financing a conventional power project," said Rick Donner, a vice president and senior credit officer at Moody's.

In Texas, BP is planning to install a 212 kW/840 kWh battery at the 25 MW Titan 1 wind farm. The project will help BP to gain a better understanding of co-locating renewables with storage and develop larger-scale systems at other wind and solar sites.

"The battery pilot project at our Titan 1 wind farm will provide BP Wind Energy valuable insights as we seek opportunities to use energy storage more effectively across our diverse portfolio," said Laura Folse, Chief Executive of BP Wind Energy.

BP operates 13 wind farms in the US, from Texas to Pennsylvania, with a combined capacity of 2259 MW.

# Villanueva fires up in Mexico

■ PV farm 41 per cent complete
■ Plans for CCUS strategy published

Mexico has inaugurated the largest solar photovoltaic (PV) plant in Latin America, moving it closer to its goal of 22 GW of installed solar capacity by 2030.

The 754 MW Villanueva complex in the desert state of Coahuila was built by Enel Green Power Mexico at a cost of $650 million. It is the first energy plant to start operating since Mexico passed its energy reforms, Enel said in a statement.

Enel won a license to develop Villanueva in Mexico's first long-term power auction. Construction started in March 2017 and its operation is backed by a 15-year power purchase agreement (PPA) to sell capacity to national electric utility CFE and a 20-year contract to sell clean energy certificates.

Enel Green Power head Antonio Cammisecra said: "The inauguration of Villanueva is a milestone for Enel Green Power and Mexico itself, as it is the first power plant to start operations after the country's energy sector reform.

"We have taken a major step towards a more sustainable future for the country while consolidating our leadership in Mexico's renewable market and once again delivering effectively on the projects awarded in renewable tenders."

According to Enel, Villanueva is currently around 41 per cent completed. The company is also building the 200 MW Amistad wind farm in the state of Coahuila, the 238 MW Don Jos PV project in the state of Guanajuato and the 93 MW Salitrillos wind farm in the state of Tamaulipas.

Mexico is aiming for 5.4 GW of installed solar capacity by 2019. It initiated its energy reforms in 2013, ending 75 years of state monopoly in the sector.

The reforms are designed to attract private capital to the energy sector and boost economic growth.

Last month Mexico's energy ministry published a roadmap for carbon capture use and storage (CCUS).

The roadmap includes plans to publish a Mexican standard for CCUS methods and technologies, the formulation of a national CCUS strategy, and a strategy for national carbon capture and geological storage (CCS).

# Alberta opens doors to renewables bids

Alberta has opened its latest round of renewable energy bids as part of plans in the Canadian province to reach ambitious renewable energy targets.

The Alberta Electric System Operator (AESO) has introduced Rounds 2 and 3 of Alberta's Renewable Energy Program (REP) by seeking Expressions of Interest (EOI) from interested parties. It is aiming to procure 700 MW of renewable energy capacity in total in order to support Alberta's 30 per cent renewable energy goal by 2030.

The procurement target will be up to 300 MW in Round 2 and 400 MW in Round 3, and the process is expected to attract some C$10 billion ($7.8 billion) in new private investment. These rounds follow AESO's Round 1 tender, which chose four projects totalling almost 600 MW in late 2017.

"Alberta is a proud leader in all forms of energy, and our renewables programme will continue to create good jobs and help ensure we have a more diversified economy that's built to last," said Margaret McCuaig-Boyd, Alberta's Minister of Energy. "We expect this highly competitive process to continue attracting investment from Alberta and around the world."

Alberta's REP is aiming to support the development of 5000 MW of renewable capacity. Projects awarded in Rounds 2 and 3 will be expected to start operating in mid-2021, two years after those awarded contracts in Round 1.

Round 2 and 3 projects will also have to meet certain criteria with respect to indigenous equity ownership. McCuaig-Boyd said that the initiative would help to create "meaningful partnerships with indigenous communities".

The projects being developed under Round 1 of the REP include Enel Green Power Canada's 30.6 MW Phase 2 of Castle Rock Ridge wind power plant and the 115 MW Riverview wind farm in Pincher Creek; Capital Power's 201.6 MW Whitla wind project in Medicine Hat; and EDP Renewables Canada's 248.4 MW Sharp Hills wind farm in Oyen.

■ The governments of Canada and Ontario have granted C$1.6 billion ($1.2 billion) in funding to support construction of the proposed Wataynikaneyap transmission line project. Developed by Wataynikaneyap Power, the project is designed to connect remote First Nations in northwestern Ontario to the grid through the construction of 1800 km of 230 kV, 115 kV and 44 kV transmission lines.

# El Salvador boosts capacity

New power plants with a combined total capacity of 650 MW are due to start operating in El Salvador in the next few years.

The country's National Energy Council (CNE) has published a generation plan for 2018-35 and says that gas-fired, solar, hydro and wind energy capacity is likely to enter operation in the near-to-medium term. In the longer term, some 1454 MW is expected to be commissioned.

CNE's report also reveals that AES El Salvador, through its power distribution companies Caess, Clesa, EEO and Deusem, will invest $33.1 million this year, $20 million of which will go to grid modernisation.

Other investment will go into rural electrification (about $6.5 million), technological improvements ($2.9 million), the overhaul of third party lines ($2.4 million) and new vehicles ($1.4 million).

New capacity additions in the short term include Energía del Pacifico's 380 MW gas fired plant as well as 154 MW of solar capacity, 65.7 MW from hydro Chaparral and 50 MW from wind farm Ventus.

# Electricity sector blueprint reinforces clean energy commitment

India's government has reinforced its commitment to moving to clean energy sources, outlining a plan to add 275 GW of renewables by 2027 while reducing dependence on coal fired generation.

Syed Ali

India's latest power sector blueprint, the National Electricity Plan 2018 (NEP 2018), reinforces the government's commitment to clean energy, with a target of 275 GW of renewable generating capacity by 2027. The NEP 2018 updates a 2016 draft and runs through 2026/27.

The plan also includes a timeline for dealing with the most polluting coal power plants, which should ease concerns about the seeming lack of progress by the Ministry of Power in terms of tighter air pollution. There has been an apparent five-year deferral of the 2017 deadline for installation of emission controls.

The NEP 2018 includes a new target for closure of 48.3 GW of end-of-life coal plants. Specifically, the plan forecasts 22.7 GW of coal fired power plant closures over the five years from 2016/17 to 2021/22. This would include 5.9 GW of normal end-of-life retirements and 16.8 GW of closures due to inadequate space for flue gas desulphurisation equipment.

The plan notes that these retirements "would not likely pose any problem in meeting the demand (for electricity) during 2021/22". An additional 25.6 GW of coal capacity is slated for retirement in the five years to 2026/27.

With accelerated coal plant closures, and an anticipated surge in renewables, thermal power will account for only an estimated 42.7 per cent of installed capacity across India by 2027, down from 66.8 per cent in 2017.

The plan highlights the importance of moving quickly to address climate change, stating that the plan to add 275 GW of renewable capacity by 2027 would see renewables representing 44 per cent of the country's total capacity and 24.4 per cent of its generation.

The Ministry of Power is aiming to issue 30 GW of solar tenders this year and the same in 2019. At the same time, the Ministry of New and Renewable Energy is planning for an additional 10-12 GW annually of wind generation going forward, including 6.5 GW tendered in the first quarter of this year.

India's solar sector has been particularly successful, attracting significant investment in the country's PV manufacturing. China's Golden Concord Holdings Ltd and Japan's SoftBank Group Corp recently agreed to set up a 4 GW integrated facility for the production of photovoltaic (PV) ingots, wafers, cells and modules in the state of Andhra Pradesh.

The wind power sector, having slowed in 2017/18 also seems to be gaining momentum. The sector witnessed a capacity addition of only 1.7 GW in FY2018 (fiscal year ending March 31, 2018), which is a significant drop from the 5.5 GW capacity added in FY2017. This was caused by a transition from the existing feed-in tariff-based PPA regime to a competitive bid-based PPA regime in the wind energy sector.

According to recent estimates, however, wind power capacity is expected to see a 3 GW increase during the current fiscal year following projects awarded by the Solar Energy Corporation of India (SECI) and a few state distribution utilities since February 2017. SECI and the distribution utilities in Gujarat, Maharashtra and Tamil Nadu have issued bids for 7.5 GW over the past 14 months.

At the start of April, SECI held a 2 GW wind power auction that attracted bids as low as INR2.51 ($0.039)/kWh, and resulted in several 300 MW awards.

Further, in April the country took its first major step towards setting up offshore wind power farms. The government-owned research and development agency, National Institute of Wind Energy (NIWE), called for expressions of interest (EoI) from wind power companies to set up an offshore wind farm with a capacity of around 1 GW in the Gulf of Khambat, off the coast of Gujarat. Responses are due on May 25, with the opening set for May 28.

India plans to install at least 5 GW of offshore wind capacity by 2022.

# Report omits renewable targets

A recent report by a panel of experts at Japan's Ministry of Economy, Trade and Industry (METI) on long-term energy strategy toward 2050 calls for a policy shift toward making renewable energy such as solar and wind a "major source of electricity" but fails to set any target for their share of the nation's power supply.

Since Japan lags behind the rest of the world in promoting renewables, the proposed policy should be promptly backed up by clear long-term goals and a concrete road map to put them into action, says the panel.

The combined share of renewable energy sources, including hydro, in the nation's power supply stood at just 14.6 per cent as of 2015.

The cost of solar, which has fallen dramatically in recent times, leading to a massive surge in installations worldwide, has also remained high.

According to the International Renewable Energy Agency, the cost of solar power generation has declined by more than 70 per cent over the past seven years. But while the average European cost of solar in 2016 was Yen10 ($0.09)/kWh, the figure stood at Yen20 in Japan.

The panel's proposal, expected to be reflected in the government's Basic Energy Plan when it is updated this summer, comes amid the pressing need for more action worldwide to combat climate change as well as Japan's changing energy landscape after the 2011 Fukushima crisis.

Since the nuclear reactor meltdowns at Tokyo Electric Power Co.'s Fukushima No. 1 power station, the government has pledged to reduce as much as possible the nation's dependency on nuclear energy while maximising efforts to increase electricity generation through renewable sources.

■ The third unit of Kansai Electric's Ohi nuclear power plant in the Fukui prefecture of Japan has resumed commercial operation. The reactor restarted in March 2018, two months later than expected, due to safety checks on parts made by Kobe Steel. This is the sixth Japanese nuclear unit to be restarted after clearing the country's revised safety regulations since the Fukushima disaster.

# Geothermal and hydro will boost Indonesian climate change efforts

Kayan River in North Kalimantan

■ ADB loan to support Rantau Dedap ■ Hydro projects to deliver 9 GW

Syed Ali

Several rectny significant moves to further exploit geothermal and hydro resources will bring a much needed boost to Indonesia's efforts to combat climate change.

As part of the country's programme to exploit its full geothermal potential, the Asian Development Bank (ADB) recently signed a loan agreement of approximately $175.3 million with PT Supreme Energy Rantau Dedap (SERD) to help finance the second phase of the company's geothermal power project located in South Sumatra Province.

SERD is a joint venture consisting of the Indonesian geothermal power developer, PT Supreme Energy; Japanese trading and investment company, Marubeni Corporation; Japanese power utility Tohoku Electric Power; and global energy company, Engie.

The deal adds to ADB's continued efforts to scale up private sector-led infrastructure development and support clean energy investments in the Asia and Pacific region.

With an estimated 29 000 MW of potential in geothermal power generation, Indonesia has about 40 per cent of the world's geothermal reserves, making it an important resource for the country to achieve its commitments to reduce carbon dioxide emissions by 29 per cent by 2030.

The Rantau Dedap geothermal facilities will help Indonesia get closer to fully exploiting this resource. The project is expected to generate more than 90 MW of electricity, which will power up to 130 000 homes, create jobs, and avoid over 400 000 tons of carbon dioxide emissions every year by 2021.

As part of the financing, ADB will also administer an additional loan provided by the Clean Technology Fund (CTF), which is a rollover amount from an existing CTF facility for the first phase of the project.

The CTF loan for the first phase helped to confirm the commercial resource size and allow the project to proceed to financing of construction and operations.

The CTF is one of four programmes that make up the Climate Investment Funds and provides middle-income countries with concessional resources for the demonstration, deployment, and transfer of low-carbon technologies.

"This innovative, phased financing proves that adequate risk allocation allows the private sector to successfully develop geothermal projects in Indonesia," said Yuichiro Yoi, Unit Head for Indonesia at ADB's Private Sector Operations Department. "The project also demonstrates Indonesia's strong commitment to develop renewable energy sources to diversify its energy mix and reduce its carbon emissions."

Hydropower also looks set to play a major part in cutting carbon emissions, with the recent signing of a memorandum of understanding (MoU) between Power Construction Corporation of China (PowerChina) and PT Indonesia Kayan Hydropower Energy to jointly build hydropower plants on the Kayan River in North Kalimantan.

With a total investment of $17.8 billion, the two firms are planning to develop five hydropower facilities with a total electricity generation capacity of 9000 MW.

According to the North Kalimantan administration, the province has a hydroelectric potential of as much as 33 000 MW.

# Australia moves closer to finalising NEG

The Council of Australian Governments (COAG) Energy Council has agreed to move ahead with a detailed design of the National Energy Guarantee (NEG), whose final version needs to be ready in August.

In mid-October 2017 the federal government announced that Australia would develop a "truly technology-neutral" NEG with two main components – a "reliability guarantee" which will ensure that energy retailers deliver enough dispatchable energy from coal, gas, pumped hydro and energy storage systems, and an "emissions guarantee".

Australia has been making progress in developing clean energy but some argue that the rapid rise in intermittent renewables threatens security. This has seen a recent surge in energy storage projects, especially in states with high renewables penetration.

In mid-March, the South Australian government said it will help finance a new 120 MW/140 MWh energy storage project by SIMEC ZEN Energy. The storage facility, to be located at Port Augusta, 322 km north of Adelaide, will be connected to a new solar park that will be installed at Whyalla steelworks. The system will be larger than the 100 MW/129 MWh lithium ion battery facility completed by Tesla near the end of 2017 at a site near Jamestown, north of Adelaide.

The city of Adelaide is rapidly becoming the global centre of virtual power plants, with the Australian Renewable Energy Agency announcing plans at the end of March to support the rollout of an 8 MW project by the retailer Simply Energy.

The proposal to link 1200 Adelaide households with 6 MW of storage and another 2 MW of demand response capacity in local businesses represents the fourth virtual power plant (VPP) to be announced or rolled out in that city in the last two years.

Australia is also looking at other forms of storage. The Australian, Japanese and Victorian governments and a consortium of companies recently announced they would pilot an innovative supply chain that aims to generate "green energy" for use in cars, electricity generation and industry in Japan.

The Hydrogen Energy Supply Chain (HESC) project will convert brown coal from AGL's Loy Yang mine in Latrobe Valley into hydrogen at an adjacent site, and transported by road to a liquefaction terminal at the Port of Hastings. It will then be shipped to Japan for use predominantly in the transport industry.

Commenting on the technology, Patrick Moriarty, an energy expert at Monash University, said: "Brown coal to hydrogen in my view is unlikely to work as it generates the same emissions as burning coal in power plants. But in the future when we will rely mainly on intermittent renewable energy – there is a place for hydrogen produced by renewables, as this can be stored easily."

■ A consortium that includes Washington D.C., USA-based joint venture Fluence has announced that it will work together on large, new energy storage projects in Australia. The Australian Renewable Energy Agency (ARENA) and the Victorian government signed a deal for a 30 MW/30 MWh battery system at the AusNet Service Ballarat

# Malaysia to add over 1.2 GW of large-scale solar

Malaysia has awarded large scale solar (LSS) projects with a total capacity of 1228 MW under an auctioning programme.

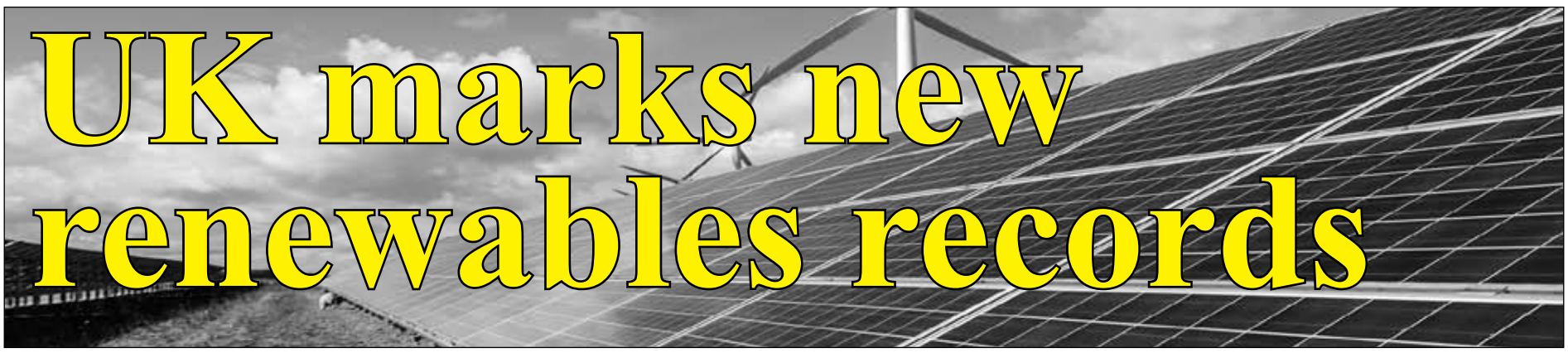
There have been 66 successful bidders for the solar power projects since the auction exercise was introduced two years ago, said acting Deputy Energy, Green Technology and Water Minister Datuk Seri Devamany S. Krishnasamy.

"These LSS projects are expected to reach commercial operation between 2018-2020," he said at the opening ceremony of the 4th International Sustainable Energy Summit 2018 in Kuching.

Devamany said the auction exercise had demonstrated a healthy price decline and that in some bids, solar had reached grid parity with gas fired power plants.

The fall in price is seeing solar increase its penetration. In April, Malaysian utility Tenaga Nasional Bhd (TNB), signed long-term power purchase agreements (PPAs) for about 210 MW of solar projects to be built across the country.

The PPAs, which will run for 21 years, were signed with seven firms, which will design, construct, own, operate and maintain a 30 MW photovoltaic (PV) plant each. The solar parks will be commissioned between December 31, 2019 and December 31, 2020.



# UK marks new renewables records

Low carbon sources continue to replace coal in the UK generating mix, new data shows. However, coal is still needed as a back up supply, highlighting vulnerabilities in the system caused by volatile renewables and potential gas shortages.

Siân Crampsie

The UK's drive to invest in renewable energy over the last two decades has resulted in a fundamental shift in its generating mix and falling emissions.

Britain set a new record last month by meeting all of its electricity needs from non-coal sources for a full three-day period, just a week after the last record of 55 hours of coal-free generation was set.

Power generated from wind energy and natural gas dominated the generating mix in England, Wales and Scotland. The data indicates that coal's declining role in the power mix is likely to continue.

Recent data from EnAppSys shows that coal's share of the GB power mix fell to a Q1 record low 9.4 per cent (8.13 TWh) in the first quarter of 2018 – in sharp contrast to the 58.4 per cent (40.33 TWh) generated in Q1 2012.

Meanwhile government data shows that wind generated 15 per cent of the UK's entire electricity demand in 2017 – the highest annual amount ever – up from 11 per cent in 2016. Renewables overall provided 29.4 per cent – up from 25 per cent.

Emissions have also fallen. Government data shows a three per cent drop in greenhouse gas emissions in 2017 over 2016 levels, with the change attributed to growth in renewables and improved energy efficiency.

"The plunging price of renewables is allowing low carbon energy to replace coal and gas," said Nina Schrank, Energy Campaigner for Greenpeace UK. "This meant that at the end of last year over half of our electricity came from low carbon sources, and most of that from wind and solar, overtaking nuclear power.

"These fast-moving trends will continue into the next decade as a new generation of offshore wind turbines come online and demonstrate the technology's ability to provide the bulk of UK demand."

Last month National Grid warned operators of large conventional and nuclear power plants that they may be instructed to curtail output this summer to accommodate rising amounts of renewables generation.

It said in its annual Summer Outlook for energy supply and demand that the growing number of wind and solar plants – many of which are connected to local distribution grids – would reduce demand on the high voltage transmission grid.

It also said that the rise of distributed renewable generation plants were also resulting in increased volatility in the electricity system.

According to EnAppSys, the GB electricity market still requires coal-fired plant as a "fall back" when supplies are low. On Thursday March 1, for example, National Grid issued a gas deficit warning to indicate a potential shortage of gas on the system while coal stepped into the breach, generating 10.5 GW of power – effectively the highest possible level of coal output achievable at the time.

Paul Verrill, Director of EnAppSys, said: "The ability of the system to fall back on coal in this phase of the market has proven highly beneficial and marks a major strategic shift in the way coal plants are being used in GB power generation.

"The additional electricity that coal produced on March 1st helped reduce gas use, reducing the risk of gas interruption. This showed the value of having a diversified fuel supply in the GB energy mix and demonstrated the role coal could play as a back-up source of generation."

# Construction starts at pioneering hydrogen plant

The world's largest hydrogen pilot plant is taking shape in Linz, Austria, its backers have announced.

The H2Future project consortium says that it has officially given the go-ahead for construction to start at the 6 MW facility, which will be used to carry out research into future breakthrough technologies that are needed to meet global climate goals over the long-term.

The project partners, which include voestalpine, Siemens, Verbund, and Austrian Power Grid, say that the pioneering plant will be able to produce 1200 $m^3$/h of "green" hydrogen. At its heart will be the world's largest PEM (proton exchange membrane) electrolyser module, which will convert water into hydrogen and oxygen.

The project, which is also supported by research partners K1-MET and ECN, has won €18 million of EU funds and will be located at the voestalpine premises in Linz. It will be used to test the potential applications for green hydrogen in the various process stages of steel production, and integration into the power reserve markets for the power grid.

"To integrate the volatile renewable energy from wind and solar power into the energy system, we will need even more storage capabilities in future," said Wolfgang Anzengruber, CEO of Verbund. "In addition to our pumped-storage plants in the Alps, and battery storage solutions of various dimensions, we see huge potential in energy storage with green hydrogen.

"For us, 'green' hydrogen is the perfect example of the sector coupling which is urgently required for decarbonising power generation, industry, and transport."

According to the project partners, construction of the pilot facility at the voestalpine site in Linz has now accelerated. The foundations are in place and construction of the hall is currently under way. The core electrolysis components will be delivered this summer, with the plant going live within a year.

The start of the comprehensive two-year test programme is planned for spring 2019. The goal is to achieve a record output efficiency of 80 per cent in converting electricity into hydrogen. The hydrogen can be stored for use in a multitude of applications: as a raw material in the industry, as seen in Linz, but also as a fuel for mobility and as an energy carrier in electricity and gas supply.

# MHI Vestas sees success in Scotland and Belgium

- EOWDC installs 8.8 MW machine
- Northwester 2 first to feature 9.5 MW turbine

MHI Vestas is striding forward with plans to develop its portfolio of offshore wind turbines.

The joint venture firm says that the first of 11 wind turbines has been installed at the innovative European Offshore Wind Deployment Centre (EOWDC) in northeast Scotland.

The Vattenfall-owned facility, located off the coast of Aberdeen, will use specially designed V164-8.4 MW and V164-8.8 MW turbines mounted on suction bucket foundations.

The installation of one of the 8.8 MW units in early April represented the first commercial deployment of a turbine of this size anywhere in the world.

MHI Vestas has also announced that its first ever 9.5 MW offshore wind turbine will be deployed at the Northwester 2 offshore wind farm in Belgium.

The company has signed a conditional supply agreement with Northwester 2 developer Parkwind for 23 of its V164-9.5 MW units, with installation work due to start in 2019.

MHI Vestas said that the Parkwind deal was a "notable milestone" for the offshore wind energy sector.

Parkwind, an offshore wind farm developer, said that the timetable for the 224 MW Northwester 2 wind farm would be challenging, but said that the industrialisation of offshore wind in Belgium, a highly collaborative approach, and supply chain readiness, would make it possible.

"This challenging timeline has played an important role in the choice for MHI Vestas as turbine supplier having the capability of delivering the V164-9.5 MW," said Co-CEOs of Parkwind, Eric Antoons & François Van Leeuw. "Parkwind is very delighted to have MHI Vestas for the fourth time as a partner."

# Italy-Montenegro connector delayed

The slow pace of construction of renewable energy projects in the Balkans has caused a design change and a delay to a proposed transmission grid interconnector between Italy and Montenegro.

The proposed 1000 MW subsea interconnector was due to start operating in 2018. However, market conditions in the Balkans have caused Montenegro grid operator CGES and the Italian power grid company Terna to push back start-up operations to 2019.

The interconnector's power transmision capacity will also be halved to 500 MW, Terna said.

The 415 km long power interconnector project was agreed in 2010 and is meant to enable exports of renewable energy from the Balkans to Italy and boost regional energy security. It will run from Pescara (near Villanova in Italy) to Rta Jaz (Montenegro).

Pescara, Italy: starting point of the interconnector

# Turkey ramps up geothermal targets

■ Geothermal sector remains strategically important ■ Akkuyu construction officially marked

Siân Crampsie

Turkey has quadrupled its target for installed geothermal energy to reflect rapid growth in the sector.

The country's General Directorate of Renewable Energy (YEGM) says that it has already reached its 2023 target for geothermal energy of 1000 MW, and so is now aiming to install a total of 4000 MW by 2030.

"Turkey ranked fourth in the global geothermal energy league in terms of installed capacity in 2017 so works should continue without interruption," said Oğuz Can, head of YEGM, at an industry gathering in April.

Turkey's Ministry of Energy and Natural Resources views geothermal energy as a strategically important resource and has supported the expansion of the sector from an installed capacity of 25 MW in 2007 to over 1000 MW now.

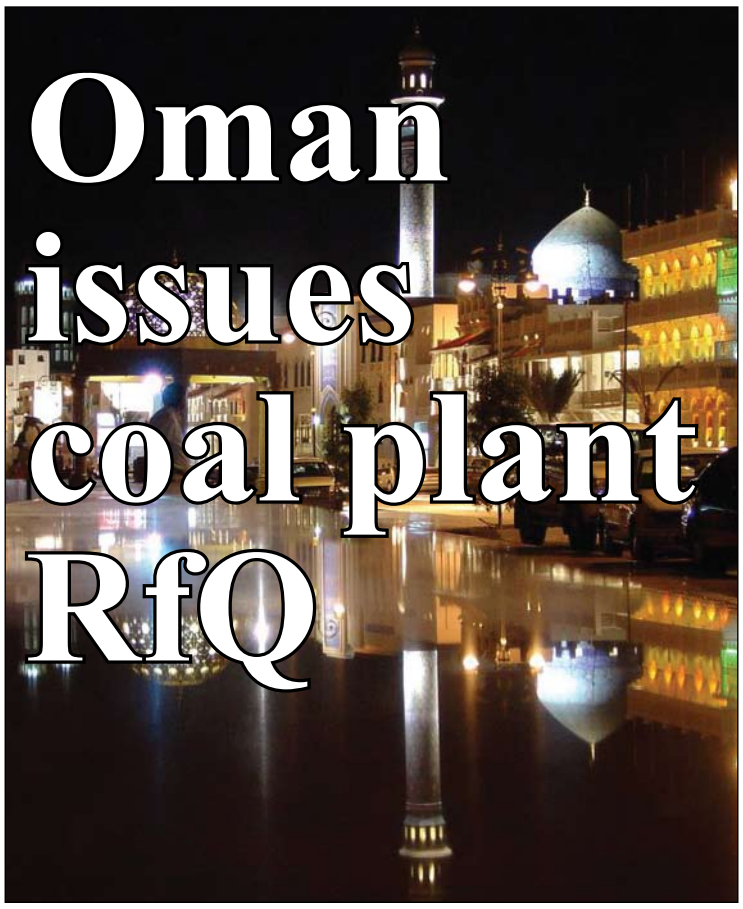
The country's Association of Geothermal Power Plant Investors (JESDER) said in 2017 that it expects up to $1 billion to be invested into geothermal development in 2018. There is over 700 MW of geothermal capacity in development or planned in Turkey.

Separately, Turkey and Russia have announced the official start of construction on Turkey's first nuclear power plant at Akkuyu.

The $20 billion power plant will be built by Russian State Nuclear Energy Agency Rosatom and will be made up of four units, each with a capacity of 1200 MW. Russian President Vladimir Putin and Turkish President Tayyip Erdogan marked the official start of construction of Akkuyu's first unit, watching by videolink from Ankara.

"When all four units go online, the plant will meet 10 per cent of Turkey's energy needs," Erdogan said, adding that despite delays Turkey still planned to start generating power at the first unit in 2023.

The nuclear plant is part of Erdogan's 2023 vision and will reduce the country's dependence on energy imports. Rosatom is seeking equity partners to take a 49 per cent stake in the project.



# Oman issues coal plant RfQ

■ Duqm aims to diversify generating mix
■ Second solar IPP in planning

Oman is firming up plans for the development of its first independent power project (IPP) based on clean coal technology.

The proposed Duqm power plant will have a capacity of 1200 MW and will play a key role in Oman's plans to diversify its energy mix and reduce reliance on natural gas.

The Oman Power and Water Procurement Company (OPWP) last month issued a Request for Qualifications (RfQ) inviting international developers to submit their technical qualifications as the first step in a competitive tender for the development of the landmark project in Wusta Governorate.

The project will be developed on a build-own operate basis. OPWP has set 7 June 2018 as the deadline for the receipt of qualification credentials from interested bidders.

Oman is also developing plans for solar photovoltaic (PV) capacity and waste-to-energy schemes.

Last month OPWP indicated that the competitive bidding process for Oman's second solar IPP was being prepared and would be launched soon.

Oman's first solar IPP – a 500 MW photovoltaic (PV) scheme planned in Ibri – is expected to be awarded in the third quarter of 2018.

OPWP CEO Yaqoob Saif al Kiyumi told local media in April that the company planned to procure a succession of utility-scale solar projects totalling around 3000 MW by 2025. Wind energy projects are also being considered, he added.

Some 28 international companies have submitted responses to a request for Qualifications issued by OPWP for the Ibri II solar project. The firm planned to announce the names of qualified bidders by the end of April and then issue the tender in May.

# Irena reviews renewable energy growth

New data on the global renewable energy sector shows that the global energy transition is continuing to move forward at a rapid pace.

The International Renewable Energy Agency (Irena) has reported that by the end of 2017, global renewable generation capacity increased by 167 GW and reached 2179 GW worldwide. This represents a yearly growth of around 8.3 per cent, the average for seven straight years in a row.

According to Irena, rapidly falling prices, technology improvements and an increasingly favourable policy environment are the main factors driving growth. "Renewable energy is now the solution for countries looking to support economic growth and job creation, just as it is for those seeking to limit carbon emissions, expand energy access, reduce air pollution and improve energy security," said Irena Director-General Adnan Z. Amin.

"Despite this clear evidence of strength in the power generation sector, a complete energy transformation goes beyond electricity to include the end-use sectors of heating, cooling and transportation, where there is substantial opportunity for growth of renewables," Mr. Amin added.

Solar photovoltaics (PV) grew by 32 per cent in 2017, followed by wind energy, which saw a ten per cent growth. Underlying this growth are substantial cost reductions, with the levelised cost of electricity from solar PV decreasing by 73 per cent, and onshore wind by nearly one-quarter, between 2010 and 2017, Irena said.

China continued to lead global capacity additions, installing nearly half of all new capacity in 2017. Ten per cent of all new capacity additions came from India, mostly in solar and wind. Asia accounted for 64 per cent of new capacity additions in 2017, up from 58 per cent last year.

Europe added 24 GW of new capacity in 2017, followed by North America with 16 GW. Brazil set itself on a path of accelerated renewables deployment, installing 1 GW of solar generation, a ten-fold increase from the previous year.

Off-grid renewables capacity saw unprecedented growth in 2017, with an estimated 6.6 GW serving off-grid customers. This represents a 10 per cent growth from last year, with around 146 million people now using off-grid renewables.

# GCC states lead MENA expansion

Middle East and North African (MENA) countries need to invest $260 billion over the next five years to meet rising electricity demand, according to new analysis by Arab Petroleum Investment Corp (APICorp).

The Dammam-based energy development bank said in a report that the MENA region needs to install 117 GW of power generating capacity by 2022. It estimates that power capacity in the region needs to expand by 6.4 per cent per year on average by 2022 to meet growing demand.

Some $152 billion is needed for the electricity generating sector while $110 billion is required for transmission and distribution.

According to APICorp, population growth and urbanisation, rising income levels, industrialisation and low electricity prices are all driving rising electricity demand. While economic growth has slowed compared with historical highs, the International Monetary Fund, IMF, still expects an increase of 3.2 per cent in 2018 and 2019, rising to 3.5 per cent in 2022. The region's population is also expected to grow at an average rate of 1.5 per cent per year in that same period, the report noted.

APICorp noted in its report that GCC countries dominate the MENA region's power landscape, accounting for 47 per cent, or 151 GW, of current installed generating capacity. It says that GCC countries will need to invest $55 billion to create 43 GW of additional generating capacity and another $34 billion in transmission and distribution over the next five years.

The UAE needs to invest at least $33 billion to meet its expected additional 16 GW capacity requirement over the medium term. APICorp estimates that nearly 10 GW of capacity additions are already in execution, including 5.6 GW of nuclear. Solar power also features heavily in the UAE's plans and is expected to account for 25 per cent of the generation mix once its latest $13.7 billion (5 GW) solar park is fully commissioned.

3D model of the Hanhikivi 1 nuclear power plant

# Hanhikivi 1 builds momentum

Building any new nuclear plant is a huge task – one that often results in protracted construction times. Fennovoima is looking to buck the trend, as site preparation makes progress at its Hanhikivi 1 plant.

**Junior Isles**

Despite the well-publicised delays at the Olkiluoto 3 (OL3) project in Finland, the country has not been put off the idea of building new nuclear plants. In 2010, the government granted Fennovoima a permit to build a new nuclear plant, which, when completed, will play a key role in providing zero-carbon base load power at a competitive price.

Since receiving the government's blessing, Fennovoima has been meticulous in the project's development, doing its best to learn lessons from OL3. It is an approach that has seen the project reach an advanced stage of site preparation just five years after signing the engineering, procurement and contruction (EPC) contract with Rosatom.

Known as Hanhikivi 1, the plant takes its name from the Hanhikivi peninsula where the site is located. It is a coastal site near the municipality of Pyhäjoki in Northern Ostrobothnia on the shore of the Baltic Sea in Northern Finland.

The project's origins date back to 2006-07 when several Finnish industrial companies and electricity suppliers began looking at how they could have electricity at a competitive and stable price in their own portfolio. This led to the establishment of Fennovoima in 2007.

Voimaosakeyhtiö SF, a Finnish holding company, owns 66 per cent of the shares in Fennovoima. Its shareholders include dozens of major Finnish industry corporations such as Outokumpu and Fortum, and local energy utilities. As these companies require a high amount of energy for their operations, a reliable and stable priced power supply is crucial for their businesses.

RAOS Voima, a 100 per cent Finnish subsidiary of Rosatom, owns the remaining 34 per cent of the shares in Fennovoima. RAOS Voima plans to sell its share of the electricity from the plant on the NordPool market.

Fennovoima operates under the "mankala principle", i.e. it will sell all the electricity generated by the plant to the owners at cost price in proportion to their ownership. This price includes operating and financing costs, as well as the organisational costs of the company. The mankala principle has been widely used in Finland's energy sector for decades – about 40 per cent of the electricity in Finland is produced by the mankala companies.

With its organisational structure in place and having secured the green light for the project from Parliament, Fennovoima began the process of site selection. The company studied four potential sites and, based on environmental and geological characteristics, chose the Pyhäjoki location in 2011. This site will host a single reactor capable of generating 1200 MW of electricity.

Hanhikivi 1 is based on tried and tested Russian nuclear technology. It will employ a 3+ Generation VVER-1200 pressurized water reactor that has all the safety features proposed by the various authorities post-Fukushima. Steam from the reactor will be used to drive a 1200 MWe Arabelle steam turbine supplied by GE (formerly Alstom).

Importantly, the VVER has a proven track record. There are about 37 VVER plants operating well around the world and the technology has demonstrated outstanding operation at the Loviisa plant in Finland. According to Fennovoima, the availability of the Loviisa units is among the top five in the world.

Yet the decision to partner with a Russian supplier was not solely dictated by technology.

Toni Hemminki, CEO, Fennovoima, explained: "When we moved from 1600 MW to 1200 MW in the negotiations, Rosatom was the best candidate to provide the best business case. It was the total business package – the financing and technology – that allowed Fennovoima to make the final investment decision in early 2014."

Hanhikivi 1 will require a total investment of €6.5-6.7 billion, depending on the cost of interest payments. About 25 per cent of the required project financing (about €1.7 billion at the time of plant start-up) will be provided as equity from the owners.

The remaining 75 per cent will be in the form of debt financing. It has already been agreed that about half (€2.4 billion) of this debt financing will be sourced from the Russian Federation National Welfare Fund. The other half of the debt (about €2.6 billion) is currently under negotiation but will be covered by export credit agencies and foreign commercial banks. These loans will predominantly be used to cover the supply of power island equipment and reactor components.

The project is by far the biggest in Finland and one of the largest in Europe. It will have a significant impact on both local and national economics. According to Finnish research organisation VTT, the project will increase GDP by 0.25 per cent in the best year during the 2020s.

It will also have a significant impact in terms of job creation. During the peak of construction, it is estimated that there will be about 4000 people on site. Hemminki noted: "There will be more people working at the site [at this point] than the current number of people in Pyhäjoki. And during the operation phase we will employ 450-500 people."

Yet one of the key plus points of the plant, said Hemminki, will be its contribution to tackling climate change. "We strongly believe that we are part of the solution in the fight against global warming," he stressed. "Industry and analysts are asking: how do we stay within the 2°C limit set in the Paris Agreement in order to avoid climate change? Here nuclear plays quite a significant role.

"Currently, global nuclear production is about 2500 TWh [annually]. For some perspective, our plant will produce 9 TWh. If we want to succeed, according to the International Energy Agency's 2°C scenario, we would need to increase global nuclear production to 6100 TWh per year by 2040. This means we would need to add one Hanhikivi 1 plant per month between now and 2040. "

This may be a tall order, especially for a technology that faces strong headwinds in some parts of the world. Yet nuclear certainly makes sense for Finland.

Jorma Aurela, Chief Engineer at the Ministry's energy department

The plant will be located on the Hanhikivi peninsula on the shore of the Baltic Sea in Northern Finland, near the municipality of Pyhäjoki

# **Special Project** Supplement

explained: "Finland is a flat country. Hydropower is over 10 per cent but less than 15 per cent, and that will remain the same. We have a specialty that is peat power and we have 4-5 per cent in our electricity production [mix]. In 2010, at the time we decided to build Fennovoima's project, we also made two other big decisions. The first was for energy efficiency and the second was to have 6 TWh coming from wind power by 2020."

He also noted that due to an expensive feed-in-tariff of about €80/MWh to support onshore wind, the Ministry is lobbying the government to convert more wood from the country's extensive forest to biofuels for power production.

Acknowledging that replacing base load coal fired capacity at a competitive price will be challenging, he said: "Nuclear is not even being discussed because we have made the decision to commit to it."

Nuclear currently produces around 30 per cent of Finland's electricity, a figure that could rise to between 40 and 45 per cent when OL3 and Hanhikivi 1 come on line.

Commenting on plans to increase the nuclear share, Liisa Heikinheimo, Deputy Director General of the energy department at the Ministry of Employment and Economy said: "In the government programme, coal use has to stop in 2020… then it will be a play of mostly renewables and nuclear for electricity production.

"When OL3 comes on line, nuclear will account for around 36-37 per cent of production. When we add Fennovoima [Hanhikivi 1] it will be more than 40 per cent but not more than 45 per cent; it depends on what happens with the Loviisa units." Discussions are ongoing as to whether their operating licence will be extended.

The price of power from Hanhikivi 1 was obviously a key factor in the decision to build the project. At €50/MWh, the price of power from the plant is not only lower than renewables, it is notably far lower than the price that will be delivered by other high profile new build projects recently agreed.

Hemminki said: "In the first years of operation we will start with a price of €50/MWh. This is significantly lower than the UK [Hinkley Point C] project, which has a strike price of €92.50/MWh… the owners believe the business case is robust."


Importantly, Fennovoima has also signed a fixed price turnkey EPC contract with Rosatom for plant construction. This means the price that the owners will have to pay for construction will not escalate in the event of an overrun on the project schedule.

Overrun on budget and schedule is one of the biggest challenges developers of large nuclear plants face. OL3's construction costs of OL3 were first estimated at €3.2 billion. Now nearly ten years behind schedule, final construction cost for the plant owned by TVO is expected to be €8.5 billion.

Fennovoima has therefore been painstakingly thorough in its project preparation and development, drawing on experiences from other projects.

Hemminki said: "We have hired a lot of people that have come from TVO, Fortum and STUK [the Finnish nuclear regulatory agency]. The tactic is to figure out what we can do differently from the beginning, from when the contract was negotiated. We have already taken a number of issues into account… One key is that we have to make sure the plant design is more mature than in previous projects."

The project preparation phase – which saw the selection of Rosatom as plant supplier, and the execution of the environmental impact assessment – ran from 2013-2014. In 2015, it entered the infrastructure development and design phase. Expected to run through 2018, this three-year period is being used for nuclear power plant design and project planning, which is running in parallel with site preparation work.

In fact site work began at the end of 2014 with construction of the access road, followed by the clearing of trees. Fennovoima obtained an electrical connection to site in April 2015.

Commenting on the early stages of site preparation, Construction Director, Jouni Sipiläinen said: "In parallel to construction of the access road, we continued with construction of the roads to the site. We then handed over the construction site to RAOS [a Finnish subsidiary of Rosatom] in July 2015, after which they began to build their construction base and roads around the plant area."

Notably, all the roads leading to and inside the site have been built at 4.6 m above sea level in order to withstand all potential floods.

Sipiläinen explained: "Before the Fukushima accident, roads were at a level of 3.5 m. After Fukushima, we changed our design to raise the level of the roads by 1.1 m."

The first building to be set up on site was the training building, which became functional at the start of 2017. Here, construction staff take part in introductory site training and receive their site access cards. If training classes are full, the building can accommodate 80 people plus Fennovoima staff, i.e. around 90-95 in total. The security gate building, which will be the access control point to the area under Fennovoima's scope of work, as well as to the plant when it is in operation, is also up and running.

A temporary staff accommodation area is also currently under construction. This will be capable of housing about 1000 people. "We started in spring last year and about 200 places are already ready. The rest will be ready by around the end of 2019," said Sipiläinen.

While site preparation has been progressing smoothly, the fluidity of the plant layout design has been challenging.

Sipiläinen explained: "The most challenging thing has been that the architect-engineer, Atomproekt (a subsidiary of Rosatom), has not been able to freeze the plant layout. That prevents us from freezing the baseline and continuing deeper excavation. The plan now is that we will have the frozen configuration baseline in September this year so that we can continue excavation work. "

So far a total of around 400 000 $m^3$ has been excavated and blasted – about a third of the 1.2 million $m^3$ to be excavated.

A significant amount of offshore work is also under way. Dredging and underwater blasting has been carried out for the cooling water inlet and outlet areas.

"In the inlet area, including the sea lane coming from the sea, we have had some dredging and underwater blasting work. Almost 900 000 $m^3$ has been removed. This work is on hold at the moment due to ice – we can only do underwater blasting between May 20th and October 10th," said Sipiläinen.

**All the roads leading to and inside the site have been built at 4.6 m above sea level in order to withstand all potential floods**

**Hemminki: the owners believe the business case is robust**

**So far a total of around 400 000 $m^3$ has been excavated and blasted**

**A temporary staff accommodation area is currently under construction**

# **Special Project** Supplement

**A significant amount of offshore work is under way**

**Forsström: STUK has to ensure this is a safe nuclear power plant**

It is expected that all offshore work will be completed during that window this year. Onshore plant excavation will start September of this year and will be completed during August/ September next year.

Other major work being carried out this year will be the start of construction of Fennovoima's administration building. This will be completed by the end of 2019. Two temporary office buildings are also being built for 600 staff, which should be finished by the end of this year.

In terms of staff, Fennovoima is following a "resource plan", whereby it is recruiting four or five times a year. Sipiläinen noted: "We are working with consultants to help us find the people we are looking for.

Currently, most staff recruitment is taking place in Finland but as the project progresses, it is likely to become more international.

"It depends on the phase," said Sipiläinen. "Currently we are doing the earthworks and construction work, so it is quite local. But when the power plant is being built, it will be more international."

At the moment there are over 230 people working on the site. Manpower on site will peak when construction work is running in parallel with installation work – some time in 2022.

Having achieved the major contractual milestone of handing the site over to RAOS in 2015, Fennovoima is diligently working towards the next major milestone – obtaining the Construction Licence. This will allow civil works to start on the nuclear plant itself, with pouring of first concrete.

The construction licence was expected to be issued in 2018 but 2019 is now the new target.

Minna Forsström, Fennovoima's Project Director, commented: "STUK has to ensure this is a safe nuclear power plant. So the safety assessment is clearly key. STUK has a lot of questions and requirements – there can be more than 10 000 requirements; it's a complicated process."

The company therefore says that this year it will focus on the review and delivery of the Construction Licence documentation and expects to start production of the long lead items such as the reactor pressure vessel and steam turbine.

Fennovoima is submitting the Construction Licence documentation in batches to STUK, noting that it has made "quite good progress".

Explaining the submission process, Forsström said: "We do this in many steps; actually there are 10 batches but in practice there are actions almost every day. There is constant dialogue; we meet with STUK people every few days. This is different from many other countries. They are constantly following what we are doing. They have access to our models and can check how the development is going.

"They also carry out inspections – about 10 to 12 of Fennovoima, as well as of the major sub-suppliers and of RAOS Project itself. STUK also approves the major components and the major suppliers."

Key suppliers include Atomenergomash (a subsidiary of Rosatom) for long lead items such as the reactor pressure vessel and steam generators, GE Steam Power Systems for turbine generator set; Rolls-Royce (protection automation) and Schneider Electric (operational I&C).

As batch submissions for the Construction Licence continue, excavation and blasting work at the site is ongoing. "We have to complete all the blasting and excavation work before we start concrete construction," said Sipiläinen. "Blasting and excavation should be completed by August next year."

This will mark a significant milestone in the project's development and in some ways, the point at which the real work begins.

## Main design parameters

| | |
|---|---|
| Rated reactor core thermal power (MWth) | 3200 |
| Thermal efficiency (%) | ~37 |
| Electric power (MW) | 1200 |
| Primary circuit pressure (bar) | 162 |
| Number of fuel assemblies | 163 |
| Number of control rods | 121 |
| Primary circuit loops/Steam generators | 4 |
| Rated core coolant flow rate ($m^3/h$) | 85 600 |


Renewable energy sources should be utilized whenever possible. However, they alone are not enough. We need all emission-free forms of electricity production, including nuclear energy.

Fennovoima is building a nuclear power plant in Pyhäjoki, Finland. The greenfield power plant is called Hanhikivi 1. Fennovoima employs about 350 professionals from different countries. During the upcoming years, we will have plenty of new vacancies for skilled technical professionals.

We have what it takes to produce an emission-free solution for Finnish electricity production. Would you like to join our team?

See all our open positions **fennovoima.com/recruitment**

FENNOVOIMA

# ABB hints at return to long-term growth

Having gone through a year of transition, ABB says it is set for growth on the back of improving economic conditions and increasing electrification.

Junior Isles

Promising first quarter results indicate that Swiss engineering company ABB is returning to long-term growth.

The company reported first-quarter orders at $9.8 billion, 6 per cent higher than a year earlier on a comparable basis.

The growth figure, which compared with declines of 3 per cent in the previous quarter and in the first quarter of 2017, has been attributed to improving global economic conditions. This has boosted demand across the company' power grids, electrification, automation and robotics businesses.

Growth was strongest in ABB's robotics business, which reported an 11 per cent rise in orders. Sales had been boosted especially by demand for robots in China, but also from the global car industry as production shifted towards electric vehicles, said ABB Group's Chief Executive, Ulrich Spiesshofer.

Spiesshofer has streamlined ABB to focus on higher growth markets and to cut costs but has struggled to reverse declines in sales. The group's products and services are based on automating industries and delivering electricity from power stations to final users, with much of its revenue dependent on investment spending by governments and utilities.

Now with all divisions showing order growth, and operating profits up 4 per cent at $1.1 billion, Spiesshofer said: "The transition year 2017 is behind us."

Speaking on the sidelines of the Italian Formula-E Championship in Rome, which the company now sponsors, he told *TEI Times*: "We have streamlined ABB both from a portfolio perspective and operationally and have strengthened the company significantly… We took out more than $1.3 billion of white collar costs and today run the company with a much more simplified business model and a new performance management system tied to a new compensation system."

Spiesshofer said the changes had produced a steady top line result for the full year, despite a difficult market in parts of the portfolio and the company's transition programme.

He said that with the transition year behind it, ABB was now "clearly focused on the future".

According to Spiesshofer, the growth in renewables will mean more feed-in points on the supply side, longer transmission distances and greater volatility, which will call for skills and capabilities in transporting electricity, as well as more grid control products. He also added that growing consumption, including more electric vehicles, will drive the need for more electricity off-take points.

"If you take these two drivers, on the supply and demand side, which will require digitalisation and enhanced control of the grid… it presents a tremendous opportunity for us in the future," he said.

## BP pledges action on emissions

BP has pledged to limit its methane emissions and invest in carbon offsetting as part of a new commitment to reduce its carbon footprint.

The company has set out an ambitious and wide-ranging strategy with near-term, specific targets for reducing carbon emissions associated with its business as well as encouraging customers and suppliers to do the same.

The strategy, it says, will help to meet the dual challenge of increasing world energy demand and reducing greenhouse gas emissions.

"The world is growing like never before, creating opportunity for billions of people," said Bob Dudley, BP group CEO. "And all this growth requires energy. But as the world demands more energy it also demands that it be produced and delivered in new ways, with fewer emissions."

Among BP's plans are targets to keep net greenhouse gas emissions from its operations at or below 2015 levels out to 2025 and to generate sustainable reductions of 3.5 million tonnes of annual $CO_2$ equivalent greenhouse gas emissions throughout its businesses by 2025. It says it will use new technology to improve energy efficiency as well as limit the emissions intensity of methane and reduce flaring of oil and gas.

It added in a statement that it would invest in carbon offsetting programmes if it fails to achieve the targets on emissions it has set.

BP is also growing the low-carbon side of its business with annual investments of $500 million in renewable energy and clean technologies. This includes building more wind and solar farms as well as new battery storage capacity.

## Rolls-Royce simplifies with L'Orange sale

- Woodward buys fuel injection unit
- Sale follows strategic review

Rolls-Royce is continuing to refocus its business on core segments with the sale of L'Orange to Woodward Inc.

The €700 million deal will result in Woodward taking control of fuel injection system supplier L'Orange, and integrating it into its Industrial business segment. The move will help Rolls-Royce to simplify its business, while enabling Woodward to expand into key industrial segments.

Warren East, CEO of Rolls-Royce, said: "This transaction builds on the actions we have taken over the last two years to simplify our business. The divestiture of L'Orange enables Rolls-Royce Power Systems to focus on other long term, high growth opportunities and our company to allocate our capital to core technologies and businesses that drive greater returns for the group."

L'Orange's 2017 pro forma sales were €244 million, with pro forma underlying EBITDA of €74 million and pro forma underlying operating profit of €64 million.

Thomas A. Gendron, Chairman and Chief Executive Officer of Woodward, said: "L'Orange is an excellent strategic and financial fit for Woodward, and this transaction exemplifies our acquisition strategy to invest in markets with solid long-term fundamentals. The acquisition of L'Orange brings innovative technology, bolsters relationships with key customers and enhances the profitability of our Industrial segment."

Its fuel injection technology is used in engines that power industrial applications including marine power and propulsion systems, special-application vehicles, oil and gas processing, and power generation.

Rolls-Royce said it would continue to be a key customer of L'Orange after the acquisition through its MTU and Bergen brands. The sale follows a strategic review of the L'Orange business earlier this year.


# Total accelerates utility ambition

Total's acquisition of Direct Energie shows that the company is serious about its ambition to build value across the electricity value chain, analysts say.

Siân Crampsie

Total says that an agreement to purchase a majority stake in Direct Energie will help it to establish itself as a leading alternative supplier of energy for French and Belgian customers.

The French energy giant has agreed a friendly takeover of Direct Energie in a €1.4 billion deal that will see it purchase around 75 per cent of the company's share capital. The takeover will help to shake up the energy market in France, which is dominated by EDF and Engie.

"Through this transaction, Total is actively pursuing its development in electricity and gas generation and distribution in France and Belgium," said Patrick Pouyanné, Chairman and CEO of Total.

"This friendly takeover is part of the group's strategy to expand along the entire gas-electricity value chain and to develop low-carbon energies, in line with our ambition to become the responsible energy major."

The deal will enable Total to add Direct Energie's 2.6 million client portfolio to its own portfolio of 1.5 million. It will set Total well on its way to achieving a target of over 6 million customers in France and more than 1 million customers in Belgium by 2022.

The acquisition of Direct Energie will also expand Total's generating portfolio by adding 1.35 GW of installed capacity to its existing 900 MW asset base. Direct Energie's portfolio includes 800 MW of gas fired power plant and 550 MW of renewables. The utility also has a 400 MW gas fired power plant under construction and a 2 GW pipeline of renewables projects in France.

Total is aiming to have an installed capacity of 10 GW within five years, it said.

The deal follows Total's entry into the residential retail market in 2016, when it acquired Belgian firm Lampiris. Other oil and gas firms have also moved into electricity and gas retail in an effort to diversify their businesses away from fossil fuels.

Last year Shell agreed a deal to buy UK retailer First utility, which serves around 825 000 homes in the UK with energy and broadband services.

In France, Engie has 3.5 million electricity customers while state-owned EDF has 25.6 million, more than 80 per cent of the total. However, EDF lost 1 million customers last year as competition intensified.

"Total's acquisition of Direct Energie shows that the company is serious about its ambition to build value across the electricity value chain, with both gas and renewables playing a key role," said Valentina Kretzschmar, research director, corporate analysis, at global natural resources consultancy Wood Mackenzie. "The $1.7 billion acquisition of Direct Energie is Total's largest investment in low-carbon assets to date."

## Americas

### Siemens wins 100 MW in wind auction

Siemens Gamesa has secured an order in Mexico for the supply of 100 MW following the country's November 2017 wind power auction.

Under the contract, Siemens Gamesa will install 29 of its SG 3.4-132 turbines at a wind farm located in the Mexican state of Coahuila. The company will supply the turbines in the first quarter of 2019.

Siemens Gamesa views Mexico as a key target market for wind power and says it has established itself as the leading supplier of wind turbines in the country.

### GE signs Petrobras deal

GE's Power Services business has signed a deal with energy firm Petrobras to provide maintenance services for 11 power plants in Brazil.

The $300 million deal represents GE's largest transactional power generation services agreement in Latin America. The fleet under the contract represents approximately 80 per cent of the Petrobras total installed fleet and generates 4.3 GW of energy.

The four-year agreement includes inspections, parts and repairs for 20 of GE's heavy-duty gas turbines (four 6FA, six 7FA, 10 GT11N2), 23 of GE's LM6000 aeroderivative gas turbines, three GE steam turbines and 13 GE generators, which Petrobras has been operating at the 11 power plants since 2001.

### MidAmerican places 77 MW order

MidAmerican Energy has selected Siemens Gamesa Renewable Energy (SGRE) to supply the wind turbines for a 77 MW project in Iowa, USA.

SGRE will supply 25 SWT-2.625-120 and 5 SWT-2.3-108 wind turbines for the Wind XI project. The order includes the option to add up to five additional SWT-2.625-120 wind turbines for a total capacity of 90 MW.

The $3.6 billion Wind XI project is set to start operating in December 2018.

## Asia-Pacific

### MHPS receives steam turbine order

Mitsubishi Hitachi Power Systems, Ltd. (MHPS) has received an order to provide a steam turbine power generation system for a pulp and paper mill in Sumatra, Indonesia.

With an output of 97 MW, the system will be used as an in-house power source, while steam generated from energy production will be used in the pulp and paper production processes. The new system will be delivered through Mitsubishi Corporation and is scheduled to begin operations in late 2019.

The power generation system will consist of a back-pressure turbine, a boiler and a generator. MHPS will supply the core components, such as the steam turbine and generator, as well as an oil unit and instrumentation and control devices.

### Suzlon bags 500 MW

Suzlon has won two wind turbine orders for a total of 500 MW of capacity in India following a bidding process held by the Solar Energy Corporation of India (SECI).

The wind turbine company will provide 238 of its S111 140m units, rated at 2.1 MW, for the projects, located in Kutch district, Gujurat. Suzlon will execute the projects on a turnkey basis as well as provide operation and maintenance services, it said.

### SGRE wins India orders

Siemens Gamesa Renewable Energy (SGRE) has won multiple wind power orders for a total of 140 MW from several industrial customers and a leading independent power producer (IPP) in India.

The projects will have installed capacities ranging from 2 MW to 58 MW and are set for commissioning by June 2018. The orders entail engineering, procurement and construction (EPC) across several sites, and involve installation of 41 of SGRE's G97-2.0 wind turbines and 29 of its SG2.0-114 units.

SGRE said that the orders were placed by different industrial customers, such as textile, auto parts and pharmaceutical companies.

### R-R signs CGN contract

Rolls-Royce has signed a contract to modernise rod control system equipment in 14 of CGN's CPR1000 nuclear power units in China.

The contract is the first of its kind for Rolls-Royce in China and was signed with CGN subsidiary, Suzhou Nuclear Power Research Institute (SNPI). The newly formed partnership will also allow the CGN group to achieve cost reduction and efficiency improvements for the operations of its power plants.

### China orders H-class GTs

Siemens has secured its first order for an H-class gas turbine from mainland China.

The company will supply two H-class gas turbines, two steam turbines and four generators for a power plant project in Guangdong Province, it has announced. The customer is Huadian Fuxin Energy Corporation Limited, a subsidiary of China Huadian Corporation Ltd (CHD), one of the five state-owned power producers in China.

The components will be installed at the CHD Guangzhou Zengcheng combined cooling, heat and power plant project, located in Zengcheng District of Guangzhou City. After completion the project will be the most efficient gas fired power plant in China, Siemens said.

Commercial operation is scheduled for the end of 2019.

### Neoen plans wind-storage project

Renewable energy IPP, Neoen, has awarded Siemens Gamesa Renewable Energy (SGRE) a contract to build a pioneering wind farm in Australia, comprising 56 wind turbines and a 20 MW/34 MWh energy storage unit.

SGRE will build the entire complex on an engineering, procurement and construction (EPC) basis and then maintain it for 25 years. It will install its SG3.4-132 wind turbines at the site as well as a lithium-ion battery energy storage unit.

The 194 MW wind farm and storage facility – known as the Bulgana Green Energy Hub – will be located in the state of Victoria near the town of Stawell.

Construction is set to begin right away and the commissioning of the facility is expected by August 2019.

## Europe

### France readies PV tender

France is preparing a tender for the installation of 300 MW of solar photovoltaic (PV) capacity.

The move is part of wider plans to close the country's oldest nuclear power plant, the 1800 MW Fessenheim facility. The tender will be held in phases between November 2018 and November 2019 and will include ground-mounted PV systems as well as roof-mounted plants.

### Siemens Gamesa equips four wind farms in Spain

Siemens Gamesa Renewable Energy (SGRE) will supply 166 MW at four wind farms to be developed by Gas Natural Fenosa Renovables in Spain.

The firm says it will install 48 of its SG3.4-132 wind turbines across the four sites, as well as provide maintenance services for four years. The four projects fall under the scope of the renewable capacity allocated to Gas Natural Fenosa Renovables as part of the auction held last May.

The four wind farms are due to be commissioned in mid-2019.

### Rooftop solar planned for Finland

Fortum Corporation says it has won S Group's competitive bidding process for the implementation of a solar electricity system on the rooftops of about 40 commercial buildings in Finland.

With a total output capacity of about 10 MW, the solar project represents the biggest ever supply of rooftop solar electricity systems to be installed on rooftops in the Nordic countries. Fortum will carry out project planning, project management and equipment procurement.

Finland's installed solar power capacity is approximately 35 MW.

## International

### ACWA, Shanghai sign CSP contract

Saudi Arabia's ACWA Power and Chinese firm Shanghai Electric have signed an engineering, procurement and construction (EPC) contract for the fourth phase of the Mohammed bin Rashid Al Maktoum solar park.

The 700 MW fourth phase of the giant solar scheme represents the largest concentrated solar power (CSP) investment project in the world based on the independent power producer (IPP) model. ACWA Power and Shanghai Electric won the EPC contract in late 2017 and are scheduled to commission the project in stages starting from late 2020.

The project will feature a 260 m-high solar tower, the tallest of its kind in the world, and will also be equipped with the world's largest thermal energy storage unit.

The CSP project will use two technologies to generate clean energy: the 600 MW parabolic basin complex and the 100 MW solar tower, and they will cover an area of 43 $km^2$. "This project involves an investment of $3.9 billion (AED14.2 billion), and has achieved the world's lowest levelised cost of electricity (LCOE) of ¢7.3 per kW/h for Concentrated Solar Power," said HE Saeed Mohammed Al Tayer, MD & CEO of Dubai Electricity and Water Authority (DEWA).

### Four bid for Saudi wind farm

A tender for the construction of Saudi Arabia's first wind farm has resulted in four bids, Bloomberg has reported.

The Saudi Arabian Energy Ministry's Renewable Energy Project Development Office last year issued a tender for the 400 MW wind farm, which is set to be located at Dumat Al Janda city. It has received four bids for the project, including ones from ACWA Power, EDF, Enel and Engie, Bloomberg reported.

Saudi Arabia is planning to develop 9.5 GW of renewable energy by 2023 as part of an initiative to reduce dependence on oil and gas.

### Engie, Meridiam win Senegal PV contracts

Engie and its investment partner, Meridiam, have been selected by Senegal's Electricity Sector Regulation Commission (CRSE) as preferred bidder in a tender for two solar photovoltaic (PV) projects totaling 60 MW.

The two projects are part of the Scaling Solar initiative in Senegal and are located in Kahone, Kaolack region, and in Touba-Kaël, in the Diourbel region of Senegal.

Engie and Meridiam will hold a 40 per cent shareholding in the project company. Fonsis, the Senegalese sovereign fund, will also be a shareholder with a 20 per cent equity stake. The construction and the operation of the plants will be managed and executed by Engie.

### Jordan tender sees 16 solar bids

Jordan's Ministry of Energy and Mineral Resources has received 16 bids in a 200 MW solar tender.

The tender is for the construction of four 50 MW solar power plants in the Ma'an Development Area. A separate tender for 100 MW of wind capacity in southern Jordan is due to take place in November.

The energy ministry added the Kingdom's total wind and solar power capacity reached 732 MW at the end of 2017. It aims to boost that to more than 2.4 GW by 2021.

GE recently announced that it will supply its 3.6-137 wind turbines for Mass Energy Group's first wind farm in Jordan totalling 100 MW.

GE and its consortium partner Elecnor have signed an EPC contract for the project.

The wind farm is set to become operational by 2019 and will support Jordan's commitment to meeting its renewable energy targets.

### GE leads Ostroleka C

GE Power has been chosen as the lead engineering, procurement and construction (EPC) contractor, in consortium with Alstom Power Systems, to build the Ostroleka C ultra-supercritical (USC) coal fired power plant in Poland.

GE Power will design, manufacture and deliver ultra-supercritical technology components, including the boiler and steam turbine generator, for the 1000 MW plant in north-eastern Poland. It will also provide advanced environmental control systems such as electrostatic precipitators and wet flue gas desulphurisation plant.

The $1.4 billion project is being developed by Energa and Polish power utility Enea and is expected to be operational by mid-2023.

### Jenbacher gensets head for Russia

GE has signed a supply agreement with GreenTech Energy Company (GTE) for the supply of 21 Jenbacher gas engines to Russia by the end of 2018.

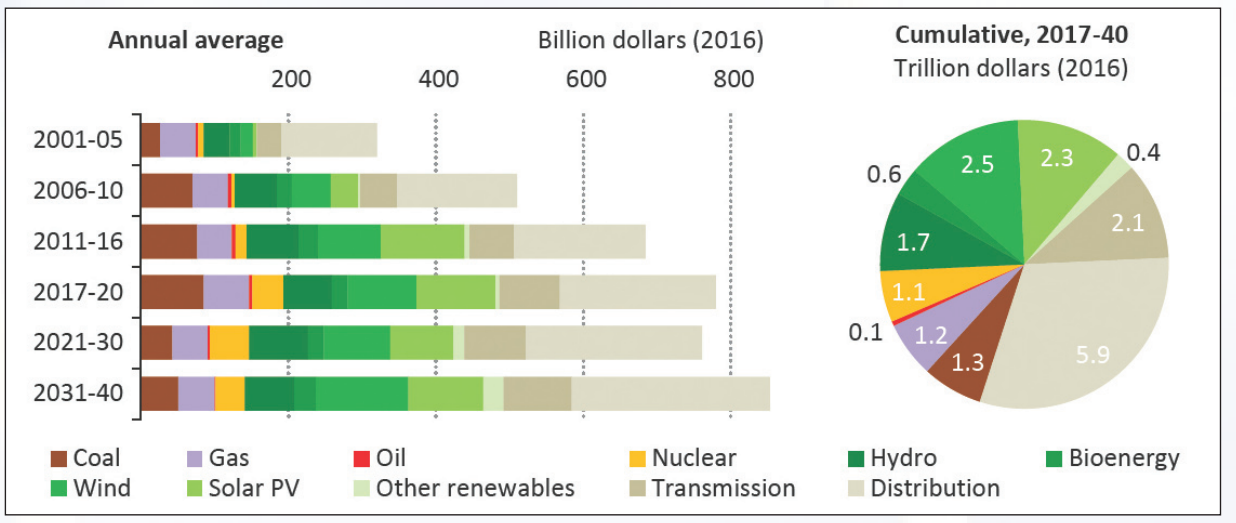
The 21 units – ten J320 units, ten J420 units and one J316 unit – will have a combined power output of 26 MW and will be deployed across Russia as combined heat and power (CHP) units in a variety of industries, including the food and beverage, glass, agriculture and chemical processes.

## Cumulative gross power plant capacity additions by region and source in the New Policies Scenario, 2017-2040 (GW)

| | 2017-2025 | | | | | | 2026-2040 | | | | | | 2017-2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coal | Gas | Oil | Nuclear | Renewables | Total | Coal | Gas | Oil | Nuclear | Renewables | Total | Total |
| North America | 3 | 137 | 8 | 3 | 213 | 365 | 0 | 208 | 6 | 7 | 349 | 569 | 934 |
| United States | 2 | 107 | 7 | 3 | 175 | 295 | - | 153 | 5 | 5 | 287 | 450 | 745 |
| Central & South America | 5 | 26 | 2 | 2 | 69 | 105 | 5 | 66 | 3 | 4 | 144 | 222 | 327 |
| Brazil | 1 | 6 | 0 | 1 | 35 | 44 | 0 | 6 | 2 | 3 | 72 | 82 | 126 |
| Europe | 34 | 44 | 1 | 8 | 222 | 309 | 22 | 124 | 2 | 32 | 517 | 697 | 1 007 |
| European Union | 11 | 26 | 0 | 4 | 183 | 224 | 5 | 88 | 1 | 21 | 462 | 577 | 801 |
| Africa | 18 | 57 | 10 | - | 57 | 143 | 32 | 115 | 11 | 7 | 202 | 366 | 509 |
| South Africa | 13 | 3 | 0 | - | 8 | 24 | 24 | 7 | 0 | 7 | 23 | 61 | 85 |
| Middle East | 3 | 81 | 12 | 6 | 16 | 118 | 1 | 140 | 3 | 12 | 96 | 251 | 369 |
| Eurasia | 17 | 71 | 0 | 11 | 10 | 109 | 15 | 66 | 0 | 17 | 47 | 146 | 255 |
| Russia | 8 | 52 | 0 | 10 | 7 | 78 | 6 | 42 | 0 | 16 | 38 | 102 | 180 |
| Asia Pacific | 342 | 193 | 10 | 74 | 895 | 1 513 | 433 | 297 | 20 | 89 | 1 940 | 2 778 | 4 291 |
| China | 141 | 77 | 0 | 52 | 540 | 811 | 72 | 76 | 0 | 59 | 1 022 | 1 229 | 2 039 |
| India | 120 | 30 | 4 | 9 | 191 | 354 | 251 | 59 | 8 | 24 | 546 | 886 | 1 240 |
| Japan | 5 | 23 | 0 | 3 | 35 | 65 | 3 | 23 | 0 | 3 | 76 | 105 | 171 |
| Southeast Asia | 41 | 26 | 3 | - | 48 | 118 | 58 | 83 | 5 | 2 | 120 | 269 | 387 |
| World | 422 | 609 | 43 | 105 | 1 484 | 2 662 | 508 | 1015 | 44 | 168 | 3 294 | 5 030 | 7 692 |

*World Energy Outlook 2017, © IEA/OECD, Table 6.4 , page 249*

## Global annual average power sector investment and cumulative investment to 2040 in the New Policies Scenario




*World Energy Outlook 2017, © IEA/OECD, Figure 6.10, page 251*

## Cumulative investment in the power sector by region and type in the New Policies Scenario, 2017-2040 ($2016 billion)

| | 2017-2025 | | | | | | 2026-2040 | | | | | | 2017-2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fossil fuels | Nuclear | Renewables | Total plant | T&D | Total | Fossil fuels | Nuclear | Renewables | Total plant | T&D | Total | Total |
| North America | 134 | 59 | 410 | 602 | 370 | 972 | 207 | 80 | 579 | 865 | 626 | 1 491 | 2 463 |
| United States | 108 | 43 | 340 | 491 | 311 | 802 | 162 | 65 | 477 | 704 | 497 | 1 201 | 2 003 |
| Central & South America | 26 | 9 | 139 | 173 | 154 | 327 | 54 | 16 | 275 | 346 | 304 | 651 | 978 |
| Brazil | 6 | 5 | 68 | 80 | 78 | 158 | 5 | 11 | 134 | 151 | 152 | 303 | 461 |
| Europe | 111 | 71 | 478 | 661 | 394 | 1 054 | 142 | 181 | 947 | 1 269 | 637 | 1 906 | 2 960 |
| European Union | 52 | 54 | 402 | 507 | 286 | 794 | 81 | 133 | 845 | 1 059 | 452 | 1 512 | 2 306 |
| Africa | 74 | - | 126 | 201 | 180 | 381 | 141 | 27 | 387 | 556 | 592 | 1 148 | 1 529 |
| South Africa | 23 | - | 17 | 40 | 20 | 60 | 46 | 27 | 43 | 116 | 61 | 177 | 237 |
| Middle East | 78 | 21 | 35 | 134 | 77 | 211 | 113 | 42 | 188 | 343 | 219 | 562 | 773 |
| Eurasia | 108 | 43 | 22 | 173 | 98 | 270 | 109 | 67 | 108 | 284 | 161 | 445 | 715 |
| Russia | 71 | 41 | 16 | 127 | 57 | 184 | 63 | 62 | 90 | 215 | 100 | 315 | 500 |
| Asia Pacific | 517 | 223 | 1 348 | 2 087 | 1 437 | 3 525 | 745 | 261 | 2 555 | 3 560 | 2 776 | 6 336 | 9 861 |
| China | 151 | 146 | 760 | 1 057 | 714 | 1 771 | 103 | 158 | 1 266 | 1 527 | 1 169 | 2 696 | 4 467 |
| India | 159 | 26 | 240 | 426 | 283 | 709 | 336 | 67 | 594 | 996 | 631 | 1 627 | 2 336 |
| Japan | 33 | 15 | 79 | 126 | 77 | 204 | 26 | 22 | 128 | 177 | 141 | 317 | 521 |
| Southeast Asia | 82 | - | 98 | 180 | 207 | 387 | 149 | 9 | 227 | 385 | 470 | 855 | 1 242 |
| World | 1 048 | 426 | 2 558 | 4 031 | 2 710 | 6 741 | 1 510 | 674 | 5 039 | 7 223 | 5 315 | 12 538 | 19 279 |

Note: T&D = transmission and distribution.

*World Energy Outlook 2017, © IEA/OECD, Table 6.5, page 252*

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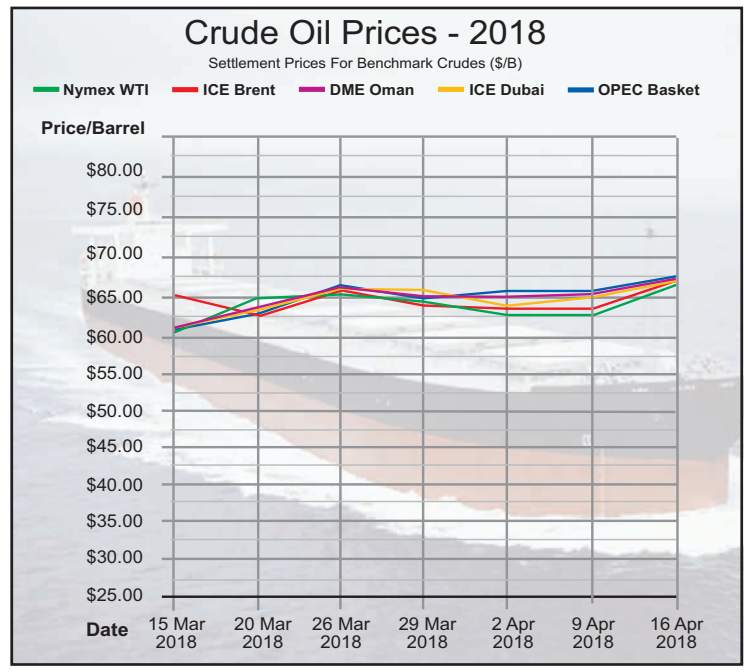
***Source: World Energy Outlook 2017***

## Oil

# Opec nears market balance, but will it stop there?




- Opec cuts impact crude stocks
- Brent crude flirting with $80/b

David Gregory

In recent weeks the price of Brent crude has been moving in the $70/b range and flirting with $80/b, while at the retail pump in the US, the price of a gallon of gasoline has touched $3.00 for high octane. With the US economy actually making gains, and after having been through this several times, it is clear that if the American economy is going to stay healthy, the price of gasoline must stay low. But how is that possible in a global market?

US President Donald Trump has caught on to this and in mid-April tweeted: "Looks like Opec is at it again. With record amounts of Oil all over the place, including the fully loaded ships at sea, Oil prices are artificially high Very High! No good and will not be accepted."

It could be that somewhere in the wee hours of the morning, President Trump caught one of the reports about how Saudi Arabia and Opec, and their non-Opec allies, particularly Russia, are considering an extension of production cuts at least until the end of the year. This would likely push up prices to $80/b in the coming weeks and possibly to $100/b by the end of the year.

For all oil producers, America included, high oil prices are nothing but good news. Saudi Arabia is looking to diversify its economy by 2030 and it will use the money earned from the planned sale of Saudi Aramco shares to do it. The higher the price of oil, the more valuable the shares will be during the initial public offering (IPO), which is now expected to take place in 2019. If oil is at $100/b at the end of this year, it could be good news for Riyadh and friends, but not for Trump's political base, many of whom are earning little more than $10/hour.

In its April *Oil Market Repor*t, the International Energy Agency (IEA) reported that the production cuts by Opec and partners have impacted crude oil stocks and the five-year stock average has fallen to close to the current level of supply. However, prolonged production cuts run the risk of pushing prices up to a point where they would have a negative impact on the global economy – a situation that has occurred on several previous occasions.

It might be noted that on several occasions in the past, when the price of oil is around $30-40/b, the Saudis claimed $70-75/b is a fair price. However, when the price goes beyond that, all concern for a fair price is forgotten.

Prices have not only improved because of the Opec/non-Opec productions cuts. Markets have been wary over Trump's threats to end US participation in the Iran nuclear research deal. If he fails to certify the agreement on May 12, a number of unhappy things could happen, including the removal due to US sanctions of large volumes of Iranian oil off the market.

The continuing collapse of Venezuela's economy, government and oil sector is another issue that worries traders, along with the continuing rockets that the Iranian-backed Houthis in Yemen keep firing at Aramco facilities.

And there is the possibility of Libya slipping into even greater chaos in the aftermath of General Khalifa Haftar, head to the Libya National Army (LNA), suffering a stroke and no longer being a factor in Libya's political future. It has been the LNA's control over much of eastern and southern Libya that has allowed the country to increase production to 1 million b/d.

The outcome of a meeting in Washington between Trump and French President Emmanuel Macron in mid-April suggested that Trump might consider signing the sanctions waiver, and a planned meeting with German Chancellor Angela Merkel was expected to lead to a further attempt to persuade Trump to stick with the Joint Comprehensive Plan of Action (JCPA) that took effect in January 2016.

By continuing with the JCPA and keeping Iranian crude on the market, Trump can address one factor that could push crude oil prices higher. Trump also has the option to release crude oil from the Strategic Petroleum Reserve. Obama took such a step in June 2011 to address crude prices of $115/b and gasoline prices of more than $4.00 at the pump. Furthermore, higher oil prices will only provide incentive to shale oil producers, be they in the US or elsewhere, as well as alternative energies, which continue to gain ground whether crude oil prices are high or not.

## Gas

# Demand for LNG on the rise, as Asia leads market

Data from 2017 shows that demand for LNG increased last year and that most of that demand growth came from Asia and from China in particular.

Mark Goetz

Prompted by the anticipated growth in demand in Asia, a bull market and incentives by the government of British Columbia, Shell last month took steps to revive the shelved Canada LNG project, which will be based in Kitimat.

The $40 billion project, led by Shell in partnership with PetroChina, Korea Gas and Mitsubishi, will consist of two trains, each with a 6.5 million tons/year capacity, and be designed with the intention to supply the LNG market in Asia for the next 40 years.

When warranted, another two trains of equal capacity will be constructed. The consortium is expected to make a final investment decision (FID) later this year. That decision was put on hold in 2016, when circumstances were not looking as good as they do now.

Data from 2017 shows that demand for LNG increased last year and that most of that demand growth came from Asia and from China in particular. That trend is forecast to continue through 2018 and into the near future, although demand growth in China may not be as significant as it was during 2017.

According to Thomson Reuters Eikon, global LNG imports have increased by 40 per cent since 2015 to nearly 40 million $m^3$ per month, with growth accelerating in 2017. Imports last year were up by 20 per cent, primarily due to increased demand in China, and also in South Korea and Japan. Last year, China unseated South Korea as the second-largest importer of LNG globally, and is likely to retain that position behind Japan.

The surge in China came on the heels of a government decision to cut the country's reliance on coal in an attempt to clean up the environment and ease air pollution. The shift was a tough move and created some energy shortages during the winter months, resulting in a boost of LNG imports and as a consequence, it took up the slack in the Asian gas market.

During the LNG Forum, which took place in Singapore last month, participants expressed their optimism that the burgeoning market for LNG in Asia would provide the market with impetus. Growing demand is such that new LNG production due to come on-stream soon will not have to search too hard for buyers.

Some 40-50 tons annually will soon come on-stream, primarily in the US and Australia. Canada and Russia also intend to make a big impact on future markets.

Furthermore, Anadarko announced in late April that it had lined up enough buyers to proceed with its planned LNG project in Mozambique, which involves ExxonMobil and Eni. LNG projects in East Africa, that will draw natural gas from huge offshore resources in the Indian Ocean, are expected to come on-stream in the early to mid-2020s.

And, in the East Mediterranean, where Eni is a major player, there is considerable discussion about that region's potential for significant LNG exports.

Speaking at the Singapore conference last month, Jean-Pierre Mateille, Vice President of trading for the gas and power division at Total, which is a major LNG investor, commented on the bullish shape of today's market and its future prospects.

"For the past three years, we were told at every conference that we'll have a gas bubble, that gas is oversupplied, that we won't be able to sell LNG – but that bubble never came," he said, according to *Reuters*.

Comments from other executives were also cited by *Reuters*, including Shell's Executive Vice President Steven Hill, who said that despite new supply from the US and Australia, demand would eventually catch up. Trafigura's Head of LNG Hadi Hallouche, said that FIDs are not being made fast enough to keep up with demand that will soon be growing at a rate of 20-30 tons every year.

Meanwhile, Japan, too, is keen to promote the LNG market. A ruling by its Fair Trade Commission (FTC) last year said that LNG contracts that included restrictions on destinations were in violation of Japan's anti-monopoly laws. Several major Japanese LNG buyers have stated that they will not sign long-term supply contracts containing stipulations as to where the gas could be delivered or sold. This ruling enables Japanese buyers to resell its purchased LNG to other parties. The ruling will likely further loosen up the market and actually encourage its development.

The Japanese government recently announced that Japan Bank for International Cooperation (JBIC) will provide loans for US LNG export terminals as a means of supporting US LNG exports, which will help the US reduce its trade deficit in Asian markets. Japan said the loans would be made to promote US LNG exports to Asian countries.

# A strategic approach to decarbonising transport

Decarbonising transport is essential if the EU is to meet its climate change targets. Eurelectric argues that the electricity sector has a crucial role to play in these efforts. **Henning Häder**

The decarbonisation of European transport is a growing challenge for the EU. Today, transport is responsible for about a quarter of EU greenhouse gas emissions and is almost exclusively dependent on oil products for fuel. It is also the only major sector in the EU in which GHG emissions are still rising (+16 per cent since 1990) with cars and vans accounting for around 75 per cent of EU transport emissions. Reversing this trend and creating a sustainable transport sector is mandatory if Europe is to meet its commitment to the Paris Agreement.

Meanwhile, the European electricity sector has committed to becoming carbon-neutral well before 2050 in its new vision statement, calling for decarbonisation at an accelerated pace. The transformation of the power sector is in full swing, making electricity an increasingly attractive option as an energy carrier in transport. To achieve the needed emission cuts in transport and allow the EU to meet its Paris Agreement commitments, the electrification of road transport will have to play a crucial role.

With sales of electric vehicles (EVs) increasing, battery costs falling sharply (-80 per cent 2010-2016), Europe holds the key to entering the era of electro-mobility. The first three quarters of 2017 saw around 40 per cent more plug-in vehicles sold across Europe compared to the same period in 2016.

But while transport emissions are on the rise, the EU's regulatory master plan to drive and lead the global shift to electric transport is still being discussed. What is needed now is concrete and ambitious action from European policymakers to speed up the development and roll-out of zero emission vehicles including electric mobility; otherwise Europe will miss its commitments made under the Paris Agreement, as well as its global competitiveness in a key sector of our economy.

In recent months, several countries joined a growing movement to force the phase-out of vehicles that run on fossil fuels. France and the UK announced plans to ban new diesel and petrol cars by 2040; Norway confirmed its plan to phase them out by 2025, and the Netherlands by 2030.

Meanwhile China, the world's largest car market, announced ambitious sales targets as of 2019, having introduced a 10 per cent mandatory sales quota of low- and zero-emission vehicles for 2019, rising to 12 per cent in 2020.

This movement has triggered an avalanche of announcements from car companies about their intention to produce more EVs. The number of models is expected to grow rapidly: Volkswagen Group announced 80 new electric models by 2025; BMW will boast 12 different EVs by 2025; and new models launched by Volvo from 2018 onwards will be partially or completely battery-powered.

Considering that EVs are getting ready for mass deployment, policymakers and industry players must ensure that these technologies live up to their potential.

These industry announcements are to a large extent driven by vehicle manufacturers realising that the world is going electric. In the marketing and commercial battle ahead, being a technology driver will be a must in order to not lag behind international development.

However, the regulatory frameworks will play a crucial role in this transition. With the Chinese electric vehicle sales quota, and a similar system promoting low and zero-emission vehicles in California, important regions of the world are pushing manufacturers to deliver specific numbers of clean vehicles.

Meanwhile in Europe, in November last year the European Commission published its proposals for emission standards proposals for new cars and vans until 2030. These targets suggest a 30 per cent emission reduction compared to 2021 levels. Unfortunately, they fail to include a mandate for the sale of low- and zero-emission cars, which has proven very effective in other markets. If adopted, the Commission's plans will certainly bring more electric vehicles onto European roads, but the lack of ambition would mean that Europe will continue to lag behind other markets such as China.

Equally important, the proposals lack the ambition required to reduce the European transport sector's emissions by 60 per cent in 2050 compared to 1990 levels. This is a serious problem, as any solution to limit global warming to 2°C above pre-industrial levels, requires sharp emission reductions in the transport sector. With clean technologies for aviation and maritime transport only emerging slowly and being relatively expensive, road transport will have to deliver the major part of these emission reductions, at least in the short to medium term.

For many EU Member States, the low level of ambition in the European Commission's proposal might prove to be a serious problem. The emission reductions from cars and vans constitute an important contribution to their national Effort Sharing Regulation targets.

These national targets legally oblige Member States to reduce emissions from those sectors not falling under the EU's Emissions Trading Scheme, the EU ETS, (including transport, agriculture and building sectors). Under the current Effort Sharing commitment Spain, for example, has set itself a target of 10 per cent GH reduction until 2020.

**Häder: concrete and ambitious action is needed from European policymakers to speed up the development and roll-out of zero emission vehicles including electric mobility**

Road transport has significant potential to reduce emissions, usually at lower costs than other sectors like agriculture and buildings. Having vehicle manufacturers produce less emitting vehicles is also one of the cheapest options for Member States to reach their emission reduction goals.

Although $CO_2$ standards for cars are crucial, they are not the only relevant legislation for the electrification of transport. The Renewable Energy Directive, currently also under legislative review, proposes to oblige fuel suppliers (including electricity suppliers) in the transport sector to deliver a certain share of renewable fuels in their fuel mix. Until now, this target was put on Member States, with poor results. Most Member States will not reach their target of 10 per cent renewables in transport, and those who will achieve it will do so almost exclusively with the help of first generation biofuels. Such biofuel is produced directly from food crops and thus stands in direct competition to edible crops. While biofuel can certainly bring part of the solution going forward, electricity holds a much larger potential to scale up clean mobility.

A fuel suppliers' obligation or target, combined with a flexible trading system where under-achievers have to buy credits from over-achievers, would deliver emission savings in transport fuels at the lowest cost possible. The share of electricity from renewable energy sources in Europe is already at 30 per cent today, and electricity is to play a key role in greening Europe's transport fuels.

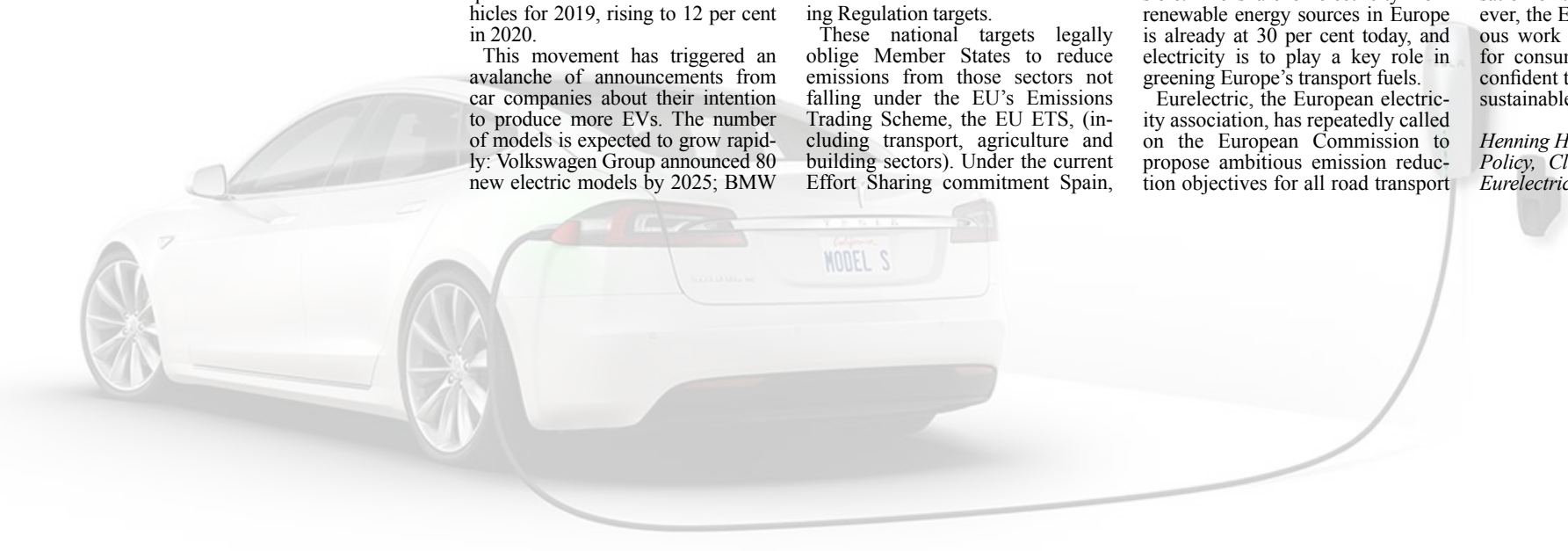
Eurelectric, the European electricity association, has repeatedly called on the European Commission to propose ambitious emission reduction objectives for all road transport segments for 2030, having in mind the deep decarbonisation required of light road transport by 2050 at the latest. The sector has also called for the introduction of mandating sales quotas on vehicle manufacturers in order to ensure that a proportion of their car sales stems from zero-emission vehicles.

The electricity sector has come a long way in its transformation towards low carbon generation. In 2016, 59 per cent of all the EU's electricity was generated from carbon free sources and this share continues to increase every year. The European power industry also announced in 2017 that it would not invest in new-build coal fired power plants after 2020.

Allowing EV batteries to load and store sustainable electricity will in addition allow a higher share of renewables to be utilised. This so-called "smart charging" can be done with existing technology, and in fact, many EV charging point manufacturers offer smart charging points. This allows electro-mobility service providers to offer customer contracts that ensure that charging is done when renewable sources generate and electricity prices are low.

Finally, clean mobility is an opportunity for the European Union and its industry to send a bold and clear signal of its commitment to the Paris Agreement. With electricity set to be decarbonised well-before 2050, the sector will be a key enabler to accelerate the decarbonisation of the transport sector. However, the EU needs to present a serious work plan on EV deployment, for consumers and investors to be confident to step into the new age of sustainable transport.

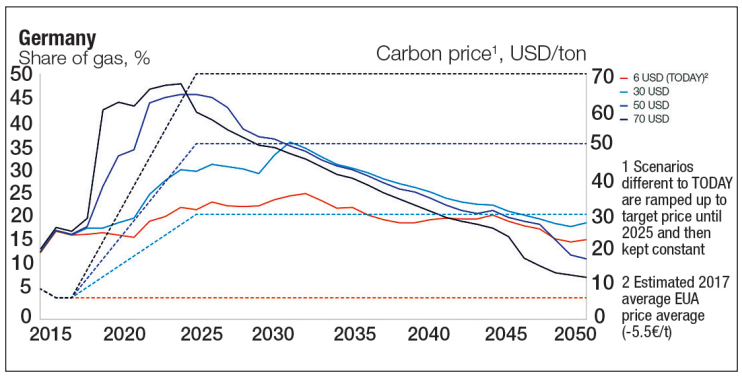
*Henning Häder is Manager of Energy Policy, Climate and Sustainability, Eurelectric.*



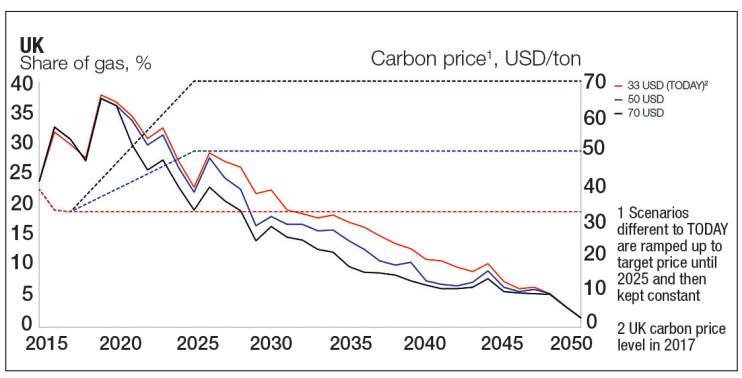
# Can carbon prices fire up gas demand?

Modelling by McKinsey Energy Insights shows how carbon pricing affects the outlook for gas in various markets.

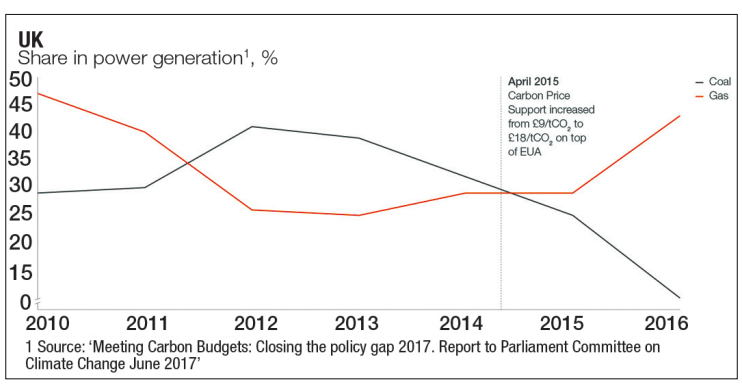
**Frithjof Wodarg, Bram Smeets, Jerry van Houten, Sebastien Leger and Tristan Swysen**



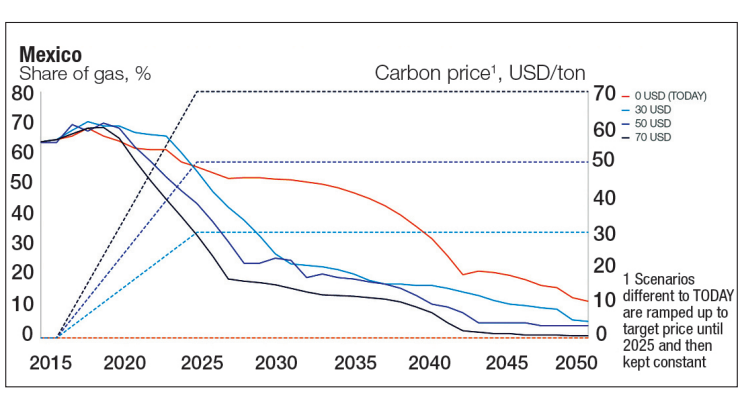

**Germany: Share of gas power generation mix with different carbon price scenarios**




**UK: Share of gas in power generation mix with different carbon price scenarios**




**UK scenario: Historical share of gas and coal in power generation**




**Mexico: Share of gas in power generation mix with different carbon price scenarios**

With governments revising their energy policies to meet the goals of the 2015 Paris Agreement, carbon prices are back on the table. Even the oil and gas industry has argued in favour of carbon prices, expecting them to lead to increased gas demand. But what effect will carbon prices realistically have on natural gas consumption and emissions, and how will it vary over time and by location?

McKinsey Energy Insights has developed an annual Global Energy Perspective (GEP). Using the GEP Power Model, we assessed how carbon prices can shift the power generation mix and analysed scenarios of multiple carbon price levels in different markets, modelling the effects on the generation mix as well as on emissions and power prices.

GEP found four key trends in all markets:

- There is a carbon price that maximises gas consumption by being sufficiently high to displace coal and sufficiently low to avoid the displacement of gas by renewables in combination with storage
- This "optimal price" from a gas perspective depends heavily on country-specific conditions. For gas consumption, country-specific carbon prices could be advantageous over a global price
- The optimal price decreases significantly over time as the economics of renewables continue to improve. Gas tends to benefit from higher carbon prices (above $30/t) until 2025/30, accelerating the shift from coal to gas. Beyond 2030, gas is penalised by (nearly) any level of carbon prices
- With regards to emissions, the shift from coal to gas is a significant abatement source in most countries. High carbon prices in the short-run (until 2020) can shift generation and achieve substantial emission reductions by 2030 (e.g. prices of at least $30/t after 2020 would reduce emissions in the power sector by over 40 per cent in 2030 for Germany).

While higher carbon prices make coal less attractive, the impact on natural gas strongly depends on the local conditions. We uncovered six factors that affected the degree to which natural gas is favoured when carbon pricing is introduced. Overall, we assume relatively stable coal prices of around $12/MWh (t) until 2050, while gas prices increase to a plateau in the early 2020s at around $23/MWh (t). These ix factors are:

- The carbon price changes the competitiveness of natural gas in comparison to other sources; as the carbon price rises, gas gains competitiveness over coal, but it also loses competitiveness over renewable energy sources (RES)
- The existing power generation and capacity mix in the market defines the current market share of natural gas, the other power sources it is competing with and at what relative marginal costs (e.g., coal or nuclear as baseload competition)
- The (future) prevalence of nuclear power defines the role of gas as a baseload or balancing technology in an environment with carbon pricing
- Age of generation fleet: In a market with old gas plants, natural gas will also tend to be pushed out of the capacity mix earlier
- The speed of renewable energy expansion, driven by declining RES levelised cost of electricity (LCOE), increases the demand for balancing capacities such as gas in the short-run; in the long-run, RES then outcompetes gas
- The availability and maturity of storage technologies can smooth supply (and demand) fluctuations in most instances in which natural gas would be an alternative.

Based on these factors, we can identify three country archetypes that illustrate how country-specific conditions lead to different manifestations of general trends:

- Increased gas demand with higher carbon prices compared to today due to coal-to-gas switching (e.g., Germany)
- Marginal impact on gas demand with higher carbon prices compared to today due to RES balancing need after coal was replaced (e.g., UK)
- Decreased gas demand with higher carbon prices compared to today due to gas-to-RES switching in countries that have a high share of gas (e.g., Mexico).

For our analyses, we compared a base case to three scenarios (i.e. Germany, UK and Mexico). For the base case, we froze the current local carbon prices in 2017 for the entire period (referred to as "today"). In three scenarios, carbon prices increase linearly to $30, $50, or $70/t of $CO_2$e in 2025. As the UK's carbon price today is already at 33 $/t, there is no $30 $/t scenario for the UK.

In the Germany scenario (where gas demand increases with higher carbon prices compared to today), higher carbon prices would increase the share of natural gas in the generation mix in the next 15 years. Higher carbon prices increase the share of natural gas in the generation mix by replacing coal. Post-2030, the impact of higher carbon prices on the share of gas declines and it can even have a negative impact on gas as it starts to be replaced by RES.

The resulting shift from coal to gas has an immediate effect on emissions: high prices in the short-run accelerate the replacement of coal. A carbon price of $30/t in 2025 (roughly the UK level today) would reduce emissions by ~50 Mt/yr $CO_2$e or 22 per cent until 2030 and help meet the 2030 target. If carbon prices remained at today's level (and no other measures are taken), Germany would fail to reach its 2030 targets.

In Germany, the optimal carbon price for gas consumption decreases over time: $30-50/t until 2025 and $30/t or lower post-2030.

In the UK scenario (where higher carbon prices compared to today only have marginal impact on gas demand), higher carbon prices (~$33/t) and a reduction in gas prices have already led to a shift from coal to gas. Since 2012, the share of coal in the generation mix dropped – from ~42 per cent in 2012 to ~10 per cent in 2016 (according to 'Meeting Carbon Budgets: Closing the policy gap 2017 Report to Parliament Committee on Climate Change June 2017').

Increasing the carbon price beyond $33/t would only decrease gas consumption by making it less competitive when compared with renewables in combination with storage.

The current carbon price of ~$33/t (European Emissions Allowance (EUA) + GBP18) has already positioned the UK to reach its 2030 emissions target for the power sector of ~32 Mt/yr $CO_2$e (estimate based on overall national targets in the 5th carbon budget; 'Meeting Carbon Budgets: Closing the policy gap 2017 Report to Parliament Committee on Climate Change June 2017'). In 2016, emissions in the power sector already fell by 24 per cent compared to 2012 and even by 62 per cent when compared to 1990 ('Meeting Carbon Budgets: Closing the policy gap 2017 Report to Parliament Committee on Climate Change June 2017').

In Mexico (where gas demand decreases with higher carbon prices compared to today), the share of gas could be negatively affected by a carbon price; a carbon price of $30/t could reduce the share of gas by nearly 50 per cent in 2030.

In the short-run (until 2025), a carbon price in Mexico has limited impact on the share of gas (replacing the remaining ~10 per cent share of coal in the generation mix).

At the same time, carbon prices would significantly accelerate the decline of gas after 2025; cheaper RES (and later storage) would outprice gas and reduce the share of gas in generation to 20-30 per cent by 2030.

A carbon price of $30/t would have a significant impact and reduce emissions by 50 per cent or ~50 Mt/yr $CO_2$e by 2030. Interestingly, any further increase in the carbon price would yield only disproportionally smaller reductions in annual emissions in 2030.

In conclusion, it is clear that higher carbon prices significantly reduce carbon emissions and generally favour gas to replace coal in the short term (until 2025/2030).

Beyond 2025/2030, depending on each country's specific conditions, higher carbon prices help RES replace gas, thereby achieving lower marginal abatement for emissions in 2030.

*Frithjof Wodarg, Bram Smeets, Jerry van Houten, Sebastien Leger and Tristan Swysen are authors of the McKinsey Energy Insights Global Energy Perspective (GEP).*

# Taking solar efficiency to the next level

**Despite its massive success in recent years, driven by falling costs, silicon solar PV cells are fast approaching their limit in terms of efficiency. Recent progress in the use of perovskites for solar PV applications, however, looks set to take the technology to the next level. Junior Isles reports.**

Solar photovoltaic (PV) technology has been a real success story. Driven by falling costs that have seen the levelised cost of energy (LCOE) plummet to grid parity or below in many countries, solar PV is leading the charge in global renewables deployment.

According to the International Energy Agency (IEA), boosted by a strong solar PV market, renewables accounted for almost two-thirds of net new power capacity globally in 2016. New solar PV capacity around the world grew by 50 per cent, reaching over 74 GW. The IEA also noted that rapid deployment of solar PV, led by China and India, helped solar become the largest source of low-carbon capacity by 2040.

Cost reductions can largely be attributed to greater manufacturing efficiencies through higher volumes, but to drive further reductions the industry recognises there will need to be a step-change in cell efficiency. The commercialisation of perovskite-based tandem solar cells could be the development the industry is looking for.

Ten years ago, the conversion efficiency of solar cells was around 11-12 per cent; today it is typically a little over 20 per cent. The theoretical efficiency of conventional silicon solar cells, however, is about 29 per cent. Since the theoretical limit can never be achieved, many in the industry believe the most that can be cost-effectively reached is probably around 25 per cent.

Commenting on the need for new technology, Frank Averdung, CEO, Oxford PV said: "The improvement potential of conventional silicon technology will be exhausted in three years or so. Alternative technologies will need to come into play to drive efficiency. And one way of addressing this is with tandem cells. This is where you have two silicon cells on top of each other for greater efficiency."

**Averdung: Oxford PV has brought the technology from lab scale to an "early industrial" scale**

It is a concept that has been known for 40 years or so, having been used in space applications. But while cost is not an issue in a space project or satellite, for a rooftop installation in Europe the high cost would not be acceptable.

Averdung believes, however, perovskites will make tandem cells economically feasible for terrestrial applications.

Perovskite is a calcium titanium oxide mineral composed of calcium titanate discovered in the Ural Mountains in 1839 but it also lends its name to a class of compounds, which have the same type of crystal structure as calcium titanate. This structure known as the perovskite structure is named after Russian mineralogist Lev Perovski.

This crystal structure can be created in different materials to give the material different properties. It has been used, for example, in high temperature superconductors. The potential use for solar cell applications, however, was realised around 2011/2012 by Henry James Snaith, a physics professor in the Clarendon Laboratory at the University of Oxford, United Kingdom.

His work in the labs led him to be the co-founder of Oxford PV, which has since been working to develop the technology to a level where it is nearing commercialisation.

Averdung explained the perovskite-on-silicon tandem solar cell technology. "You create these layers of perovskite material on top of an existing silicon cell to make a sandwich, which acts pretty much as one solar cell. This increases the efficiency of the bottom cell by between 20 and 30 per cent."

As with many technological advances, however, commercialisation has not been without its challenges. In the early lab projects, it was found that the material was very sensitive to moisture and temperature and so was not very durable.

Oxford PV has therefore focused on developing alternative material compositions and other ways of building the cells. According to Averdung, these activities have enabled the technology to be brought from lab scale to an "early industrial scale".

He said: "Typically, in academia they make very tiny solar cells – sometimes 1 $mm^2$ is good enough to demonstrate that the cell is working, or achieves a certain efficiency. Unfortunately, that is a long way from going to a cell that is six square inches. We have therefore worked on tens of thousands of different samples of 1 $cm^2$ and generated millions of data points, and have since scaled up to 9 $cm^2$."

This, however, being the limit of the equipment at the Oxford R&D lab, meant the company had to look at how it could increase the cell size still further. In late 2016 it acquired a thin film solar manufacturing operation in Brandenburg an der Havel, near Berlin, Germany, that was previously owned by Bosch.

"They were selling the asset, so we bought the entire site including some of the equipment. It was the only site that had all the criteria we were looking for – a complete manufacturing infrastructure with still some equipment left, and in an area where we could find experienced thin film photovoltaic engineers," said Averdung.

With the R&D and development carried out in the UK and the engineering and manufacturing taking place in Germany, Averdung says this utilises the strengths of both countries.

The move has enabled Oxford PV to scale up the cell to the industrial size of 156 mm x 156 mm, while increasing cell efficiency. The company is now in the process of putting in more equipment in order to increase output and bring the product to a level where manufacturing partners can put the cell into commercial manufacture.

As the plant is in Germany, Averdung says it will ensure commercialisation of the technology will be unaffected by Brexit and also remains eligible for all EU funding.

Such funding has been important in the journey towards commercialisation. In late December last year, Oxford PV received EU bank financing of €15 million.

The European Investment Bank (EIB) loan, awarded to Oxford PV Germany GmbH, is the first financing in Germany under the InnovFin – EU Finance for Innovators' Energy Demonstrator Projects', with the financial backing of the European Union under Horizon 2010 Financial Instruments – aimed at supporting European innovators tackling tomorrow's challenges and supporting climate action.

More recently, Oxford PV secured a further £8.02 million in funding from existing investors including Statoil and Legal & General Capital.

The money essentially supports the investment in the demonstration pilot line facility in Brandenburg.

"The funding supports the transfer from 'lab to fab', understanding that you never move from the lab straight into volume manufacturing and that there is an intermediate step, which is the pilot line," said Averdung. "The funding allows us to invest in the capital equipment needed to increase the throughput and pay for operating costs such as people, etc. It's a three-year programme at the end of which the pilot line will be fully established."

Having started in 2016, i.e. the time at which the site was bought and the EU funding application submitted, the programme will be completed around the summer of next year. The first cell is expected to be available shortly after.

Yet bringing a new technology like this to market is never easy, especially when the incumbent technology – silicon solar cells – is so successful. But with the limitations in cell efficiency presenting a looming obstacle to an industry that is expected to grow by a factor of 10 over the next 10 years, companies will be keen to move the technology forward.

"The industry will double in size every three years, which is amazing. So although there are already fairly big companies in this field – multi-billion dollar companies – they are still small compared to what they will be 10 years from now," noted Averdung. "Companies with a more strategic view realise there's a necessity for continuing with the efficiency roadmap because it's part of the LCOE roadmap."

He says Oxford PV's business model will be to not get involved in manufacturing cells, noting that is better done by the existing big players in the industry. The company therefore plans to licence the technology to industrial partners and, as he puts it, "those that have a strategic view on things".

He said: "We want to licence to companies that are large enough to bring this technology to the market, companies that respect IP [Intellectual Property] and companies that, realising the potential of this technology from early on, want to work with us."

According to Averdung, Oxford PV has already reached an agreement with one such big company as a joint development partner that will help optimise the technology – initially for manufacturing their own wafers. In return, that partner will gain early access to the technology.

"Manufacturability is a big element that is necessary for successful market introduction," said Averdung. "Making a product on a small scale in a lab manually is different to volume production where you produce 3600 wafers every hour. So you need that competence from a partner in helping you to work out the right manufacturing processes, how to scale up those processes and whether they are fast enough to later on support manufacturing."

With the first partner in place, it is possible the industry could be witnessing a step-change in solar PV cell efficiency in the 2019-2020 timeframe. The next 18 months will be an even more exciting time for the solar PV industry.

# Changing the formula

Junior Isles

The moving energy landscape is changing things for all of us, sometimes for the better. I recently had the pleasure of attending a press visit to attend a Formula-E Championship race in Rome, Italy. Not so long ago, it would have been impossible for a journalist in the power and energy field to justify such a trip but the whole energy transition is seeing a cross-pollination of technologies and overlap of industry sectors that could not have been anticipated just a few years ago.

While the electricity sector is making tremendous progress in decarbonisation, there is much to be done in transport. The realisation that decarbonisation of transport will be crucial in meeting carbon emission targets is seeing the move to electric vehicles gain momentum. It is a trend that presents new opportunities for utilities.

Tom Harper is Director of UK Utilities at global management consulting firm A. T. Kearney and also runs a team within the company called Helios. Speaking during a recent webinar on electricity storage and battery vehicles, he said: "There's been a huge convergence of previously isolated industries. Prior to today, there has been a very nice segregation of oil and gas, utilities, and the automotive sector. But when you look at the disruptive forces on all of those industries, it drags you straight into the world of electrification."

He noted that by 2030 in the UK there would be more generating capacity available from electric vehicles than from the planned Hinkley Point C nuclear power station. It is an interesting development that could offer new models for electric utilities.

"Within electric vehicles, you have a pre-financed asset, said Harper. "If you're looking for a way of financing and enabling energy storage at scale… right now it's one of the most economically viable ways of large corporates getting access to, and harnessing, the value of stored energy."

There is a growing interest in the ability of vehicles to provide power back to the grid. According to Harper, vehicle-to-grid (V2G) could provide a new "value pool" for utilities to interact with customers and generate revenue. He estimates it could generate £350-1500 per year per vehicle in cash by aggregating and trading electric vehicle loads at times of peak demand on the power exchange markets.

Indeed utilities are already gearing up to seize the opportunity. Last month alone saw several significant announcements by major electricity companies.

UK energy company OVO unveiled a range of products that, together with its intelligent platform VCharge, will form the components of a distributed, domestic energy system for the future. The range includes what it claims to be the world's first widely available, domestic bi-directional vehicle-to-grid charger to enable drivers to also sell surplus energy from their electric vehicle batteries back to the electricity grid.

OVO CEO and Founder Stephen Fitzpatrick said: "Renewable energy and electric vehicles are perfect partners for the 21st Century. Today we're launching the world's first widely available vehicle-to-grid charger, helping to solve one of the biggest challenges facing the energy sector. We're enabling thousands of EV batteries to help balance the grid in times of peak demand, more renewable energy to come onto the system, and households to reduce their electricity bills.

Other big players also announced expansion of their EV activities. Swedish utility Vattenfall last month created a new business unit in a drive to expand its EV charging network in Northwest Europe and become a leader in the field in the next five years.

The company already has 8800 charging points at home, in Germany and in the Netherlands. It wants to also grow in markets such as the UK, France and Norway. Vattenfall has launched a programme to electrify its own fleet of 3500 vehicles. As part of it, it will use EVs or hybrid-cars by 2022.

Commenting on the plan, Tomas Bjoernsson, head of the new E-mobility unit said: "From now on we expect our charging network to double in size every year in order meet a sharp increase in electric vehicle growth." He added that the company aims to reach SEK 1 billion ($119 million) in revenue in five years.

Also in April, German utility E.On said it is expanding its electro-mobility business internationally and intensifying competition in Norway, one of the world's leading markets for electric vehicles. The company is launching a nationwide product campaign to promote its mobility offerings for private customers, companies, and local authorities. It said its goal is to profit from the rapidly growing market and to establish itself as a leading provider of charging solutions in the Nordic countries.

The whole V2G movement and increasing electrification also means new markets opportunities for equipment manufacturers.

ABB, which hosted the Rome press trip as a new sponsor of Formula-E, sees a number of synergies.

Ulrich Spiesshofer, CEO, ABB Group told *TEI Times*: "For electric mobility success, you need four things: you need the vehicle; the charging; grid reinforcement to make sure charging does not lead to blackouts; and if you want to have a real sustainable chain, you need to integrate renewables to really remove the carbon. ABB is No. 1 in three of these activities. We are No. 1 in fast charging for cars, No. 1 in the power grid business and No. 1 in integrating renewables. And we have a firm ambition to drive this in the future. So for me, e-mobility is much more than the charging station. It is a demand pattern that has significant impact on the topology of the grid."

Speaking from the pit lanes in Rome, Frank Duggan, President Region Europe and Member of the Group Executive Committee of ABB Ltd, Switzerland, said: "It aligns with ABB on a number of levels. Firstly, the whole area of e-mobility and e-cars – we are the biggest manufacturer of the fastest chargers in the world. We are also very strong in renewable energy. And to go to e-mobility, you have to use a lot of renewable energy. This is all changing the dynamic of the grid, which plays into our sweet spot."

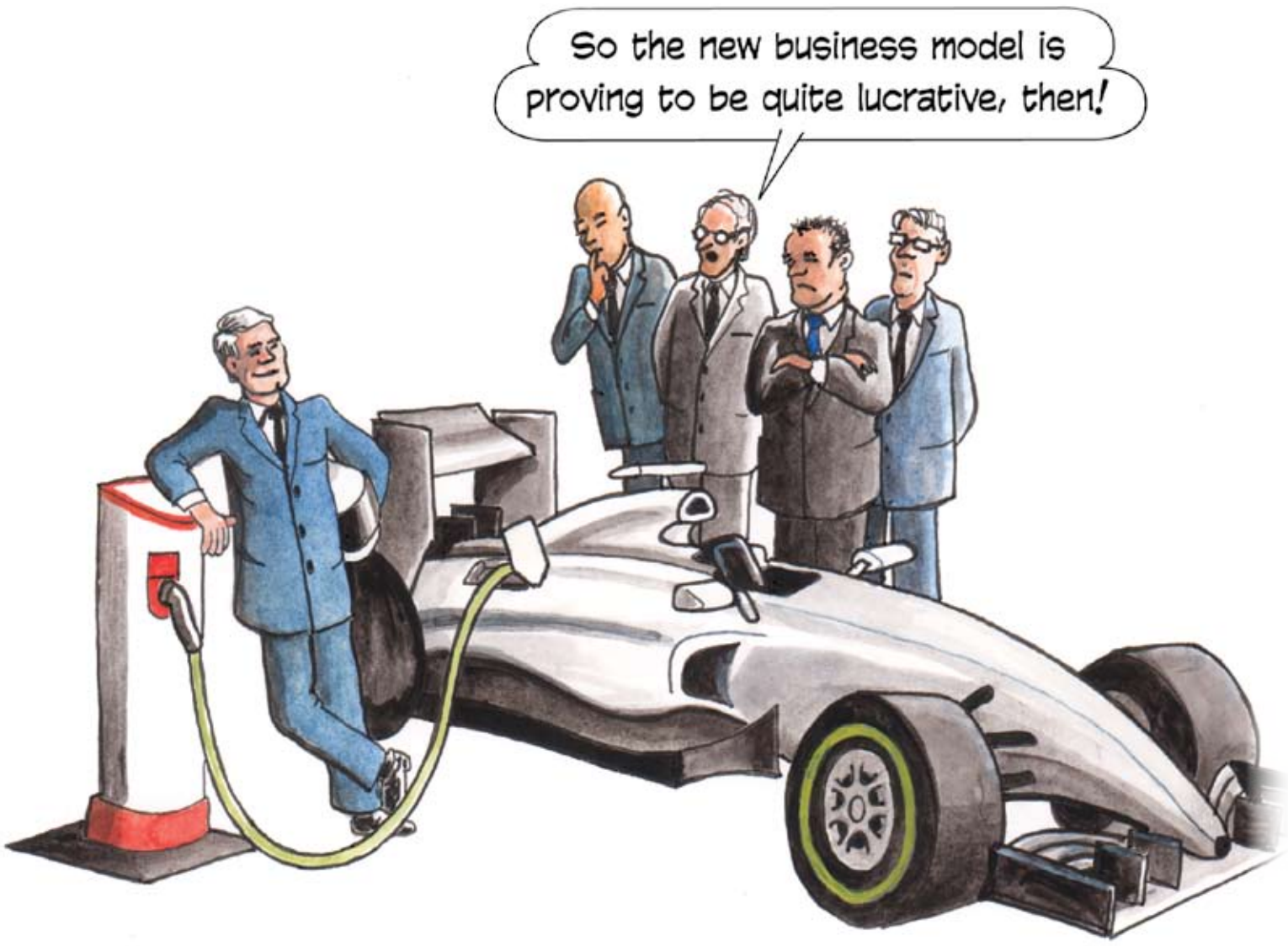
The sponsorship of Formula-E now brings the company greater public visibility. "As a B2B company, for a company of our size, the general public perhaps doesn't know ABB's name as well as some of our competitors who have consumables. So this was a way of getting the brand more into the eyes of the general public," said Duggan.

ABB is only four or five months into a seven-year sponsorship of Formula-E, so its relationship with the sport is still in its infancy. But as a technology company "always looking at innovation and pushing boundaries", Duggan says it is taking a long term view on what might come out of it in terms of technology.

"This is different from Formula-1 because what we see here is a big live laboratory for testing new technology… some of the stuff they are doing here in Formula-E, you will see end up in everyday cars.

"Sometimes you develop something and it really doesn't inspire or hit the world for many years. We developed HVDC in the mid-1950s but its real use and growth only really started in the last 10 years. So I do believe in the coming together of partners like this. Formula-E is an opportunity to develop new technologies and collaborate with other partners."

From a personal point of view, long may the integration and overlap of formerly distinctly separate industries continue. Not only does it deliver new and unexpected outcomes and opportunities for industry players, it also makes for somewhat more enjoyable press trips – not that there is anything wrong with visiting power plants and equipment manufacturing facilities.

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