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Special Supplement

The massive Samcheok Green Power Project in South Korea takes circulating fluidised bed technology to the next level.

Some like it hot

Greenhouse gas emissions have reached an all-time high, yet some world leaders seem reluctant to stand behind the green push. *TEI Times* hears what more can be done. ***Page 14***

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Slowdown in clean energy investment threatens climate goals

Birol: decline in investment for renewables and energy efficiency "is worrying"

The energy transition seems to have paused as investments in clean energy falls, according to the International Energy Agency's latest World Energy Investment report. **Junior Isles**

The latest data published in the International Energy Agency's *World Energy Investment* (WEI) *2018* report reveals a "worrying" fall in clean energy investment.

According to the report, renewable power investment fell to $298 billion in 2017 from $318 billion in 2016, representing the biggest absolute drop since the agency started keeping track of clean power in 2000.

The report also finds that after several years of growth, combined global investment in renewables and energy efficiency declined by 3 per cent in 2017 and there is a risk that it will slow further this year.

The IEA's figures show that although electricity investment has shifted towards renewables, networks and flexibility, expected output from low carbon sources fell 10 per cent in 2017 and did not keep pace with demand growth.

This indicates that investment is not growing in a way that supports deep decarbonisation of the power system, said the IEA. At the same time as investment in renewables falling by nearly 7 per cent, nuclear investment in 2017 plummeted 45 per cent.

"Such a decline in global investment for renewables and energy efficiency combined is worrying," said Dr Fatih Birol, the IEA's Executive Director. "This could threaten the expansion of clean energy needed to meet energy security, climate and clean air goals. While we would need this investment to go up rapidly, it is disappointing to find that it might be falling this year."

While energy efficiency showed some of the strongest expansion in 2017, it was not enough to offset the decline in renewables. Moreover, efficiency investment growth has weakened in the past year as policy activity showed signs of slowing down.

Michael Waldron, one of the report's lead authors noted: "The fastest growing area was in energy efficiency. Although slower than in 2016, this

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Clean energy investment remains steady in first half of 2018

Overall clean energy investment was steady in the first half of the year, thanks to a strong second quarter for wind power investment, led by the US and China, according to research company Bloomberg New Energy Finance (BNEF).

Its latest figures show world investment in clean energy in the first six months of 2018 at $138.2 billion, down just 1 per cent from the same period in 2017. The second quarter, from April to June, actually saw a rise year-on-year of 8 per cent to $76.7 billion.

The first half of 2018 shows solar investment down 19 per cent compared to the same period last year at $71.6 billion, with wind up 33 per cent at $57.2 billion. The slippage in solar reflects two main developments – significantly lower capital costs for photovoltaic projects, and therefore fewer dollars spent per megawatt installed; and a cooling-off in China's solar boom. These trends are set to gather pace in the second half, says BNEF.

Justin Wu, head of Asia-Pacific at BNEF, said: "On June 1, the Chinese government released a policy document restricting new solar installations that require a national subsidy, with immediate effect. We expect this to lead to a sharp drop in installations in China this year, compared to 2017's spectacular record of 53 GW."

Pietro Radoia, senior solar analyst at BNEF, added: "It will also mean overcapacity in solar manufacturing globally, and yet steeper price falls. Before the Chinese announcement our team was already expecting a 27 per cent fall in PV module prices this year. Now we have revised that to a 34 per cent drop, to an end-2018 global average of 24.4 U.S. cents per watt."

In its *World Energy Investment 2018* report, the International Energy Agency also said that policy changes in China could result in a slowdown in investment in solar PV this year.

In the first half of 2018, China invested $35.1 billion in solar, down 29 per cent from 1H 2017. However, BNEF expects the full extent of the government-ordered cutback to become clear only from the second half of the year onwards. Its analysts see a possibility that that world solar installations in 2018 could fall for the first time on record. In 2017, they totalled 98 GW, far more than for any other technology, renewable or non-renewable.

The jump in wind power investment in the first half of 2018 came thanks to a stream of large project financings from the US to Taiwan and from India to the Netherlands and Norway.

The news comes as the World Bank released figures that show it invested $20.5 billion during the 2018 fiscal year on projects which address the impacts of climate change. This represents 32.1 per cent of all funding and exceeds its target of spending at least 28 per cent of its finances on tackling the problem by 2020.

"We have not just exceeded our climate targets on paper, we have transformed the way we work with countries and are seeing major transitions to renewable energy, clean and resilient transport systems, climate-smart agriculture and sustainable cities," said the bank's Chief Executive Officer Kristalina Georgieva.

As a result, the bank will set new targets at the December UN climate conference in Poland.

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was up 3 per cent. At the same time, however, renewable investment was down by nearly 7 per cent. When you put energy efficiency and renewables together, which are two things that are critical to the clean energy transition, you find that this combined investment was down three per cent – this is after two years of increase."

The IEA also said there has been a 13 per cent decline in renewables for transport and heat, which is important for the decarbonisation of sectors outside of electricity. This, it says, is largely due to insufficient policy support.

An important finding from the report is that electrification, a key part of the energy transition is continuing.

The electricity sector attracted the largest share of energy investments in 2017, sustained by robust spending on grids, exceeding the oil and gas industry for the second year in a row.

In 2017, total investment in the energy sector was about $1.8 trillion. This was led by the electricity sector, which saw an overall investment of $750 billion, sustained by investment in networks. It was the third consecutive year that energy investment had declined, falling by 2 per cent in real terms compared with 2016.

"It was a smaller decline than in previous years, where we'd seen a dramatic fall-off in oil and gas spending, partly related to the decline in oil and gas prices as well as falling costs," said Waldron.

Last year the largest decline in energy occurred in the electricity sector, falling by 5 per cent, largely due to a significant decline in investment in power generation.

However, the fact that investment in the electricity sector is outpacing oil and gas is a good indication that electrification of the energy system is gaining momentum, said the IEA.

Waldron cautioned, however: "We see this as a long term trend tied to energy transition but the relationship is very close in terms of the numbers and it's a trend that could easily reverse next year.

"The share of fossil fuels in energy supply investment actually ticked upward from 58 per cent last year to 59 per cent in 2017. This was in stark contrast to a significant fall in previous years. Previously, this figure was up at around 68-70 per cent, indicating that there has been a pause in the shift towards the investment in clean energy."

The report observed that while the private sector typically leads clean energy investment, governments are increasingly playing a more important role in terms of driving investment across the entire energy sector. The IEA noted that the share of investments by state-owned enterprises (SOEs) in oil and gas, and thermal power generation was "more resilient" than the private sector.

Waldron said: "The private sector plays a greater role in cleaner sources of investment – renewables and energy efficiency – but even in this broad category we saw a bit of an uptick in the role of SOEs in terms of driving investment."

This says the IEA, was partly due to the role of China and the increase in solar PV in the country. As China accounts for more than 40 per cent of global investment in solar PV, its policy changes have global implications. This confirms past IEA reports that have highlighted the critical importance of policies in driving investment in renewable energy.

Denmark sets new renewables target, as cost of offshore wind slides

Luter says improved methods of developing and producing blades will help cut LCOE in offshore wind

- Plan for 2.4 GW of offshore wind
- MHI Vestas says "still room to go lower" on cost of energy

Junior Isles

Offshore wind looks set to play a key role in Denmark's recently agreed new target for renewables.

At the end of June the government reached an agreement with all the parties in the Danish parliament that will get Denmark to 55 per cent of renewable energy by 2030. This means all of its electricity and heating needs will be covered by renewable energy sources.

The deal includes new commitments for the build-out of offshore wind. Three new offshore wind farms with a capacity of at least 2.4 GW will be built in the next decade. The first of those offshore wind farms will be tendered in 2019-2020 and commissioned between 2024 and 2027.

In addition, DKK 4.2 billion ($657 million) has been earmarked for technology-neutral green energy auctions in the period 2020-2024 where different technologies such as wind and solar compete to deliver power at the lowest price.

Future onshore wind deployment in Denmark will be supported through auctions. The government plans to reduce the number of wind turbines from 4300 to 1850. This means that onshore wind in Denmark is becoming a repowering market where old turbines are replaced by state-of-the-art models.

Commenting on the plan for new offshore wind capacity, WindEurope Head of Advocacy & Messaging Joël Meggelaars said: "It's good to see that 2.4 GW will be added to Denmark's growing offshore wind capacity. This is only a floor as two out of the three projects could become larger, potentially bringing the offshore volume to 3 GW. But we would have liked to see some of that ambition being frontloaded. Denmark's offshore build-out comes to a halt in 2021. And in 2024 at the earliest the supply chain can get back to work."

Denmark has several offshore wind farms in operation, approved or under construction, including the 406.7 MW Horns Rev 3, the 605 MW Kriegers Flak, and the Vesterhav Syd and Vesterhav Nord near-shore wind farms.

The plan to boost existing capacity comes as new data that the levelised cost of energy (LCOE) from offshore wind continues to fall. Last month the Danish Energy Agency launched an updated LCOE calculator, which shows that costs to build and operate an offshore wind farm in the country have declined by more than 30 per cent compared to previous projections.

The LCOE for a Danish offshore wind project is expected to have fallen to €46/MWh excluding grid and system costs with a production start in 2020, the new calculations show.

Compared to previous assumptions, CAPEX is expected to have gone down by close to 40 per cent. Also, improvement in operation and maintenance is expected to reduce OPEX by more than 20 per cent. At the same time, improvement in wind and power-train design is expected to increase the amount of full-load hours of Danish offshore wind projects by 10 per cent, giving a capacity factor of more than 50 per cent.

Increasing turbine size has also been a key factor in the falling cost of offshore wind. April this year saw the installation of the world' most powerful single turbine – MHI Vestas' V164-8.8 MW turbine – at Vattenfall's European Offshore Wind Deployment Centre (EOWDC) in Aberdeen, Scotland.

Commenting on the falling cost of offshore wind, James Luter, Director of Production, MHI Vestas Offshore Wind said: "In 2014, we were saying the cost of energy from an offshore turbine was around £130/140 per MWh… now we are seeing bids of around £57 per MWh and we believe there is still room to go."

Speaking from the company's lead blade manufacturing site on the Isle of Wight, Luter said improved methods of developing and producing blades will play a key role in further reducing the LCOE from offshore wind.

"If you look at other industries, such as car manufacturing, we're still quite young in the whole maturity phase. So there's a long way to go in terms of cost reductions. There's plenty we can learn from other industries," he said.

Luter pointed out that prototyping of the V164-8MW platform was a "big leap forward", one that has seen the company rapidly grow its market share in the offshore wind sector. He adds that the joint venture between Vestas and MHI will see the continued adoption of manufacturing techniques and processes at the Isle of Wight facility, which will all contribute to lowering costs.

Calls for clarity after renewable subsidies end next year

With all aspects of the UK's Feed-In Tariff (FiT) for small and medium scale renewables due to close next March, the renewables industry and potential investors are urgently requesting clarity on the policy framework going forwards.

Last month the government announced that the FiT, which supports the deployment of small-scale renewables such as solar panels and small wind turbines, is to close with no policy to replace it.

Alongside this announcement, the Department for Business, Energy and Industrial Strategy published a Call for Evidence on potential new policies for small-scale renewables.

The FiT was established in 2010 and provides payments to owners of small-scale renewable generators at a fixed rate per unit of electricity produced, ensuring that the cost of installation is recouped over the lifetime of the generator. As the cost of renewables has plummeted over the past eight years, this fixed rate payment has fallen by up to 90 per cent.

The 2015 Feed-in Tariff review set out that the current FiT scheme would close in April 2019. The government committed to setting out its policy on post-2019 support for small-scale renewables over a year ago but this has been repeatedly delayed, causing huge uncertainty for companies in the sector.

RenewableUK expressed disappointment at the announcement. Executive Director Emma Pinchbeck said: "Confirmation that there will be no replacement for the feed-in tariff is a major blow to small-scale renewables in the UK. The government has known the FiT would be closing for three years and the fact that they are only now beginning the conversation about new policies is far too little, far too late for many companies."

The news is expected to hit the solar industry particularly hard. Subsidies have helped the industry to flourish and bring down costs. According to the Solar Trade Association (STA), an average domestic solar system cost £12 000 in 2010; today it is nearer £5000.

Chris Hewett, CEO of the STA said: "The good news, as we look beyond FITs, is that solar is coming of age and while solar always makes great environmental sense it now makes economic sense for most investors without public subsidies given fair treatment by government.

"The bad news is that government has been crystal clear on what policy measures will stop – even very basic rights to fair export payments – but they are frighteningly vague on what comes next. There is real dismay that there is now a serious and needless policy gap between the end of FiTs and the start of the new regime."

This was echoed by James Court, Head of Policy & External Affairs at the Renewable Energy Association, who said that "positive words" from the government about renewables has to be "backed up by good deeds".

"While nobody in the industry was expecting an 11th hour reprieve for the Feed-in Tariff, the removal of the 'export tariff" for new projects will lead to the truly bizarre situation where consumers who own technologies such as solar will give electricity they don't consume to the grid for free.

"Post-subsidy could be a reality, but in an energy market where nothing, not even gas power stations, can be built without government support, it is unrealistic to expect consumers, businesses or developers to continue installing small scale generation. This could be achieved by tax incentives, market enablers, and planning or building regulations, but we are currently left in an unnecessary policy vacuum without any firm proposals put forward by government."

The Anaerobic Digestion & Bioresources Association (ADBA) noted that the decision also puts at severe risk the more than 300 AD combined heat and power (CHP) plants currently in the planning pipeline.

Charlotte Morton, Chief Executive of the Anaerobic Digestion & Bioresources Association (ADBA), stressed: "It is vital that the government rethinks its baffling decision to have no new low-carbon electricity levies until 2025, which risks creating a valley of death that small-scale technologies such as AD could easily fall into."

EU programme delivers superconducting cable breakthroughs

An international workshop in La Spezia, Italy hosted by ASG Superconductors and co-organised by Nexans and IASS Potsdam in July revealed that several breakthroughs have been achieved within Demonstration No 5 of Best Paths ('BEyond State-of-the-art Technologies for rePowering Ac corridors and multi-Terminal HVDC Systems').

Best Paths is the largest research project funded by the European Union in the energy field in the last decade.

Project leaders said that for the first time a high-voltage superconducting cable system has been designed that operates with direct current. All existing superconducting projects only use alternating current.

A key innovation also revealed was that the cable is manufactured using magnesium diboride as a superconductor, which is very economical to produce.

Giovanni Grasso, Sales and Business Development Manager Columbus Superconductors, said: "The reliability of our magnesium diboride wires has already been demonstrated by a number of full-scale prototype devices, such as MRI systems, induction heaters and fault current limiters… Thanks to projects like Best Paths, the transition from demonstrators to products in the energy sector will be faster and targeted to customers' needs."

The next step for the widespread use of this technology, according to the project team, would be to develop testing guidelines for high-voltage direct current superconducting cables together with a consortium of manufacturers to ensure safety and quality standards.

Argentina tenders first of seven transmission lines under PPP

■ 500 kV Rio Diamante-Charlone line on the block ■ 78 MW of wind capacity reaches financial close

Siân Crampsie

Argentina is continuing to make investments in its power sector with the announcement of tender terms for a high voltage power line.

The project would be the first transmission line tendered under the new Public Private Participation (PPP) scheme and would see the construction of the 490 km, 500 kV Rio Diamante-Charlone line in the centre of the country.

The Ministry of Finance and Energy said that applicants in the tender must have experience in the construction of substations and power lines of over 300 kV, acquired either in Argentina or abroad.

Transmission projects must be up and running within 33 months from the signing of a PPP contract while operation and maintenance services will be provided for up to 15 years.

According to Escenarios Energéticos 2030, energy scenarios published by the Ministry of Energy in December 2017, Argentina expects to add between 14 GW and 18 GW of unconventional renewable energy capacity and reach 25 per cent generation from unconventional renewables by 2030.

The government says that the growth in renewables means that the country's transmission and distribution grid will require reinforcing, and so it plans to tender seven 500 kV transmission line projects in the short term. The seven transmission line projects would total 2175 km in length and represent $2.2 billion of investment.

In June, Argentine energy group Genneia SA said it had closed a $131 million project financing for two wind projects with a combined capacity of about 78 MW.

The financing covers the 50 MW Villalonga project in the province of Buenos Aires and 28.35 MW Chubut Norte in the province of Chubut that were awarded to Genneia as part of the first round of Argentina's RenovAr renewable energy auction programme.

Genneia signed the contracts with Argentina's Ministry of Mines and Energy for these projects in January 2017. The firm said that the financing involves Denmark's export credit agency EKF, which provided the majority of the senior debt, Dutch development bank FMO, and Latin American development bank CAF, which participated with long-term uncovered loans.

Japanese bank SMBC provided long-term financing under an EKF cover facility and acted as a global coordinator for the deal.

SCE expands EV programme

Southern California Edison (SCE) says it is ready to support the growth of electric vehicles (EVs) in the US state of California.

The utility has proposed a $760 million programme to support the installation of 48 000 EV charging ports over four years.

The programme would follow on from the firm's Charge Ready pilot scheme, which it launched two years ago, and under which it installed more than 1000 EV charging ports.

"Achieving California's ambitious goals for reducing air pollution and harmful greenhouse gas emissions will require 7 million electric cars on California highways by 2030," Caroline Choi, SCE senior vice president for regulatory affairs, said in a statement. "Taking Charge Ready to the next level will allow SCE to develop charging infrastructure needed to support a big portion of those cars."

Charge Ready will increase the availability of EV charging stations where people park their cars for extended periods of time, like workplaces, campuses, recreational areas and multi-unit dwellings.

California's Air Resources Board (ARB) recently said that the state has cut its greenhouse gas emissions to below 1990 levels for the first time.

According to the ARB, emissions in California have been reduced by 13 per cent since their 2004 peak, equal to taking 12 million cars off the road. At the same time, its economy, now the fifth largest in the world, grew by 26 per cent.

Under a 2006 law passed by the then Governor Arnold Schwarzenegger, California must reduce its emissions to 431 million metric tons by 2020 – the same as they were in 1990. Data released by the ARB shows that as of 2016 the level was at 429 million tons.

"California set the toughest emissions targets in the nation, tracked progress and delivered results," said California Governor Jerry Brown. "The next step is for California to cut emissions below 1990 levels by 2030 – a heroic and very ambitious goal."

The greatest falls were seen in the electricity sector, which has reduced emissions by 18 per cent, largely due to the growth in renewable energy.

US advances SMR development

The US government is seeking to further development and innovation in the small modular reactor (SMR) sector with funding for several key projects.

The US Department of Energy (DOE) has awarded funding to NuScale, GE Hitachi and Columbia Basin Consulting Group for research and development in advanced reactor design and demonstration.

The projects are part of a wider funding announcement last month by the DOE covering a total of $20 million for nine nuclear projects, and follows a similar funding award for nuclear energy announced in April.

Further funding announcements are expected in 2018 and over the next five years as part of efforts by the US government to support advanced reactor development and establish domestic capabilities in the US nuclear sector.

The latest funding award includes $7 million from the DOE for NuScale to advance the licensing and design for its SMR in order to meet a commercial operation date of 2026 for its first plant. DOE has also awarded $400 000 to Columbia Basin Consulting Group to develop a pre-conceptual design and preliminary cost estimate for a lead-bismuth SMR, and $1.925 million to GE Hitachi Nuclear Energy to reduce the costs of its BWRX-300 SMR.

NuScale is aiming to build its first plant at the Idaho National Laboratories. It became the first SMR design to complete the Nuclear Regulatory Commission's phase 1 design review in April 2018. The latest funding will support completion of the independent verification and validation licensing report, completion of the reactor building design optimisation, and level sensor prototype testing.

For its project, GE Hitachi said it would bring together a team consisting of Exelon Generation, Hitachi-GE Nuclear Energy (HGNE), Bechtel and the Massachusetts Institute of Technology (MIT) to examine ways to simplify the reactor design, reduce plant construction costs, and lower operations and maintenance costs for the GEH BWRX-300, a 300 MWe small modular reactor.

Specifically the project partners will look at reducing costs through elimination of Loss of Coolant Accidents (LOCAs), the use of an embedded (below grade) design and construction and the use of pooled off-site resources that can be applied simultaneously at multiple sites.

GE Hitachi estimates that the BWRX-300 will require up to 60 per cent less capital cost per MW compared to other water-cooled SMRs or existing large nuclear designs. If these savings can be achieved, the BWRX-300 can become cost competitive with power generation from combined cycle gas and renewables.

New York plans offshore wind solicitation

New York state is likely to make awards of up to 800 MW of offshore wind capacity in 2019.

The New York State Energy Research & Development Authority (NYSERDA) says it will issue a solicitation for offshore wind energy in the fourth quarter of 2018.

The move is expected to jump-start the state's offshore wind industry, and could be followed a year later by a second solicitation.

It follows the unveiling by New York Governor Andrew Cuomo in June of a 1.5 GW energy storage roadmap designed to help the state build its clean energy economy.

New York is aiming to develop 2.4 GW of offshore wind by 2030, capitalising on the falling costs of offshore wind achieved in Europe.

"This action represents another major step toward establishing a clean energy future that is secure, reliable and cost-effective," Governor Cuomo said. "Robust offshore wind development is not only critical to meeting our clean energy and carbon reduction goals, this investment has the potential to create thousands of jobs and fuel a $6 billion industry for New York as it combats climate change."

Through the solicitation, NYSERDA will procure Offshore Wind Renewable Energy Certificates (ORECs) from awarded facilities.

Each electric utility and other third-party suppliers of electricity serving retail customers in New York will support these new offshore wind resources through the purchase of OREC's from NYSERDA.


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Bangladesh gets moving on big power projects

■ Rooppur II granted licence ■ Agreements signed for 6000 MW of gas fired plant

Syed Ali

Bangladesh is moving forward with plans to build several power plants that will add thousands of megawatts to the grid.

ASE Group of Companies, a part of Rosatom State Atomic Energy Corp (Rosatom), announced that construction work for the second unit of the Rooppur Nuclear Power Plant (RNPP) will start soon, after the Bangladesh Atomic Energy Regulatory Authority (BAERA) granted a licence to the Bangladesh Atomic Energy Commission in July.

Rosatom is supplying two 1200 MW VVER nuclear power plants to Bangladesh, construction of the first of which started in 2017, with commercial launch expected in 2023.

Bangladesh also signed two inter-governmental and inter-agency agreements with India, under which India's Global Centre for Nuclear Energy Partnership (GCNEP) will provide training and consulting services for the project's implementation.

Granting of the licence for Rooppur was one of several major announcements last month that will enable the country to substantially boost its installed capacity.

Also in July, the Bangladesh Power Development Board (BPDB) signed a deal with GE to build a 3600 MW LNG-based power plant on the southeastern island of Moheshkhali in Cox's Bazar.

The development of the land for the project is estimated to cost $1.6 billion and the power plant will cost $2.8 billion, according to details of the memorandum of understanding signed in Dhaka.

GE also signed a separate memorandum of understanding with Summit, the largest private power producer in Bangladesh, to join a joint venture already planned by Summit and Japan's Mitsubishi Corporation for a $3 billion power project. Summit said the joint investment is the largest FDI attracted by any Bangladeshi private company.

Under the agreement Summit, Mitsubishi and GE will build a 2400 MW power plant. Summit will hold 55 per cent equity while Mitsubishi will take 25 per cent and GE 20 per cent.

The deals come on the heels of an announcement in late June by the Asian Development Bank (ADB), which agreed to provide Bangladesh with a $500 million loan to help build a state-of-the-art 800 MW gas fired power plant in Khulna. Part of the loan will also be spent linking the plant to natural gas and power transmission facilities.

The total cost of the project is $1.14 billion, with the Islamic Development Bank contributing $300 million and the government contributing $338.5 million. The project is due to be completed by the end of June 2022.

"Amid the rising demand for energy in a growing economy, the Rupsha power plant will be the first of its kind in Bangladesh, vastly increasing the availability of efficient and cleaner energy," said ADB Energy Specialist Aziz Yusupov.

Bangladesh faces a major challenge in providing modern and affordable energy, while suffering from recurring generating capacity shortages in the power sector, ADB said.

In fiscal year 2017, the peak hour demand was estimated at 10 400 MW but the power generation capacity was just 9479 MW.

The net peak power demand is expected to exceed 13 300 MW by 2020 and 19 900 MW by 2025, as existing power generation facilities gradually retire and need replacing.

Australia seeks strategy to tackle rising energy costs

Australia's Federal Energy Minister Josh Frydenberg has indicated the coalition government could financially support new power generation as part of a set of measures to tackle rapidly rising power costs.

The Australian Competition and Consumer Commission (ACCC) has recommended the government underwrite new power plants to help companies that have not been able to obtain financing to build projects.

Frydenberg said the competition watchdog had identified a failure in the market but stressed the ACCC's report had not favoured any particular technology.

"What they're saying is the government needs to step in here to provide some sort of assurance," said Frydenberg. "This is something that does have a lot of merit and we'll consider it."

Some Nationals and Liberals have claimed the recommendation is vindication for their push to build new coal fired power plants. But Frydenberg said it could include coal, gas, renewable energy or battery storage.

Prime Minister Malcolm Turnbull pushed back against pressure to subsidise coal, arguing that backing one technology over another is a recipe for higher power prices.

The ACCC report, which estimates electricity bills could drop up to 25 per cent for the average household if the report's 56 recommendations are all implemented, received support from Turnbull. "Australians are crying out for an energy policy that is focused on them," he said.

The report states that average annual annual residential power bills have increased by $426 in the decade to 2017-18, with the biggest causes being network costs (35 per cent), wholesale electricity prices (22 per cent), environmental policies (20 per cent) and increased retail margins (16 per cent).

It recommended that government-owned networks in Queensland, Tasmania and Essential Energy in NSW should write down the value of their assets. In NSW, where networks have been privatised, the government should pay consumers a rebate to "offset the impact of over-investment" in networks, it stated.

The ACCC said governments were responsible for "policy failures" over many years at all stages of the supply chain, including selling or merging ownership of power plants, lax regulation to contain network costs and a lack of certainty on emissions reduction.

It also criticised "excessively generous" consumer subsidies for solar installations and the effects of the renewable energy target which had "distorted investment" toward intermittent power sources "in a way that was indifferent to the ability to provide energy to the market when demand requires it".

The ACCC said rooftop solar subsidies should be axed and the states should take on the cost of the solar feed-in tariffs to ease the burden of green power schemes that cost households up to $170 a year.

Renewables investments surpass fossil fuels in India for first time

Investment in renewable power generation surpassed investment in thermal power generation in India last year for the first time, according the International Energy Agency (IEA).

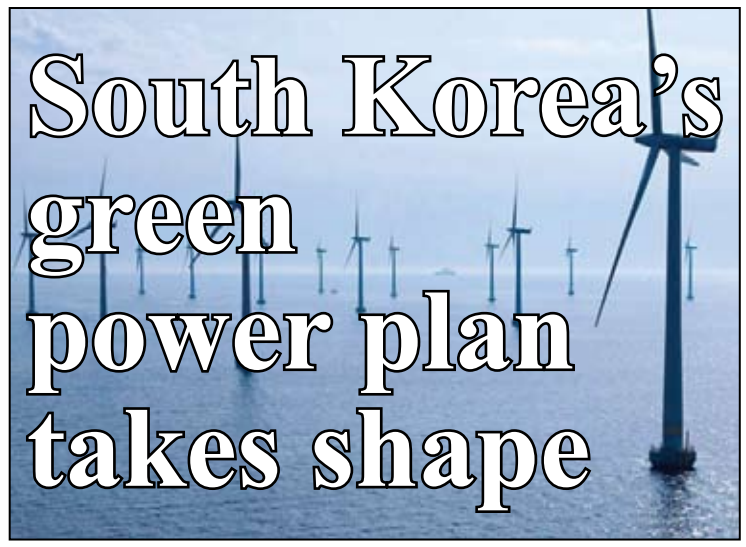
According to the IEA's *World Energy Investment 2018* report there was a global fall in investment in the electricity sector, with much of the slump attributed to a decline in coal fired projects in China and India.

The report noted, however, that it was a record year for solar PV as the average size of awarded solar PV projects in auctions rose by 4.5 times in emerging markets.

The latest figures from Mercom Capital revealed that renewable energy capacity additions continue to increase in India, and accounted for 20.93 per cent of India's capacity mix at the end of June 2018.

According to Mercom's India Solar Project Tracker, in the period from April to June 2018, solar installations totalled about 1.4 GW (preliminary numbers). Cumulative solar installations at the end of June 2018 reached 24.4 GW, representing 7.03 per cent of the total installed power capacity in India.

The numbers were confirmed by consultancy, Bridge to India, which said India's total solar power generation capacity hit 24.5 GW by March 31, 2018, when its fiscal 2017/18 ended. It said 87 per cent was utility-scale solar and the rest was rooftop and off-grid systems.



South Korea's green power plan takes shape

South Korea's Ministry of Trade, Industry and Energy (MOTIE) has announced plans for setting up large-scale offshore wind farms as it targets expanding the country's offshore wind capacity as part of its Renewable Energy 3020 Implementation Plan.

Offshore wind accounts for 12 GW of the total 48.7 GW of new renewable capacity proposed in the Implementation Plan, according to MOTIE. MOTIE also said that in the short term it plans to build up to 500 MW in small and medium-sized offshore wind farms.

South Korea officially opened its first commercial offshore wind farm in November 2017. The Tamra offshore wind farm comprises ten 3 MW Doosan wind turbines installed about 0.5-1 km offshore Geumdeung-ri on Jeju Island. The project will serve as a forerunner to developing projects with larger turbines.

At the end of June, Doosan Heavy Industries & Construction was chosen as the main contractor to develop an 8 MW offshore wind turbine within a 48-month long Large-Capacity Offshore Wind Power System Development project worth KRW 55 billion ($49 million).

The turbine will be able to generate up to 8 MW at an average wind speed of 10m/s and will have a utilisation rate of 30 per cent or higher even when the average wind speed is 6.5m/s, Doosan said.

Such developments are all part of the government's policy to wean the country off fossil fuel and nuclear and shift to renewable sources for power.

Notably, last month Korea Western Power Co., Hanp Inc., KB Securities Co., Chungcheongbuk-do provincial government, and Jincheon-gun office signed a business partnership agreement to build a green energy power plant that will host the world's largest capacity 80 MW fuel cell power plant inside Hanp's 27 000 m^2 manufacturing site in Jincheon.

Once the fuel cell power plant begins operations, it will be able to produce 656 GWh electricity, which can meet the electricity needs of about 240 000 households.

Renewables rise in Germany

■ Green growth puts pressure on grid system ■ More tenders needed to reach goals

Siân Crampsie

Renewable energy is continuing to overtake fossil fuels as Germany's main source of power as the country continues its *Energiewende* policy.

German industry group BDEW said last month that renewable energy generation passed an important milestone in the first half of 2018, becoming the single largest power source ahead of coal in the country's gross power production mix.

However the group warned that the figures show that an accelerated power grid expansion in Germany is "more necessary than ever before", and that the country still lacks a reliable backup system for periods of low renewables output.

This problem will intensify as more coal plants close, and when Germany's last nuclear plant closes in 2022.

According to BDEW, renewable energy sources increased their output by 10 per cent between the first half of 2017 and the same period one year later, raising their share in the power mix from 32.5 to 36.3 per cent in 2018. Onshore wind power saw the biggest increase of all renewable sources, bringing its share in output up from 12.5 per cent to 14.7 per cent in one year.

Power generation from hard coal dropped significantly from 15.6 per cent to 12.6 per cent, and that from lignite decreased slightly, from 22.9 to 22.5 per cent. The use of gas dropped by more than one percentage point to 12.3 per cent of the gross power production mix, while that of nuclear energy grew by one percentage point to 11.3 per cent.

In June, Germany's government launched a coal exit commission, tasked with managing the definite phase-out of Germany's coal plants without causing major economic disruptions in the affected regions. One month later, parliament passed an amendment to the Atomic Energy Act approving the accelerated phase-out of nuclear energy.

Germany's new coalition government has given up hopes of meeting its climate target of reducing carbon emissions to 40 per cent by 2020. It now expects to limit emissions to 32 per cent, compared to 1990 levels, due to unexpected economic and population growth.

In July VDMA Power Systems said that the German government's targets, which also include covering 65 per cent of the country's power generation from renewable energies by 2030, could be attained if it committed to adding more offshore wind energy to the power mix.

According to VDMA, energy policy in Germany has come to a "standstill" and the coalition government needs to hold additional tenders for offshore wind energy as soon as possible. There should also be a rapid increase of the expansion paths for all renewables, VDMA said.

Germany has 5387 MW of offshore wind capacity in operation, and a further 1944 MW under construction, half of which is expected to be on line by the end of 2018.

Germany's transmission system operator (TSO) TenneT has also called for an "optimisation" of Germany's offshore wind sector with an additional capacity auction and the linking of wind farms in the German North Sea to the Dutch grid.

UK warned on nuclear policy

A body of independent advisors has cautioned the UK government against rushing to support multiple new nuclear power stations so that it can be flexible in the future over low carbon energy choices.

The National Infrastructure Commission (NIC) has published the country's first ever National Infrastructure Assessment, and says that switching to greener forms of energy need not mean higher energy bills for consumers, and that there is a "golden opportunity" to decarbonise the UK's energy systems.

The NIC notes in its assessment that after Hinkley Point C, the government should only agree support for one more nuclear plant before 2025, and that investment should be directed into renewable technologies such as wind and solar.

It has also recommended that the government sets out clear dates and budgets for future renewables auctions, and that efforts in energy efficiency should be ramped up.

Currently, around 30 per cent of the UK's electricity comes from renewable sources like wind and solar power – up from 12 per cent only five years ago. The National Infrastructure Assessment recommends that the government take steps to push this even further and ensures that a minimum of 50 per cent of electricity comes from renewables in 2030.

The assessment report came just days before National Grid published its Future Energy Scenarios (FES) report, a document that examines how the evolving energy landscape in the UK might look in 30 years.

The FES report suggests that the UK would meet its 2050 carbon target if rapid decarbonisation is achieved through, for example, the rapid uptake of electric vehicles, renewables growth as well as improved energy efficiency.

Chairman of the National Infrastructure Commission Sir John Armitt said: "Whether for cooking, lighting, keeping homes warm or electric cars on the road, where the UK's energy comes from will need to change radically over the coming decades if the UK is to meet its legally-binding climate change targets.

"If we act now we have a golden opportunity to make our country greener, and protect the money in the pockets of consumers long into the future – something few of us expected to be able to do.

"Ministers can seize this chance by investing in renewables and other low-carbon technologies so they become the main players in our energy system – something that was considered a pipe-dream as little as a decade ago. But they need to act now to realise the full potential of what can be achieved."

National Grid's FES report suggests that reaching the UK's carbon targets by 2050 would require an installed offshore wind capacity of over 40 GW. There would also be over 33 million EVs on the road by 2038, and widespread use of hydrogen in the commercial transport sector. Its analysis also notes the importance of energy storage and interconnectors linked to other electricity markets.

"Market development, new technologies and new ways of designing and operating networks will be needed to address the operational challenges that arise," National Grid said.

Under the Climate Change Act 2008, the UK must reduce greenhouse gas emissions by 80 per cent from 1990 levels by 2050.

■ The UK government has rejected the possibility of awarding funding to the proposed 320 MW Swansea Bay tidal lagoon project in Wales because it would not meet the requirements for value for money. Developer Tidal Lagoon Power is developing a total of six tidal schemes around the UK and had approached the government for a contracts for difference (CFD) agreement for Swansea.

Long-awaited RESS approved in Ireland

■ First auction in 2019
■ Contracts based on floating FiP mechanism

Renewable energy developers in Ireland will be able to move forward with shovel-ready projects after the government approved a long-awaited renewable energy support scheme (RESS).

Ireland's Minister for Communications, Climate Action and Environment, Denis Naughten, announced in July that he had secured Cabinet approval for the scheme and would now seek State Aid approval from the EU. He added that the RESS would encourage community participation while meeting the government's policy objective of increasing technology diversity and energy security.

The new RESS will be based around competitive auctions, the first of which will be held in 2019 and aimed at getting shovel-ready renewable energy projects on-line as quickly as possible.

RESS auctions will be held at frequent intervals and will support solar and offshore wind. It will provide for a renewable electricity ambition of up to 55 per cent by 2030.

"While the auction approach will provide a route to market for multiple technologies, it will do so in a competitive, cost effective framework," said Naughten. "The use of certain 'levers', such as near term delivery dates and 'single technology caps', will accelerate the broadening of the renewable technology mix, particularly in light of falling costs for a number of renewable technologies."

The government has proposed auctioning up to 1000 GWh in the first auction, with no technology caps. Successful projects will be awarded floating feed-in premium (FiP) contracts, where payments are made to generators based on generation output, a strike price and a reference market price.

Ireland is at risk of not meeting its 2020 renewable energy targets and the government has been criticised for delaying the implementation of a new renewable energy support mechanism. Ireland's Solar Energy Association (ISEA) says that up to 2 GW of solar energy capacity could be deployed by the end of 2020 as there is currently 600 MW of PV capacity with planning consent and a further 1.4 GW in the planning system.

UAE nuclear units reach milestones

■ Unit 1 obtains licence but faces delay ■ Barakah 89 per cent complete

The United Arab Emirates is gearing up to start operating its first nuclear energy plant.

The Emirates Nuclear Energy Corporation (ENEC) said in July that it has achieved "a series of significant milestones" in the construction of Unit 3 at the Barakah nuclear power plant, while Unit 1 at the project has received an electricity generation licence from the Department of Energy.

ENEC said in a statement that it has successfully completed the major construction work at Unit 3, including major concrete pouring, installation of the turbine generator, and the internal components of the reactor vessel (RV), paving the way for the commencement of testing and commissioning.

Unit 1 is continuing to undergo commissioning and testing, and also requires an operating license from the UAE's Federal Authority for Nuclear Regulation to get the go-ahead for startup.

ENEC says that Unit 1 is likely to enter operation at the end of 2019 or beginning of 2020, later than its initially planned 2017 startup.

The delay is the second to affect the $20 billion project. ENEC said that its decision to push back commercial operation was taken after a "comprehensive operational readiness review" conducted in May.

ENEC says that as of the end of May 2018, the construction completion of Unit 2 is more than 93 per cent, Unit 3 is more than 83 per cent, and Unit 4 is more than 72 per cent, while the overall construction completion is more than 89 per cent.

In a statement in July, ENEC added that construction crews will begin transitioning from Unit 3 to Unit 4, taking with them the lessons learned during their construction of Units 1, 2 and 3.

The completion of major construction work on Unit 3 comes approximately one year after the completion of the similar work on Unit 2, and two years after the completion of the same work on Unit 1, "and demonstrates the benefits of building four identical units at the same time", ENEC said.

"These construction milestones have been achieved as a result of our extensive collaboration with our Prime Contractor and Joint Venture partner, the Korea Electric Power Corporation (KEPCO), as well as sub-contractors such as the Hyundai-Samsung Joint Venture (HSJV)," said Eng. Mohamed Al Hammadi, Chief Executive Officer of ENEC.

When fully operational, the four Barakah reactors will produce 5600 MW of electricity, around 25 per cent of the UAE's needs, according to the energy ministry.

Egypt boosts capacity with coal and wind

Egypt is continuing to attract major investors to its electricity sector as it looks to build new generating capacity to keep pace with demand.

A consortium comprising Shanghai Electric Group, Dongfang Electric Cooperation and local company Hassan Allam Construction has announced it will build a 6000 MW coal fired power plant near the Red Sea port of Hamrawein.

The consortium is reported to have out-bid the team formed by Mitsubishi Hitachi Power Systems, Elsewedy Electric and Orascom Construction as well as a Sino-American consortium led by General Electric and Harbin Electric to win the project.

The consortium was due to start negotiations with state-run Egyptian Electricity Holding Company in July. It submitted a bid of $4.4 billion for the project, lower than the next alternative offer of $6.6 billion.

Egypt is also continuing to ramp up its renewable energy capacity. Last month it officially inaugurated the Gabal El-Zeit wind farm, considered to be the largest onshore wind farm in the Middle East and one of the largest in the world.

The 580 MW wind farm was built in three phases with a total of 300 wind turbines installed across 100 km^2. It also features a novel migratory bird protection system, which uses radar to detect migrating birds and shut down operations temporarily when they pass.

Another major wind farm is also in the pipeline in the Gabal El-Zeit area. In March, the Egyptian cabinet signed a deal with the Egyptian Electricity Transmission Company (EETC) and a consortium comprising Orascom Construction, French energy group Engie, and Toyota Tsusho Corporation, to build a $400 million wind farm in Gabal El-Zeit.

The agreement is for the development of a 250 MW wind farm under a build-own-operate framework. The wind farm will be linked to the national grid for trial operation by mid-2019, and will be fully operational by the end of 2019.

Recently French firm Voltalia said it would invest $800 million in Egypt's renewable energy sector in the next five years. Among its plans is the construction of up to 300 MW of solar capacity and 500 MW of wind energy capacity.

Egypt has set a goal of obtaining 20 per cent of its power from renewables by 2022, and 42 per cent of its electricity from renewables by 2025.

■ The German Development Bank (KfW) has allocated €30 million to finance the construction of hydropower stations in seven sites in Qanater and the Delta in Egypt. The new plants would have a combined capacity of 30 MW.

Morocco completes Khalladi wind farm

The inauguration of a 120 MW wind farm has helped Morocco move closer to its gaol of energy independence, according to developers.

Saudi Arabia-based ACWA Power has officially launched the Khalladi wind farm in Tangier, and says that the facility will help Morocco to reduce its energy import bill and conserve foreign currency.

The Khalladi wind farm is located at Jbel Sendouq, about 30 km from Tangiers and represents an investment of AED1.7 billion ($170 million). The project was financed entirely by private funds, with equity from ACWA Power and ARIF Investment Fund, and long tenor debt from the European Bank for Reconstruction and Development (EBRD) in collaboration with the Clean Technology Fund (CTF), and the Moroccan BMCE Bank of Africa (BMCE).

The wind farm is one of the first private renewable energy projects in the country developed under a renewable energy law that allows private producers to sell electricity directly to clients connected to the high voltage and medium voltage grid. The Khalladi project will sell its output to several large industrial companies.

Morocco is implementing an ambitious strategy aimed at producing 42 per cent of its electrical power from renewable energy by 2020 and 52 per cent by 2030.

ACWA Power chairman Mohammad Abunayyan said that Morocco's energy sector offers attractive investment opportunities due to a well-established regulatory framework put in place by the Moroccan government. He added that the firm has already delivered the NOOR I solar plant (160 MW), and has a series of other investments in construction in the country.

■ The government of Tanzania has licensed a subsidiary of Australia's Windlab to build the 300 MW Miombo Hewani wind farm. The $300 million project will be the first wind farm in the country. Windlab Developments Tanzania has obtained an environmental and social impact assessment certificate for the project, which will be built in phases.

KenGen seeks PV finance

■ 45 MW proposal in Enbu County ■ CDC finances 52 MW PV plant

Kenyan power firm KenGen is looking to secure financing to the tune of KES5.7 billion ($56.6 million) to finance the construction of its first photovoltaic (PV) power plant, according to local media.

Nairobi-based *Business Daily* reported that the utility has approached a number of multi-lateral institutions, including the World Bank, seeking support for the project, a 45 MW plant in Mbeere South, Embu County, known as Seven Forks.

Separately, UK-based CDC and its partner, Globeleq, have announced a $66 million debt investment in Malindi Solar Group, which is building a 52 MWp solar PV power plant in southeast Kenya.

The project will provide much needed power in the Malindi area, which currently struggles with regular power shortages and relies largely on expensive thermal power plants, CDC said.

Globeleq, CDC's majority-owned independent power producer solely focused on building power generation in Africa, is the sponsor of the project. The company is working with its partners Africa Energy Development Corporation (AEDC) and IDEA Power to commence construction in the coming months.

"Power infrastructure is vital for Africa's economic growth and for the millions of individuals, families, and businesses who struggle to access the electricity they need," said CDC Chief Executive, Nick O'Donohoe. "Our investment will bring clean energy and jobs to a region of Kenya that struggles to reach its potential because of energy shortages."

Kenyas per capita electricity consumption is well below the average for sub-Saharan and 44 per cent below the level that would be expected for its level of GDP per capita, CDC said.

The company believes that the 52 MW generated by the solar plant will be consumed locally and support the creation of jobs.

Samcheok takes CFBs to the next level

The massive Samcheok Green Power Project in South Korea has now marked just over one year of full commercial operation. Utilising the largest and most advanced ultra-supercritical circulating fluidised bed (CFB) boilers in the world, it signifies the next big step for clean and flexible power from economical solid fuels. **Junior Isles**

A unique power generation project aimed at providing cheap, green energy to South Korea, is now demonstrating what is possible in terms of burning fossil and carbon-neutral fuels with minimal emissions.

The final unit of the Samcheok Green Power Project, located 40 km outside the city of Samcheok, in Gangwon-do province on the east coast of South Korea, was taken into operation in June last year. Notably, the plant, owned by state-owned power company Korea Southern Power Company (KOSPO), sees the world's first use of advanced ultra-supercritical circulating fluidised bed (CFB) boilers – a technology that enables it to burn a combination of biomass and coal of varying quality, including low rank coals.

The plant is equipped with four boilers supplied by Sumitomo SHI FW (SFW), in tandem with two steam turbine generators with a total gross capacity of 2200 MW. It is an impressive example of a project that uses a diversified mix of clean burning fossil fuel technology and renewable energy sources. In addition to the four CFB boilers, Samcheok Green Power Project is also the site of renewable power generation projects based on hydro, wind and solar sources that are in the design phase. There is also a fuel cell plant at a nearby facility owned by Korea Gas Corporation.

In many ways Samcheok reflects South Korea's energy strategy. Strong economic growth drives power demand in the country but like Japan, South Korea has no significant natural energy resources and is heavily dependent on fuel imports. It is also in a region of relatively high gas prices, compared to the US and Europe. This, combined with a reduced focus on nuclear post-Fukushima, leaves coal and renewables as the main options for meeting future electricity demand. Going forward, however, the situation with regard to coal is complicated by rising coal prices and the decreasing availability of high quality coal.

This led KOSPO to think about how it could use low quality coal. After a comprehensive evaluation of boiler technologies, KOSPO found that CFB technology could reliably fire cheaper low-quality coal together with biomass and resolve the problem.

"CFB technology has the flexibility to burn the lower quality coals that they saw becoming more abundant, namely from Indonesia," said Robert Giglio, Vice President of Strategic Business Development and Strategy at SFW, adding: "If you use a pulverised coal boiler, it has to be designed for a narrow fuel range. The coal has to be finely ground before being fed to the boiler and you could only burn a limited amount of biomass."

Another advantage of the CFB technology relates to the fact that it does not need traditional flue gas desulphurisation (FGD) systems since the CFB boilers capture the sulphur in the fuels as it burns.

Samcheok Green Power Project uses four 550 MWe (gross) ultra-supercritical boilers – making it the largest CFB plant in the world. The boilers – which represent the first phase of a plant that could be expanded at a later date – are configured as two blocks (Units 1 and 2) with each block having two boilers feeding into an 1100 MW steam turbine.

Coal and biomass are burned in once-through ultra-supercritical (OTUSC) CFB boilers. Supercritical steam conditions represent a physical point just above the triple point of water. When the boiler pressure reaches above the critical pressure of 221.2 bar (the critical point of water) and a temperature of 374°C, two-phase mixtures of water and steam cease to exist, and are replaced by a single supercritical fluid. These steam conditions allow a once-through boiler design where the high steam temperature and pressure results in much higher efficiency compared to a conventional drum-type boiler.

The normal operating mode of the Samcheok unit is coordinated control with sliding pressure operation. In normal operation the boilers are operated at the same load level and any load change requests are forwarded to the boilers simultaneously and with similar control parameters. Steam temperatures are individually controlled in order to ensure that the required temperatures in the main steam and reheated steam systems are achieved. Reheated steam shared between the boilers is continuously monitored and controlled in accordance with the applicable firing rates.

Each boiler at Samcheok produces main steam at a temperature of 603°C and reheat steam at 603°C. Superheat steam pressure is 257 bar [g]. They utilise advanced vertical tube, low-mass flux Benson evaporator technology, which is more efficient and easier to build and maintain than conventional spiral-wound supercritical boiler technology.

The vertical tube design has several advantages over a spiral tube design. It has a lower pressure drop across the boiler, resulting in higher efficiency. Samcheok has an estimated net electrical efficiency of 42.4 per cent (LHV) compared to the 38-39 per cent typically achieved with traditional boilers.

SFW says its vertical tube supercritical CFB design also makes it easier to build and maintain because structurally, it avoids the complicated support system needed for a spiral tube boiler.

Commonly used for conventional pulverised coal (PC) or pulverised fuel boilers (PF), spiral wrapping the tubes around the furnace helps even-out the temperature differences from boiler tube to boiler tube but the spiral winding has a natural tendency to structurally unwind, putting a twisting force on the boiler since it is hung from the top. To counter the twisting forces, an elaborate bracing and lateral support system is required adding cost to the boiler and making it more difficult to build and then maintain.

SFW's CFBs use the same simple vertical tube hanging design common in subcritical drum boilers, but instead uses much smaller tubes. This reduces the weight of the steam/water mixture in each tube allowing buoyancy forces to become strong enough so that even at supercritical conditions, tubes that receive more heat will naturally flow more steam and water. This provides additional cooling to limit temperature differences between different wall tubes.

SFW says that out of the hundreds of boilers sold in the market, only a few use this relatively unique technology. "This is belt and suspenders for the CFB," said Giglio. "Since the combustion temperature and heat flux is so uniform in a CFB, overheating of tubes is a rare occurrence."

The material used for SFW's supercritical boilers is much the same as for its subcritical boilers, except in the final superheater section, which is subjected to very high temperatures. With PC or PF boilers, final superheating takes place in coils hung from the top of the boiler. This is not a great place to put these coils, since they operate at the highest metal temperatures and are fully exposed to the corrosive flue gases containing molten ash.

This design weakness is avoided in SFW's CFB's by placing these coils in high efficiency fluidised bubbling bed heat exchangers called INTREXs. These heat exchangers are integrated into the bottom of the furnace extracting heat from the hot circulating bed material at a rate 4-5 times higher than in PC boilers.

As the hot solids return from the solid separators, they are collected and returned to the furnace through the INTREXs and since the solids are fluidised by air and not flue gas, they are protected from the corrosive flue gases. Further, instead of causing fouling, the fuel's ash and added limestone are used to achieve very high heat conduction rates allowing the CFB to achieve very high ultra-supercritical steam temperatures with less heat transfer surface area and a much lower combustion temperature than a PC boiler.

This means the same supercritical temperatures can be reached using a lower grade coil material than would be needed in a PC boiler or that a lower quality fuel can be used without sacrificing steam temperature or

unit reliability.

At Samcheok, ash produced by the combustion process will be recycled to produce lightweight aggregate for the construction industry and help reclaim land destroyed by coal mining in the Gangwon-do region.

SFW's CFB technology has been proven at increasing sizes for many years, achieving the 200 MW utility size in the 1990s. Today, globally SFW has delivered more than 40 CFB units of over 200 MWe scale in operation or under construction capable of burning a wide range of fuels.

The technology advance to OTUSC units was first demonstrated at the 460 MWe Łagisza plant in Poland, which entered commercial operation in 2009. Since its startup, the plant has operated on a range of bituminous coals and has demonstrated a LHV net plant electrical efficiency of 43.3 per cent. Another supercritical CFB project has also been built in Russia. This is a 330 MWe CFB unit designated Novocherkasskaya GRES No. 9, which is now under commissioning. The boiler, which is the first of its kind in the country, is capable of combusting a wide selection of fuels including anthracite, bituminous coal and coal slurry.

The Samcheok units represent the next big step in the design and scale-up of CFB's for large utility power generation.

It has been a long but steady path to this stage. Following the award of the contract in May 2011, SFW was given the Notice to Proceed (NTP) for the project in July 2011. This triggered the start of civil works. Foundations for the boilers was completed in 2013 and the shipping of structural steel to the site took place that year to allow the start of boiler erection.

The plant is equipped with four boilers supplied by SFW, in tandem with two steam turbine generators

Erection works in the Samcheok Green Power Plant Unit 1, incorporating two 550 MWe CFB boilers and a steam turbine, were mostly completed at the end of year 2015 and commissioning activities were started simultaneously with some last minor erection works still ongoing. At that time Unit 2 was still under construction.

During the cold commissioning period, carried out by lead EPC contractor Hyundai and supported by SFW technical advisors, the power unit was made ready for trouble-free starting of chemical cleaning and hot commissioning. Pipelines were flushed and operation of boiler auxiliaries, instrumentation and protection systems were checked for correct operation, guaranteeing smooth and safe start-up of the power unit.

Chemical cleaning for Unit 1 boilers was finished at the end of February 2016. First fire of Unit 1 boiler 1B took place on February 29, 2016 followed by boiler 1A a few weeks later. Commissioning activities continued with magnetite film formation, curing of the refractory linings and steam blowout process as a final step before the start of boiler testing and the tuning period.

The blowout process, used for final cleaning of the steam pipelines from construction debris before connecting steam lines to steam turbine, was carried out continuously during the daytime. Boiler HP and RH parts were steam blown simultaneously meaning that steam leaving from the boiler HP part was led to the cold reheat pipeline and through the reheaters up to the hot reheat pipeline and onwards via a temporary pipeline and silencer to the atmosphere.

The Unit 1 boilers were ready for start of the steam blowout at the end of April 2016 and boiler load was increased to the level required for sufficient cleaning of the steam pipelines, allowing restoration work on the steam piping to be started.

Restoration work after steam blowout took around one month, enabling bypass operation of Unit 1 to be started on August 19, 2016 with first boiler. During bypass operation HP- and LP-bypass stations were utilised in order to get condensate back to the process and condensate system cleaned up. Part of the condensate was dumped from the cycle to be substituted by clean demineralised water. In the course of bypass operation preliminary tuning of the boiler controls and sequences was made. Also, operation of auxiliaries and instrumentation was verified and adjusted in their hot conditions.

On August 22nd, three days after the start of bypass operation, steam was introduced to the turbine for the first time after which, turbine and generator tests were able to start. It marked the first time that one of the new Samcheok once-through CFB boilers was operated mainly with coal, while demonstrating operation of the boiler with several fuel feeding lines.

Commissioning of the unit proceeded with one boiler on line until September. Operation of the boilers and their auxiliaries was optimised under steady and transient conditions. Nominal rating with boiler 1B was reached for the first time on September 4th, with Unit 1 in 1:1 operation, i.e. one boiler supplying steam to steam turbine, at approximately 400 MWe load. The behaviour of the process was also found to be steady during high load operation at a moderate combustion temperature, resulting in excellent environmental performance.

Unit 1 combustion process optimisation and control tuning continued with 1:1 operation until October 7th and the major milestone of first tie-in and transfer to 2:1 operation was achieved at this point. During 2:1 operation steam from the HP part of the turbine has to be divided between the boilers in a controlled manner to keep reheat steam temperatures in balance. In this respect Samcheok Unit 1 has worked well from the beginning.

Successful tie-in allowed Unit 1 load to be increased to reach its nominal rating of 1 GW for the first time on October 14th. Since then Unit 1 optimisation has continued mainly in 2:1 operation. During this time, both steady and dynamic performance has been adjusted together with the steam turbine supplier to meet electrical grid requirements and satisfy the conditions for unit commercial operation.

In 2:1 operation both boilers are normally operated at equal load, based on signals from the Unit Master Control (UMC). If for some reason the other of two boilers cannot be operated at the requested load, an unbalanced operation mode is used and unit load is limited if necessary. Also, in the event that the other boiler has to be taken out of operation, tie-out (i.e. switching to 1:1 operation) takes place automatically and the unit will continue running with limited output until switched back to 2:1 operation.

These functions, which are necessary for a unit to operate well in all circumstances, were tested and optimised during hot commissioning.

Prior to taking the new unit into commercial operation it had to pass a 10-day reliability run at nominal rating (NR) load conditions, as well as tests required by the grid operator, e.g. demonstration of load change capability. The reliability run was successfully completed on December 14th and the plant was taken into commercial operation on December 16th.

A similar procedure was followed for Unit 2 in Samcheok. After its hot commissioning and optimisation stage, that unit started commercial operation on June 13, 2017.

According to SFW, boiler reliability since startup has been above 90 per cent for both units. "The plant has been running well with no unexpected problems," said Giglio.

Samcheok's CFBs are designed to burn coal mixed with biomass but are expected to primarily burn coal sourced from several international coal mines. The plan is to fire imported and domestic coals with heating values from 3400-6000 kcal/kg, and since start-up the coal fired has predominantly come from Indonesia. It is a typical sub-bituminous

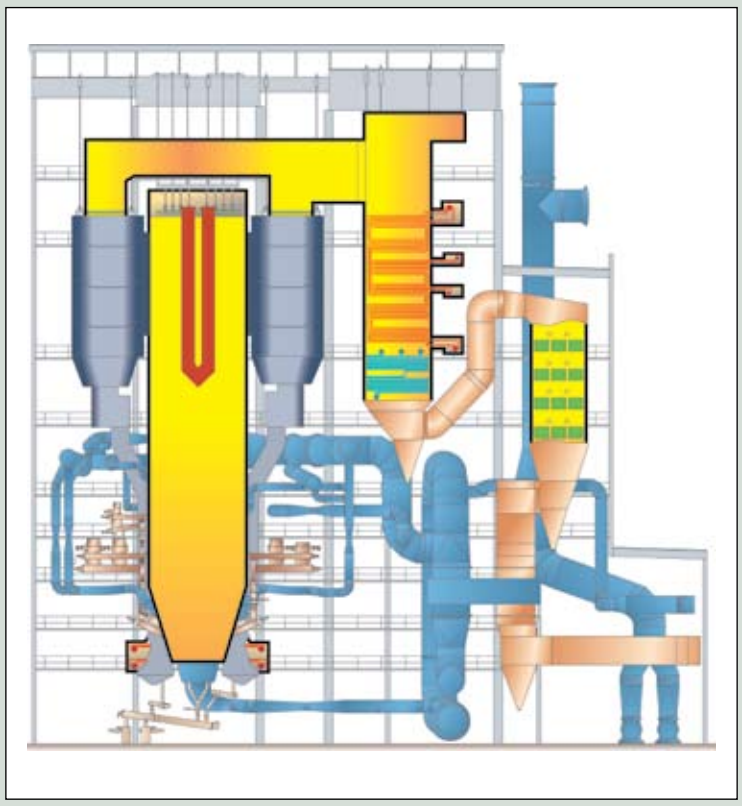
Giglio: CFB technology has the flexibility to burn the lower quality coals that they saw becoming more abundant, namely from Indonesia

Fuel specifications

	Bituminous coal	Biomass
LHV (a.r.) (MJ/kg)	14.2 – 24.9.	15.8 – 18
Moisture (%)	20 - 43	5 – 15
Ash (a.r.) (%)	1.2 - 15.3	0.7 – 5
Sulphur (a.r.) (%)	0.1 - 1	0 – 0.16

Design steam parameters at 100% load

SH steam flow (kg/s)	437.7
SH steam pressure (bar[g])	257
SH steam temperature (°C)	603
RH steam flow (kg/s)	356.4
RH steam pressure (bar[g])	53
RH steam temperature (°C)	603
Feed water temperature (°C)	297



The CFB boiler in-line arrangement incorporates supercritical steam parameters accompanied by Benson vertical-tube technology

Measured process parameters at different load levels

	50% load	75% load	100% load
Unit gross output (MWe)	500	750	978
Main steam flow (kg/s)	195	296	393
Main steam pressure (bar)	158	214	50
Main steam temperature (°C)	603	603	603
Reheat steam temperature (°C)	604	597	604
Bed temperature (°C)	812	812	833
Flue gas exit temperature (°C)	120	132	137
SO_2 emissions (ppm)*	28	0	0
NO_2 emissions after SCR (ppm)*	<50	<50	<50
CO emissions (mg/m^{3}n)*	35	8	7

** @ 6% O_2, dry*

coal with high moisture, low ash, and low sulphur with a heating value of around 4200 kcal/kg. High quality coals typically have a calorific value above 5500 kcal/kg.

Giglio commented: "In these first years of operation, the Samcheok CFB plant has been firing mainly Indonesian coals and domestic biomass. KOSPO has now begun exploring other fuels sources by test firing US and Russian coals. The plant's full fuel flexibility potential will be realised over time as the KOSPO team gets more experience and masters plant operation. Stay tuned."

According to SFW, environmental performance on these low rank coals has also been "excellent", meeting the design limits. NOx and SOx emissions are each guaranteed at 50 ppm (at 6 per cent O_2). Dust emissions are controlled by an electrostatic precipitator, so that particulates do not exceed 20 mg/Nm^3. Carbon dioxide emissions are around 800 g/kWh, which is about 25 per cent below a typical operating coal plant in Korea today.

Good environmental performance compared to pulverised coal plant is a characteristic of CFB combustion. This is because fuel particles, recycled back to the lower furnace from solids separators, have a longer residence time in the combustion zone. A high rate of solid circulation and excellent mixing inside the furnace keeps the combustion temperature even and at a moderate level over the whole load range. It also allows the use of low excess air. These two things are the main contributors to low NOx emissions and reduced ammonia consumption in the SCR.

The plant's environmental performance will be further improved as more biomass is introduced to the mix. The boilers are expected to burn about 5 per cent biomass in terms of heat input, depending on availability. This is likely to be in the form of recycled wood waste from the local lumber industry and imported wood pellets.

"At the moment they are targeting local biomass," said Giglio. "But to get to 5 per cent, they will have to look to the international market."

The successful operation of Samcheok Green Power project serves to further the argument that CFBs can play an important role in reducing emissions while providing fuel flexibility. And as environmental pressures grow, CFB technology offers an elegant solution at many levels for countries like South Korea.

Giglio concluded: "It's proving out the solution that KOSPO wanted; they wanted a reliable, fuel flexible plant; they wanted a clean plant without big expensive flue gas cleaning systems to lower South Korea's power cost; and it's working as expected."

3D cutaway of a single boiler

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BP charges EV market

BP says its purchase of the UK's largest EV charging network operator is a logical step that will complement its fuel retail business and enable it to capture a portion of the rapidly growing EV sector.

Siân Crampsie

BP has made a further move into the clean energy market with the acquisition of the UK's largest electric vehicle (EV) charging network operator Chargemaster.

In a £130 million ($171 million) deal, the oil giant will take control of Chargemaster's 6500 public charging points across the UK as well as its charging infrastructure sales business. It will give BP an important foothold in the rapidly growing EV market, and is the latest in a series of deals by oil majors into alternative and clean energy.

BP said that Chargemaster will complement its fuel retail business and enable it to support EV growth. "At BP we believe that fast and convenient charging is critical to support the successful adoption of electric vehicles," said Tufan Erginbilgic, Chief Executive, BP downstream. "Combining BP's and Chargemaster's complementary expertise, experience and assets is an important step towards offering fast and ultra-fast charging at BP sites across the UK and to BP becoming the leading provider of energy to low carbon vehicles, on the road or at home."

By 2040 BP estimates that there will be 12 million EVs on UK roads, up from around 135 000 in 2017. The growth will be partly driven by government policy to ban diesel and petrol car sales from 2040.

BP said the deal was part of a pledge to plough $500 million a year into low-carbon investments.

In May the company made a $20 million investment in StoreDot, the Israeli developer of ultra-fast-charging batteries. It has also agreed a deal with Chinese private equity group NIO Capital to finance "advanced mobility" technology. In January, it made a $5 million investment in FreeWire, a US company developing rapid-charging infrastructure.

Other oil companies are also making a push into clean energy technologies, including Total, which recently bought PitPoint, a company specialising in natural gas refuelling for vehicles and EV charging technology.

"With the rapid shift we are witnessing in consumer transport fuel choices, oil and gas retailers have the inherent advantage of an established network of filling stations, which they can easily leverage to get into a dominant position in the EV charging market to remain competitive," said Harminder Singh, Director for Power at market analytics firm GlobalData. "BP's competitors such as Shell and Total have been making rapid strides in this direction, by opening charging stations at their retail points and acquiring charging infrastructure providers."

BP said in a statement that its priority for Chargemaster will be the roll-out of ultra-fast charging infrastructure, including 150 kW rapid chargers capable of delivering 100 miles of range in just 10 minutes.

SPIC building GT programme

Siemens says it will support China's goal of independently developing and building its own heavy-duty gas turbine technology through a memorandum with State Power Investment Corporation (SPIC).

The two companies have signed a deal aimed at technology collaboration in the field of heavy-duty gas turbines and the creation of a partnership between Siemens and SPIC in China's heavy-duty gas turbine programme.

Under the memorandum, Siemens will support SPIC's research and development programme, as well as provide training and technical consultation. The cooperation will leverage Siemens' technology leadership and will expedite the finalisation of a technology cooperation agreement in the near future, Siemens said.

China is one of the world's most important markets for large gas turbines and is expected to intensify its investment in large gas turbine technology.

SPIC-chairman Qian Zhimin said: "SPIC is actively developing and implementing the China Heavy Duty Gas Turbine program. The collaboration with Siemens and other multinational gas turbine companies will accelerate the progress of the program. Both Siemens and SPIC have complementary strengths in the energy sector, and will have more space to cooperate in more business areas in the future."

InnoEnergy partnership targets Swedish energy users

InnoEnergy says it will join forces with five Swedish energy companies to invest in the design and creation of local systems built around smart energy technologies.

The company has partnered with Öresundskraft, Jämtkraft, Tekniska Verken, Umeå Energi and Jönköping Energi to launch Power2U, a venture that will offer energy optimisation services to end users and energy companies.

Its energy management platform will enable all types of buildings to benefit from the integration of new sustainable energy technologies such as solar cells, EV chargers and batteries, InnoEnergy says.

Kenneth Johansson, CEO of InnoEnergy Scandinavia, said: "We are pleased to welcome our new partners in Power2U, which is now ready for rollout. With the partnership, the solution is fast-tracked to market through each energy company's strong local presence. And we will ensure continued access to expertise, technology and resources."

InnoEnergy and its five partners will collectively invest SEK60 million ($6.85 million) in the venture, which will primarily target property owners and large energy users.

Johansson added: "The energy market is about to change fundamentally. Energy end-users are growing larger and equipping themselves with their own power generation. We expect rapid growth of local storage capacity in the form of electric cars and stationary batteries. Our joint new model is an important puzzle piece in the new energy landscape, and we are aiming for a rapid market launch starting in Sweden. We already have more international inquiries than we can handle."

SNC expands nuclear operations

- SNC grows partnership with Holtec
- JV to focus on accelerated decommissioning

SNC Lavalin is expanding its position in the nuclear energy market with the creation of a company specialising in decommissioning services.

The Canada-based firm has signed a deal with Holtec International to create a joint venture named Comprehensive Decommissioning International (CDI) that will pool the expertise of both firms to perform "accelerated decommissioning" of nuclear power plants.

According to SNC, nuclear decommissioning has become a rapid growth market in the USA due to an aging nuclear power plant fleet and lower costs of energy generation in the conventional fleet. CDI will be based in New Jersey state, USA, and will prioritise "safety and environmental stewardship" in its activities, SNC said in a statement.

It added that the partnership would also expand an existing relationship with Holtec in the small modular reactor (SMR) field.

"SNC-Lavalin continues to expand its participation in the nuclear value chain, working with its valued partner, Holtec," said Sandy Taylor, SNC-Lavalin's President, Nuclear. "Over and above our collaboration with Holtec for small modular reactors, the unique contributions of our respective companies bring a complete solution to reactor decontamination and decommissioning, bringing technology and innovation to fuel management and facilities dismantlement."

SNC and Holtec believe that the decommissioning market in the USA will be worth in excess of $14 billion over the next ten years. CDI will be well-placed to cut the total time elapsed to release plant sites for unrestricted use to eight years or fewer, pending local regulatory approvals, SNC said.

"CDI's vision is to become the leading decommissioning contractor in this market," said Pierre Oneid, Holtec's Senior Vice-President and Chief Nuclear Officer. "Now is the time to invest and the parent companies are bringing their joint skills, technologies and financial strength together to lead the way in decommissioning and spent fuel storage."

Equinor buys Danske Commodities

Equinor says that the acquisition of a Danish energy trading company will boost its position in renewable energy and supports its plan to become a broad energy company.

Equinor – formerly known as Statoil – has reached an agreement to buy 100 per cent of Danske Commodities (DC) for €400 million. DC is one of Europe's largest short term electricity traders and is also active in short-term gas trading and provides energy market services.

"Danske Commodities' trading platform and geographic footprint will support our strategy through leveraging DC's material trading position in electricity and natural gas. Their success has been due to their agility, entrepreneurialism and speed to market," said Jens Økland, Equinor's Executive Vice President for marketing, midstream and processing.

"This transaction will strengthen our ability to capture value from our current and future equity production of renewable electricity and supports our aim to grow in new energy solutions. We see excellent opportunities to develop our collective understanding of various national markets in a world where renewables to a larger and larger degree will be exposed to market risk," said Irene Rummelhoff, Equinor's executive vice president for new energy solutions.

Equinor earlier this year announced a strategy to move from being an upstream oil and gas company to a broader energy company.

The company said it is building a position in renewables and expects to invest 15-20 per cent of its capital expenditure in new energy solutions by 2030.

Americas

PG&E selects esVolta

esVolta, a developer and owner of utility-scale energy storage projects across North America, has been selected by Pacific Gas and Electric Company (PG&E) to build an energy storage system in Santa Clara County, California.

Under the proposal, which is pending approval by the California Public Utilities Commission (CPUC), esVolta will develop, build, and operate the Hummingbird Energy Storage project, a 75 MW/300 MWh lithium-ion battery storage facility. The project is slated to be in service by December 2020.

Upon completion, Hummingbird will be one of the largest battery projects in the world, and will provide an array of energy and ancillary services to California's electric grid, enhancing reliability and facilitating greater ability to integrate renewable energy resources such as wind and solar energy.

Rolls-Royce and TSK to deliver Chile power plants

A consortium comprising TSK and Rolls-Royce has signed an engineering, procurement and construction (EPC) contract with Prime Energía Quickstart Spa, a subsidiary of Prime Energia SpA, for the construction of five power plants across Chile.

Prime Energía's five power plants will offer a total combined capacity of 475 MW, which will be connected to Chile's electricity grid to provide backup capacity to the country's power supply system. They will consist of a total of 265 MTU Onsite Energy 16V 4000 gensets.

Dominican wind farm opts for Vestas

RGE has placed an engineering, procurement and construction (EPC) contract with Vestas for a 48 MW wind farm in the Dominican Republic.

Vestas will deliver and install 16 units of its V136-3.45 MW turbines in 3.0 MW load optimised mode for the project in the Puerto Plata region. The company expects to ship the machines in the first quarter of 2019. Commissioning is scheduled for the third quarter of the year.

Lagoa dos Ventos is Nordex's biggest contract

Nordex Group ha won the largest single contract in its history: it will supply and install turbines for the Brazilian wind farm "Lagoa dos Ventos" with a capacity of around 595 MW for Enel Green Power. The project comprises 191 AW125 turbines. With an installed capacity of 3.15 or 3.0 MW, the turbines will be mounted on top of 120 m concrete towers.

Nordex will start intallaing the turbines from October 2019, subsequently providing service for the turbines for at least two years. The wind farm is located in the state of Piaui in the north of Brazil. Nordex previously won another contract for 65 turbines from the same series for another project in the same province.

Asia-Pacific

EthosEnergy wins Siemens work

EthosEnergy has been awarded two multi-million dollar subcontracts by Siemens Korea for work at the Taean and Dangjin power plants.

The subcontracts are for a generator stator rewind and upgrade for units 3 and 4 at the Taean Power Plant and Unit 1, 2 and 3 at the Dangjin Power Plant.

Ethos Energy has previously completed stator rewind projects at Boryeong and Taean power plants. The work will increase the output of the generators by eight per cent from 612 MVA up to 660 MVA,

Vestas delivers 112 MW in Tasmania

Australia-based Palisade Investment Partners Limited (Palisade) has placed a 112 MW turnkey order with Danish wind turbine manufacturer Vestas for the Granville Harbour wind farm in Tasmania, Australia, Vestas has announced.

The order includes civil and electrical works, supply and commissioning of 31 V126-3.6 MW turbines as well as a 25-year Active Output Management 5000 (AOM 5000) full-scope service package to maximise energy production for the lifetime of the project.

Commercial operations at Granville Harbour are scheduled to begin in the fourth quarter of 2019.

Siemens supplies Vietnam solar farm

Vietnam's Trung Nam Group has awarded Siemens a contract to supply systems for the country's largest solar farm.

The farm is the first solar project for Siemens in Southeast Asia, and has a module capacity of 258 MWp. The deliverables include inverters, power- and distribution transformers, gas-insulated medium-voltage switchgear, circuit-breakers, and a monitoring and control system.

The project, in the southern province of Ninh Tuan, is due to start operating in 2019.

Pöyry wins Nam Kong 3 assignment

The Chaleun Sekong Energy Co Ltd (CSE) has awarded Pöyry the owner's engineering services assignment for the 54 MW Nam Kong 3 hydro power plant (NK3 HPP) project located in Attapue, Laos.

The project includes the design, civil works and installation of a Roller Compacted Concrete (RCC) dam, spillway, plunge pool, headrace tunnel, power house tailrace channel and switchyard with associated hydro and electro-mechanical work, as well as erection of a new transmission line.

Pöyry's assignment includes assistance in project management, design and design review, and site supervision services. Pöyry completed the initial river diversion works within six months from signing the project contract in November 2017, and two weeks ahead of schedule.

Vestas attains first in China

Vestas has received its first order for its V126-3.45 MW wind turbine unit in China.

The company says that an unnamed Chinese customer has ordered 20 units in 3.6 MW power optimised mode. It expects delivery of the equipment to start in January 2019, while commissioning of the wind park is scheduled for May 2019.

A three-year Active Output Management 4000 (AOM 4000) service agreement is also included, Vestas said, without providing financial details.

Azure wins in Indian auction

Indian solar developer Azure Power has secured 600 MW in a 2 GW solar auction by Solar Energy Corporation of India (SECI).

Azure Power said this marks its largest capacity win. It is expecting to sign a 25-year power purchase agreement (PPA) with SECI to sell power at INR2.53 ($0.037/€0.031) per kWh. The tariff is about four per cent higher than the lowest bid in the auction, which matched the record low seen for Indian solar tariffs in 2017.

GE lucky in Pakistan

GE Power will provide advanced boiler and steam turbine technology to Pakistan's first ultra-supercritical (USC) and lignite-fuelled power plant in Karachi, the company has announced.

Located in Deh Ghangiaro, Bin Qasim, the Lucky Electric Power project will add 660 MW of capacity to the national grid. China's SEPCOIII will construct the power plant, with a commercial operation set for 2021.

In a statement GE said that the project stands out as the first power plant located outside Thar district that will use lignite mined from the Sind Engro Coal Mining Company (SECMC) Mine at Thar Block II, in addition to imported lignite as back-up fuel.

Europe

Hitachi sets up smart project

Moixa has begun installing smart batteries on the Isles of Scilly in the first stage of a landmark programme that aims to transform the lives of islanders and provide a model for communities worldwide.

The £10.8 million ($14.2 million) project, led by Hitachi Europe Ltd., will demonstrate how solar power, batteries, smart heating technologies and electric vehicles can be used to help support the islands' energy system and reduce bills for the whole community.

The low-carbon infrastructure is due to be installed by this autumn. A not-for-profit Community Interest Company will sell power generated by the solar panels and recycle the income to reduce electricity bills for all islanders through a special Isles of Scilly energy tariff that will be launched this summer.

In the longer term, the initiative aims to cut electricity bills by 40 per cent by 2025 and meet 40 per cent of energy demand through renewables.

GE Power signs Ostrołęka contract

GE Power has signed a contract with Elektrownia Ostrołęka to build Ostrołęka C, an ultra-supercritical (USC) coal power plant in the north-east of Poland.

GE Power will design and build the power plant as well as manufacture and deliver the ultra-supercritical technology components, including the boiler and steam turbine generator.

The ultra-supercritical technology to be used at Ostrołęka C will ensure an efficiency of 46 per cent, well above the global average of 33 per cent. GE Power will also supply air quality control systems that meet with the latest EU standards.

Glass giant signs Turboden

Glass company Saint-Gobain has signed two contracts with Turboden for equipment that will help it improve the efficiency of its operations in Italy and India.

Saint-Gobain has selected Turboden's ORC technology to recover waste heat and convert it to electrical energy at two plants: a 1.2 MWe unit in India and 1.2 MWe in Italy. In Italy, the plant will also produce compressed air, which is needed in the production of glass.

TenneT awards Hollandse Kust contract

Following a European tender procedure, TenneT TSO B.V. has selected Petrofac to construct an offshore transformer station for the Hollandse Kust (zuid) Alpha wind farm zone.

Petrofac is also the preferred contractor for TenneT's next offshore project, the Hollandse Kust (zuid) Beta platform. Together, these two platforms will be part of the third and fourth large-scale grid connections for offshore wind energy in the Netherlands to be constructed under the National Energy Agreement.

Petrofac will undertake the engineering, construction, transport, installation, connection and testing of the offshore transformer station. The Hollandse Kust (zuid) Alpha platform will have a connection capacity of 700 MW for offshore wind farms and is scheduled for completion in 2021. The Beta platform (also 700 MW) is expected to be completed by 2022.

JDN, Parkwind join forces

Jan De Nul and Parkwind have signed a contract for the construction of the Northwester 2 wind farm off the Belgian coast.

The contract represents the third time that the two companies have partnered for an offshore wind farm. Northwester 2 will be located 48 km off the Belgian coast and will have the largest and most powerful wind turbines currently available on the market: MHI Vestas' V164-9.5MW.

Jan De Nul will be responsible for the design, construction and installation of 23 foundations, the transportation and installation of the cables and the transportation and installation of the wind turbines on top of the foundations. It will start works in June 2019.

International

Oman LNG orders MAN engines

MAN Energy Solutions has won an order from Oman Liquefied Natural Gas to equip a new power plant with gas engines.

The power plant will be located in Qalhat, southeast of Muscat on the Gulf of Oman, and will provide 120 MW of power to the existing LNG facility of Oman LNG. It will replace an existing gas-turbine plant and comprise nine MAN 51/60 gas engines.

SGRE to install South African wind farms

Siemens Gamesa Renewable Energy (SGRE) is to build two wind farms in South Africa: the 140 MW Kangnas project near Springbok in the Northern Cape, and the 110 MW Perdekraal East wind farm near Ceres in the Western Cape.

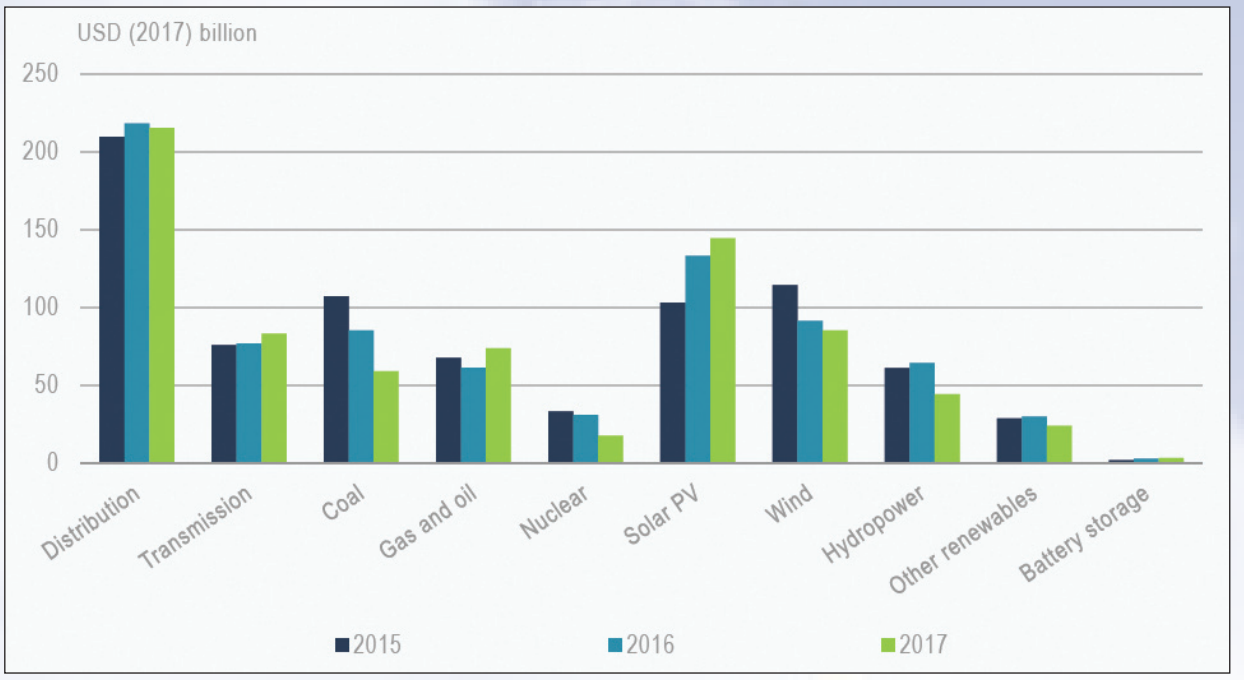
SGRE will supply a total of 109 of its SWT-2.3-108 turbine units at the two sites, which are being developed by Mainstream Renewable Power. Completion of the projects is expected in 2020.

Al Aweer orders Siemens GTs

Siemens is to supply three SGT5-4000F gas turbines for Unit H Phase 4 of the Al Aweer power plant complex in Dubai.

The 815 MW power plant, located approximately 35 km from downtown Dubai, is being built by a consortium led by Egypt-based company El Sewedy Electric Co SAE. It will increase the total output of the power plant complex to more than 2.8 GW.

Global investment in the power sector by technology



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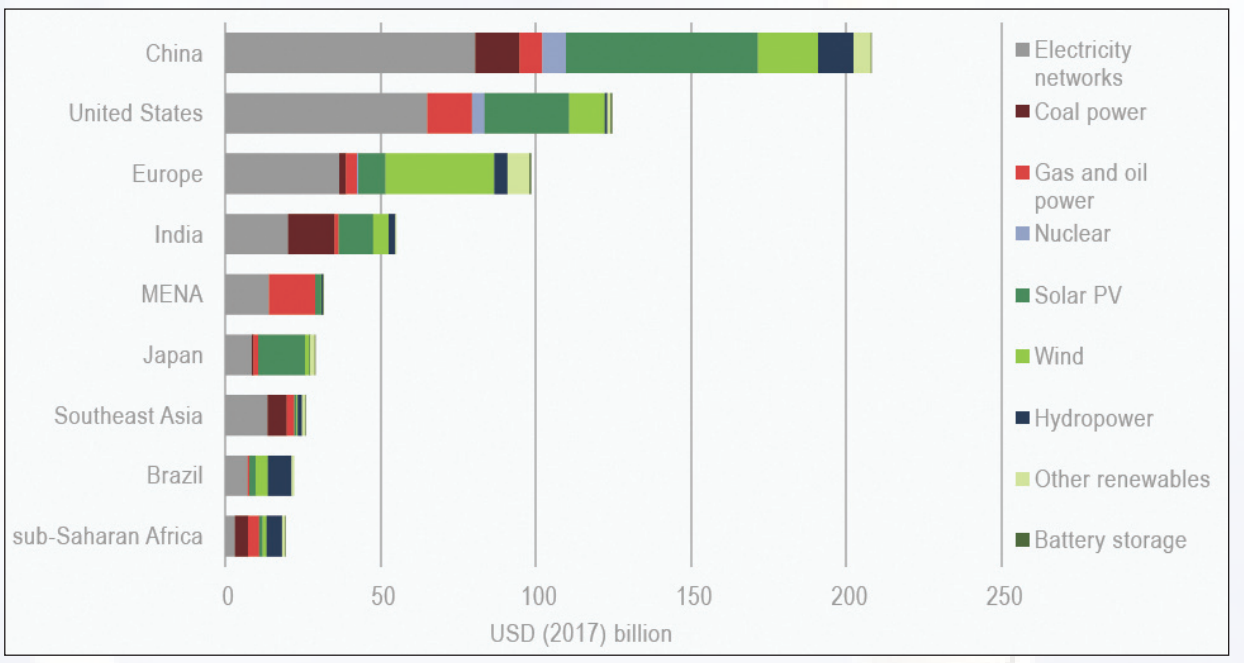
Power sector investment by major country and region, 2017



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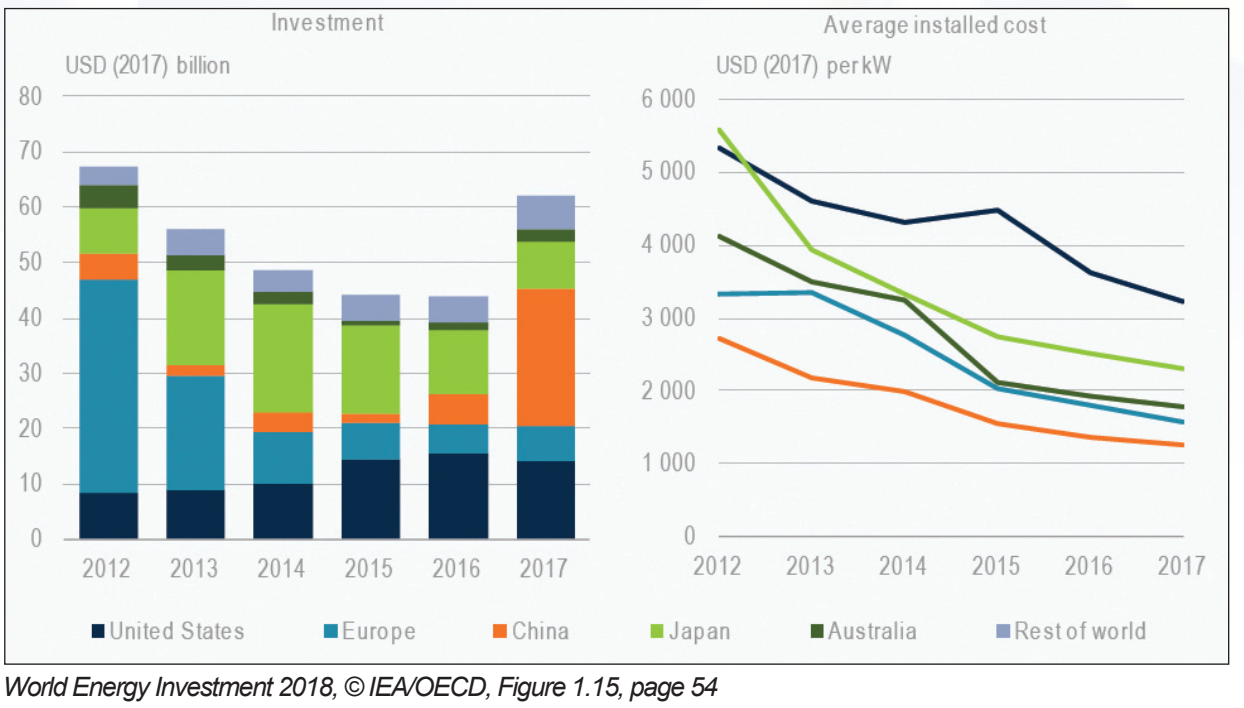
Distributed solar PV investment and average installation costs



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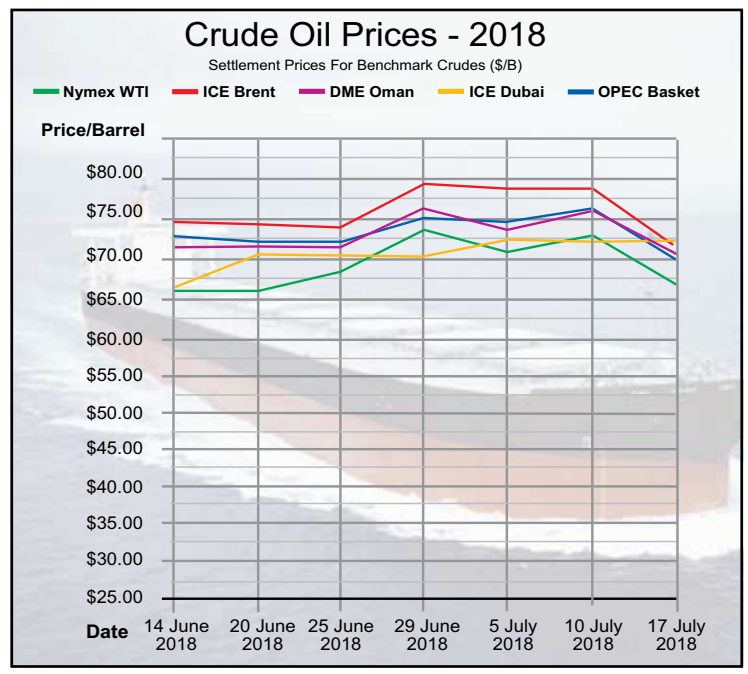
Source: World Energy Investment 2018

Oil

With over-production solved, oil supply becomes the issue



- Oil producers agree to 100 per cent compliance with oil quotas
- IEA data indicates higher prices starting to take toll on demand

David Gregory

At this point, it is impossible to predict which way prices will go in the future, although up would be the most probable guess. Everything seems volatile. Everything seems to be in flux. It might be best to use astrology charts to forecast the future of the oil market.

Since Opec/non-Opec oil producers agreed in late June in Vienna to produce at 100 per cent compliance with their respective oil quotas – in effect increasing oil output – the price of Brent crude has ranged in the high to low $70s and West Texas Intermediate (WTI) has dipped into the high $60s.

But much has happened in the last month that could force prices higher over coming months. Refineries are searching for substitute oil to cover their usual Iran liftings. Angry with the US over new sanctions and the prospect of being forced to cutback production, Iran has threatened to close the Strait of Hormuz, prompting US President Donald Trump to respond with threats of his own.

China is turning away from US oil shipments in response to tariffs imposed on Chinese imports into the US and could likely turn to Iranian crude. With both China and India importing 600 000 b/d of Iranian crude, it is not clear how those countries could shift to new suppliers.

Furthermore, continued fighting in Libya has forced a decline in production there, and other producers are seeing short-term falls in output. With retail gasoline prices in the US at close to $3.00/gallon, Trump has demanded that Opec produce more oil even though US production is reaching a point that US infrastructure can barely cope with the quantities, yet stocks have gone into decline as summer demand picks up.

The ongoing economic crisis in Venezuela continues to factor highly in questions about the oil market. And in late July, Saudi Arabia said it was halting exports through the Red Sea strait of Bab el-Mandeb after Iranian-back Houthis in Yemen attacked two tankers in the strait.

Russia's production will increase by an average of more than 11 million b/d this year, but whether that will impact the market to reduce prices remains to be seen, considering the short-term production cuts in Canada, the North Sea and Norway. Saudi Arabia and other Gulf Opec members have meanwhile boosted production, but that may not be enough to alleviate fears that high crude prices will hurt global economic performance.

No sooner than the Opec/non-Opec alliance had solved the critical issue of over-production, then the issue of supply shortage has taken the helm. In the July issue of the International Energy Agency's (IEA) monthly *Oil Market Report*, the agency commented on the pressure of global oil supply.

"This will become an even bigger issue as rising production from Middle East Gulf countries and Russia, welcome though it is, comes at the expense of the world's spare capacity cushion, which might be stretched to the limit," the report said. "This vulnerability currently underpins oil prices and seems likely to continue to do so. We see no sign of higher production from elsewhere that might ease fears of market tightness."

The IEA report went on to say that despite a strong start for demand growth at the beginning of the year, provisional data indicate that higher prices are starting to take their toll on demand. On the supply side, spare capacity production is becoming a focal point.

Meanwhile, in an interview with Canada's *Financial Post* last month, Citigroup oil forecaster Ed Morse disagreed with the 'bull market' analysis that crude oil prices would continue to rise. Although Morse agreed that Brent crude would remain high for the rest of the year and into the first quarter of 2019, he said that crude prices would decline to range between $45/b and $60/b before the end of 2019.

Major forecasters like Goldman Sachs Group, Morgan Stanley and Bernstein & Co have forecast prices at $80-$100/b. Morse said in the interview that their argument is based on "faulty analysis." According to Morse, despite the lack of capital investment in recent years, the "efficiency of capital has improved by at least 50 per cent since 2014," meaning that it takes less money to produce at a profitable rate.

He also points to the fact that technology is optimising production and will continue to do so. And he argues that decline rates are overblown. Furthermore, he told the financial website that concerns about spare capacity are also unfounded as Saudi Arabia's ability to deliver crude is widespread and sophisticated.

Gas

New era for European supply as Southern Gas Corridor nears completion

Mark Goetz

The Southern Gas Corridor is no longer an idea, it finally materialised in early July when BP initiated commercial gas deliveries from its Shah Deniz Stage 2 (SD2) project in the Caspian Sea to Turkey.

The first two components of the project, an expanded South Caucasus Pipeline (SCPX) and the Trans Anatolian Natural Gas Pipeline (TANAP) are complete and functioning. The final component, the Trans Adriatic Pipeline (TAP), which will carry Azerbaijan's SD2 gas from the Greek border with Turkey across northern Greece, Albania and the Adriatic Sea to Italy, will come into operation in 2019-20 and enable natural gas from the Caspian and perhaps other Asian gas fields to be delivered into Central Europe.

"Together with the Southern Gas Corridor pipeline system, Shah Deniz 2 will deliver significant new energy supplies to Europe, further diversifying its sources of energy and providing new supplies of natural gas which will be essential in the energy transition," Bob Dudley, BP Group Chief Executive, said in a statement announcing SD2's start-up.

The SCPX, TANAP and TAP pipelines comprise the first components of the Southern Gas Corridor (SGC). When the concept of a natural gas transport system carrying gas into Europe through a southern route that bypassed Russia first formed, it was idealistically imagined that in time, gas from Turkmenistan, Kurdistan, Iraq, Iran and Qatar could be fed into an ever-expanding system. But the current state of geopolitics in a region fraught with political and economic rivalry does not encourage that view now. By the mid-2020s, Azerbaijan hopes to boost gas exports to Europe through the corridor, but future exploration, production, and, of course, markets will determine future events. Whether other countries in the region will find markets in Europe for piped gas remains to be seen.

BP's Shah Deniz Stage 1 project came on-stream in 2006 and supplies gas to Azerbaijan, Georgia and Turkey. The $28 billion SD2 project will add 16 billion cubic metres (bcm) of natural gas annually to Shah Deniz's current capacity of 10 bcm/year. Turkey will receive an additional 6 bcm/year on top of the 6 bcm/year it currently receives from first phase Shah Deniz production. TAP will transport 10 bcm/year of SD2 gas into Central Europe in 2020.

The total cost for the SD2 project and the construction/expansion of the pipeline system to Europe is estimated at around $41.5 billion. Clearly a significant investment demanding that a great deal of Azeri gas be sold to Europe.

The opening of the corridor is every bit as significant as the completion of the Baku-Tbilisi-Ceyhan (BTC) crude pipeline, which opened in 2006 with BP as project leader.

The BTC was a controversial project that eventually materialised, but the debate about the SGC, the route it would take and what companies would be involved – notably the Nabucco consortium led by OMV – lasted for several years. Nabucco and several other proposals lost out and the current configuration of pipeline systems was selected by BP and its partners, particularly Azerbaijan's Socar, earlier this decade.

The SGC was an ambitious and controversial project and remains so even as it nears completion. Earlier this year when a new populist government came to power in Italy, officials began to question the need of TAP and others criticized the pipeline's route through olive grows in southern Italy and the disruption it would cause the local olive industry.

However, earlier this month during a visit to Baku, Italian President Sergio Mattarella assured the Azeri government that it fully supported TAP.

"The Southern Gas Corridor and the Caspian Sea gas is of great importance to Europe," Mattarella said, adding that his conversations with Azeri President Ilham Aliyev confirmed that both countries "will work to find ways to address these issues of common interest."

As far as the TAP consortium is concerned, it is reported to be redesigning the pipeline route to take consideration of Italy's olive industry concerns.

Other pipeline systems that would connect with the SGC have been planned for years, particularly the Interconnector-Greece-Bulgaria (IGB) pipeline, which will connect with TAP near the Greek-Turkish border. Work on this project is to begin later this year and in 2019-20 Azeri gas will be delivered to Bulgaria.

The plan calls for eventually gas from Azerbaijan and other sources to enter the IGB and be transported further into Eastern Europe.

Another project is the Ionian Adriatic Pipeline (IAP), which would connect with the TAP in Albania and transport gas into the western Balkan states.

Together, these additional projects would improve East European and European Union energy security and at the same time reduce Europe's reliance on Russian gas supplies, although Moscow is working hard on its own projects – TurkStream and Nord Stream II – to secure its dominant place in European gas supply.

Some like it hot?

The political climate has changed considerably since the Paris agreement was signed in 2015. Greenhouse gas emissions have now reached an all-time high and many world leaders seem reluctant to stand firmly behind a green future and push. **Dr. Geoff Nesbitt**, explores how the global climate is faring and what more can be done.

In 2015 something unusual happened. Science and politics stopped quibbling and rallied around the single most important issue facing *homo sapiens* in this millennium: climate change. At that point in time almost 200 countries agreed to unite in cutting global greenhouse gas emissions by 2020 under the Paris Climate Agreement. However, figures released by the International Energy Agency show that in 2017 carbon emissions reached a historic high, increasing by 1.4 per cent to 32.5 Gt.

So what happened? To begin with the political climate has changed considerably since the agreement was signed. For a short time it seemed that the world's leaders were united in the movement towards lower greenhouse emissions. Industry had found its climate legs with most listed corporations responding to shareholder pressure and adopting their Health, Safety, Security and Environmental (HSSE) programmes to include a yearly audit of their carbon footprint and goals for reduction.

However, in the face of all this progress on paper, little material impact has been recorded and many world leaders seem reluctant to stand firmly behind a green future and push.

Perhaps we are also wrestling with something very basic, in the form of a social contract many people have with their government on energy. In addition to the fundamentals enshrined in charters and covenants on safety, security, freedom from persecution and discrimination, access to food, water and shelter, there seems to be an unwritten guarantee of access to bountiful cheap sources of energy?

Both French and German governments have publicly acknowledged that their countries will miss their near-term emission reduction targets as greenhouse gas levels have continued to rise.

But we're still making progress. The intent to cut greenhouse emissions is still evident in the majority of countries that signed up to COP21 and while some struggle to meet initial targets, there are enough steps being taken so that in most countries the tide has turned on emissions.

This is evident in legislation being put in place to curb CO_2 emissions on land and sulphur emissions at sea and is bolstered by the stimulation and development of cleaner energy creation. If we take solar power for example, the initial wave of enthusiasm and subsidy programmes fuelled the scale up of production of conventional PV modules. The drive to meet the market pull in turn found traction in the East where investment in capacity surged, economies of scale kicked in, and costs reduced.

The result was a window of opportunity where it became feasible to carpet fields or heavy structures with first generation conventional solar PV panels. Now it's time to look at version 2.0 – lightweight, semi-flexible solar options which make solar energy affordable for applications that were previously unthinkable.

Taking a world view, both the UK and French governments have committed to ban the production and sale of new petrol vehicles by 2040 in a bid to reduce carbon emissions but think-tank The Green Alliance claims banning new combustion engine vehicles by 2030 would close the climate target gap while significantly reducing oil imports. In 2016 transportation overtook energy production in 2016 as the UK's biggest cause of carbon emissions, so this is a good place to go hunting for results.

Dr. Nesbitt: in the face of all this progress on paper, little material impact has been recorded

A 2030 deadline would close the gap by 85 per cent, the think-tank claims. Can technology help close that gap? The most immediate answer most probably lies in two well-known areas of development; battery technology and dynamic generation.

At the moment Lithium-ion leads the pack in density and charging times for mobile applications such as consumer electronics and now automobiles. For the residential or SME applications there may be environmentally greener alternatives.

Regarding dynamic charging (while under way) we are limited to fly-wheel systems or lightweight solar modules integrated into the body. As thin lightweight PV becomes more efficient and robust it will be applied.

Some of the rise in global emissions recorded by the International Energy Agency has been linked to accelerated deforestation in Brazil and the dependence on coal to meet demand for electricity in developing countries in Asia and Africa, and even some of the EU's newer members.

In late 2017 Britain's Prime Minister Theresa May announced the UK would provide a £140 million fund to assist poorer countries disproportionately affected by climate change. In early 2018, three years after the initial summit in Paris, environment ministers from China, South Africa, Brazil and India released a statement urging wealthy countries to take stronger action in leading the global effort to curb climate change.

Despite being the world's largest consumer of coal and biggest carbon dioxide producer, China is also now leading the world in clean energy technology investment, and this is driving down the cost of clean technology. Policy targets, subsidies and manufacturing incentives have led to China spending more on producing cleaner energy than the EU and US combined. According to Bloomberg New Energy Finance (BNEF) consultancy, China spent $132 billion on this last year alone.

As the cost of clean energy continues to drop and new formats make it more feasible to use, the world's wealthiest governments should recognise the opportunity to support their environmental policies with real investment. Until wealthy nations begin to make greater strides towards achieving their emissions targets, today's biggest polluting countries – those with the least to invest – will be unable to meet their aspirations and make good their signature in Paris, back in 2015.

There is a question mark over the West. We are confronted with two very different governments and sentiments in North America. Canada's Trudeau government has made funds available to encourage emission capture development to address the conundrum they face with gas and tar-sand reserves. The country profits from tremendous hydroelectric capacity and can develop this further in the form of micro-grids pulling from the extensive rivers that innervate much of the country.

In the US, the Trump government's decision to pull out of the Paris Agreement may seem like old news but the repercussions are still echoing through the parliaments of the world. But does it really spell the end for America's efforts to participate, even if it doesn't want a seat at the table?

One study published by Yale in 2017 revealed that 70 per cent of registered US voters support setting strict carbon dioxide emission limits on existing coal fired power plants to reduce global warming and improve public health, even if it meant an increase in electricity costs for businesses and consumers.

And it's not just the public that strongly supports action against climate change. Major US corporations are stimulating growth in the solar and wind industries with Alphabet (Google's parent company), Apple and Wal-Mart among the country's biggest investors in renewable energy. Not only has Apple ensured all its facilities, including data centres, offices and retail units in 43 countries are now powered by renewable energy, the consumer tech giant has persuaded 23 suppliers to commit to relying entirely on renewable energy sources.

In 2017 Alphabet invested in enough renewable energy to cover all of its electricity consumption worldwide. In addition to China's substantial investment, investments by these major corporations are further driving down the price of renewable energy sources.

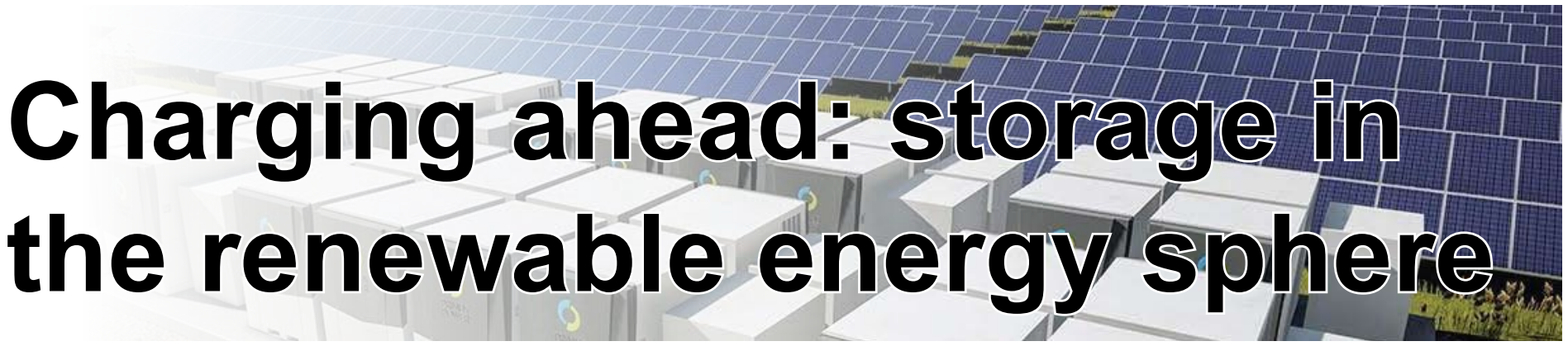
In conclusion, as a planet we are making progress on learning to live within our carbon-means. Renewable energy sources are developing quickly and becoming more cost effective as we de-bottleneck and apply our ingenuity to deploying them effectively.

Opinions differ, in some circles widely, on the precision of our climate models, but the majority of informed adults understand and accept the accuracy; we must do our utmost to reduce and ultimately remove our contributions to global warming. No one truly understands how this is going to play out, but we are awake and cognisant of our roles and finally on many fronts cooperating across our geopolitical borders.

As we move to soften many of those borders I would be concerned that the final lines may be drawn by a stronger hand than anything we could invent.

Ultimately our climate will have its say. The time to invest in emission control and renewable energy is now.

Dr. Geoff Nesbitt is CEO of Verditek plc.



Charging ahead: storage in the renewable energy sphere

Exciting new storage capabilities being developed for renewable energy resources have the potential to dramatically transform the global energy sector, as they deliver the capacity to balance electricity supply and demand.

Boris Beltermann

Renewable energy is already significantly impacting Europe's energy market. In Germany alone, renewables provide 38.5 per cent (2017) of electricity supply and are displacing fossil fuel energy production. There is still so much more to come as European initiatives aim to have 80 per cent of electricity produced from renewable sources by 2050.

As the share of renewable energy increases it will become more important to tackle the variable nature of renewables such as wind and solar in order to maintain continuous supply. Storage capacity will be an important part of this process, by ensuring renewable energy can be dispatched more efficiently in line with demand.

Battery storage can play a crucial role in supporting renewable power directly, and in facilitating the accompanying grid infrastructure. In Europe, modernisation of the electrical grid to accommodate growth in renewable energy is expected to require around €650 billion of investment over the next two decades. The cost of the investment can be mitigated in part by supporting grid-scale storage projects, which reduce the need for grid build-out at the point of network bottlenecks.

The research company IHS has predicted that installed battery storage will grow from 1.3 GW of storage projects deployed globally in 2016 to an expected 4.7 GW in 2020 and 5.2 GW by 2025.

Lithium-ion remains the battery storage technology of choice at present and we expect its dominance to continue. Lithium batteries are one of the most mature technologies, with the greatest disruption potential and with the highest energy density compared with other storage technologies currently deployed.

Research conducted by Bloomberg New Energy Finance (BNEF), estimates the cost of lithium batteries will fall to $100/kWh by 2025 compared with around $209/ kWh at present. Since 2010, lithium-ion battery pack costs have fallen from around $1000/kWh.

Beltermann: Lithium batteries are a key investment opportunity

As costs fall, new applications will emerge, especially in the energy market, with potentially significant ramifications for future energy systems, including power market design and the integration of variable renewable power. At present, lithium batteries are the only technology that can attract secure funding and bankable projects.

In 2013, the total global production capacity for lithium-ion batteries was around 35 GWh but it is expanding rapidly. The success of the first electric vehicles and the growing automaker commitment to electric mobility is spurring massive new battery manufacturing capacity. Now the global battery manufactory capacity amounts to 102 GWh and is largely based in China.

BNEF expects that global battery manufacturing capacity will more than double by 2020, to 260 GWh. It also forecasts installed battery capacity in renewable power applications to grow from 1 GWh at present, to 8.1 GWh by 2024.

These cost and technical advantages should secure the technology's dominance in the electrification of the transport sector. That in turn will benefit renewables storage, owing to economies of scale in the manufacturing of electric vehicle (EV) batteries. EV battery manufacturing capacity has trebled over the course of the past three years.

Until now, the main role for lithium batteries was in power-intensive, fast response applications such as frequency control at the below 30-minute timescale. However, technology development has vastly increased energy densities, while improving manufacturing economies of scale have sharply reduced production costs.

This is increasing the duration of lithium battery applications, to the two to four-hour scale, a range previously attributed to non-lithium technologies, such as PHP and flow batteries. Lithium is now established as the go-to technology for four-hour storage.

Battery OEMs will further assist this expanding opportunity, as they gather more data on the working parameters of batteries and begin to extend their warranties for use in different simultaneous applications.

But grid-scale battery deployment will not be without its challenges. The biggest overall barrier to energy storage in the current EU legislative landscape is the lack of a clear regulatory definition, which has led to its classification as both generation and load, and thus multiple charges and taxes.

The EU Directive 2009/72/EC refers to generation as assets that produce electricity, which could include batteries, and involves charges related to network access. In individual member states, however, batteries have also been assigned to the end-user network, thus incurring taxes related to electricity consumption. The regulatory definition of batteries is potentially confusing and out-dated.

Secondly, battery systems may require multiple sources of revenue to be bankable. For example, the pace of battery price reductions means that short-dated contracts, such as Germany's weekly frequency control tenders, may face increasing price pressure, as new battery systems come on line, effectively out-competing recently installed systems.

Improved economics of battery systems, as a result of cost reductions, technology developments and improved regulations, will help add new applications and revenue streams.

So what is the outlook for energy storage in Europe? Europe does not have a common regulatory approach to energy storage. The two principal markets at present are for frequency control in Britain and Germany. The most common application for batteries in Europe besides frequency control is for load-shifting in off-grid islands.

Britain is the most appealing market as it benefits from three possible revenue streams over a variety of timescales, enhancing the potential business case. The revenue streams comprise of a monthly firm frequency response tender; a four-year enhanced frequency response tender; and a 10-year demand-side response tender under the country's capacity market.

Germany offers a pooled market for batteries to participate in its weekly frequency control tenders, including providers from Austria and France. One downside is that battery participation in these tenders has already put downward pressure on prices and frequency control revenues.

Still, there are opportunities for grid-scale battery deployment in Europe. Aquila Capital expects lithium batteries to continue to outperform other forms of storage technology. This would be due to cost reductions, economies of scale achieved in manufacturing and its bankability (given a major supplier focus from companies such as Samsung, Panasonic and LGCHEM). Lithium batteries are therefore a key component in the future development of renewable energy and are seen by Aquila as a key investment opportunity because of their fundamental nature in the future of the renewable energy market.

Boris Beltermann is Head Investment Management, Energy & Infrastructure APAC at Aquila Capital.

Insights from Japan's Tomakomai project

From a first mover advantage standpoint, Aquila Capital has gained valuable experience from its investment activities carried out on the ground in Northern Japan. In 2016, Aquila invested in the Tomakomai project, which was then the largest solar and storage project in Asia. The facility in the island of Hokkaido comprises a 38 MW solar photovoltaic power plant coupled with a 19.8 MW/11.4 MWh lithium battery.

Following the disaster at Fukushima, Japan had to scramble to fill the gap left by the temporary closure of its entire nuclear power generation capability. Japan has since become one of the largest markets for renewables, alongside China and the United States. In 2016 alone, Japan added 14.3 GW of solar PV, nearly a quarter of global new installed capacity.

For the Tomakomai project, the sole application of the battery is for asset management initiatives – to ensure that feed-in solar production from the plant meets the frequency requirements of the grid and the local energy utility, Hokkaido Electric Power Company (HEPCO).

HEPCO required such feed-in control as a condition to qualify for generous feed-in tariffs associated with the solar power project. The Tomakomai project receives a 20-year solar feed-in tariff of JPY 40/kWh ($0.36/ kWh), which is more than sufficient to cover the additional cost of the battery.

The experience gained in the Tomakomai project can now be profitably applied further afield.

Developing battery storage adds an extra layer of complexity to a renewable-only project, including debt finance. An important priority was to identify the right lithium battery technology for the specific application and the right software, given the wide range of available suppliers and battery technologies.

Every battery project is different, and a particular application will define the specific lithium battery type and size – for example one would select a power-intensive battery for ancillary services or output smoothing and a more energy-intensive battery for a renewable energy time-shifting application.

A valuable insight that Aquila gained from investing in the Tomakomai project was in minimising the developmental lead-time. If it is delivered as a pre-installed and containerised system, the battery can be deployed in weeks rather than months.

Three-way storage breaks the mould

A new energy storage system capable of supplying electricity, heating and cooling could shape the future of the thermal energy storage market.

Siân Crampsie

The growing need for energy storage systems in a range of different applications is driving new innovation in energy storage technology, and MAN Energy Solutions believes it has one such development: a three-way energy storage system that can meet large-scale requirements for electricity, heat and cold.

Germany-based MAN's so-called Electro-Thermal Energy Storage (ETES) system uses surplus renewable electricity to generate heat and cold for storage in insulated reservoirs during a 'charging cycle'. The heat and cold can be converted back into electrical energy on demand, or distributed to different types of consumers.

The ability of the system to store electricity, heat and cold is unique, according to Prof. Dr. Hans Gut, Managing Director of MAN Energy Solutions Schweiz AG, and is also a factor that will make it appeal to a broad range of customers. "Due to the high overall efficiency, the modular character of the system and its low impact on the environment, ETES is a sustainable energy-storage solution that is suitable for a wide range of applications worldwide," said Gut.

The company also believes that it will help energy consumers in different parts of the energy value chain to play a part in combating climate change. "The biggest challenge in building stable, climate-neutral energy systems is the intermittency of renewable energy in power generation and supply," said Dr. Uwe Lauber, CEO of MAN Energy Solutions. "To match an increasing consumer demand for energy with a fluctuating supply, the world needs reliable energy-storage systems."

Energy storage technologies are beginning to make their mark in the energy system, helping energy companies and energy consumers alike manage intermittent renewable electricity production and energy costs. Batteries, in particular, are becoming increasingly viable in a global energy storage market estimated at 6 GW in 2017, according to IHS.

There is, however, a growing demand for thermal energy storage as governments attempt to electrify and decarbonise sectors such as HVAC and district heating. The global demand for cooling is set to triple by 2050, according to the International Energy Agency, largely due to the growth in air conditioning use in warmer countries. It is in this market that MAN believes its ETES technology could play a role.

The ETES system was borne out of an innovation programme involving some of MAN's newest recruits, according to Patrick Meli, Vice President, Head of Compressor Engineering at MAN Energy Solutions.

As Meli explains, MAN runs a programme, called 'Future Innovation', in which its young engineers are asked to come up with ideas and solutions that will be relevant to the world in 10-15 years' time. The engineers have a year to work on their ideas and build a business plan, which are then presented to the company's board, including the CTO and CEO.

"ETES came from this programme," notes Meli. "We realised it was an interesting idea and could see the potential for it, so we started developing it in further detail."

Those development plans included patenting the idea, but MAN hit a bump in the road when it discovered that it had already been patented – by ABB. It was keen to start discussions with ABB about taking the technology forward on a commercial basis, but had to first wait for the Zurich-based technology firm to resolve legal issues surrounding its patent.

ABB received the go-ahead in early 2017, and the two companies started talks over the use of the patent and developing ETES as a commercial system. MAN learned that ABB's idea was to use ETES for electricity storage applications only, but found that the business case was not exploited to its full potential. MAN could see the demand for three-way energy storage, and so the two companies signed a cooperation agreement in April 2018.

The cooperation agreement allows MAN to use the patent under licence to develop, produce and commercialise the ETES technology.

The ETES system consists of a turbo-compressor, heat exchange equipment, hot water storage tanks and ice storage tanks. It uses carbon dioxide gas as the medium for energy transfer, a factor that sets it apart from some other energy storage systems. "With CO_2, you are talking about a temperature level of 120°C to -4°C in the system, temperatures that can be used directly in most industrial and commercial applications," said Meli. "Other energy storage systems create much higher and lower temperatures because they do not use carbon dioxide, and this creates more complexity."

In the charging cycle, MAN's hermetically-sealed turbo-compressor HOFIM (High-Speed Oil-Free Integrated Motor-Compressor) turns surplus energy from renewable sources to compress CO_2, which is heated to 120°C. The CO_2 is fed into a heat exchanger and heats the water. The hot water is stored in insulated, isolated tanks, each one at a separately defined temperature level. Still under high pressure, the CO_2 is fed into an expander, which reduces the pressure so that the CO_2 is liquefied and cooled. The liquefied CO_2 is again pumped through a heat-exchange system, this time on the cold side of the system. Heat is taken from the surrounding water and ice is formed in the ice storage tank.

In the discharging cycle, gaseous CO_2 enters the heat exchanger on the cold side of the system where it condenses because of the cold from the ice-storage tank. The ice in the tank melts. The CO_2 pump increases the pressure of the CO_2 again. The CO_2 passes through the heat exchanger and is heated by the water in the hot-water storage tanks. The heat from the heated CO_2 is fed into the power turbine where it is converted back into electrical energy via a coupled generator. The electricity flows into the grid and is distributed to consumers.

According to MAN, there are numerous uses for the stored heat, including within the process industries or for district heating. Among other possible applications, the cold can be used to cool data centres, for cold storage or the air-conditioning of buildings. "We see this as an energy management system that can produce heat, cold and electricity," said Meli. "We have been looking at applications where these three elements are needed – for example the food industry and chemicals."

Data centres are another big draw for MAN due to their need for cooling and a need to reduce their carbon footprint. If they are located close to cities then they can feed the stored heat into district heating systems. "We have presented this idea to data centre owners and they like it," noted Meli.

Mega-cities in regions such as Southeast Asia and South America are also an option, according to MAN, as they have significant requirements for heat, cooling and electricity. The ETES system is ideal in such applications, says Meli, because of its 5-10 MWe size range. "ETES can generate 70-80 MWth in total, and store energy for several hours, creating a 300 MWh system," said Meli.

MAN has not yet demonstrated ETES at a commercial scale, but has confidence in the system to work effectively and reliably. This, in part, comes from the use of proven technology that the company has been using for many years in other industries such as oil and gas. The challenge has been the process design.

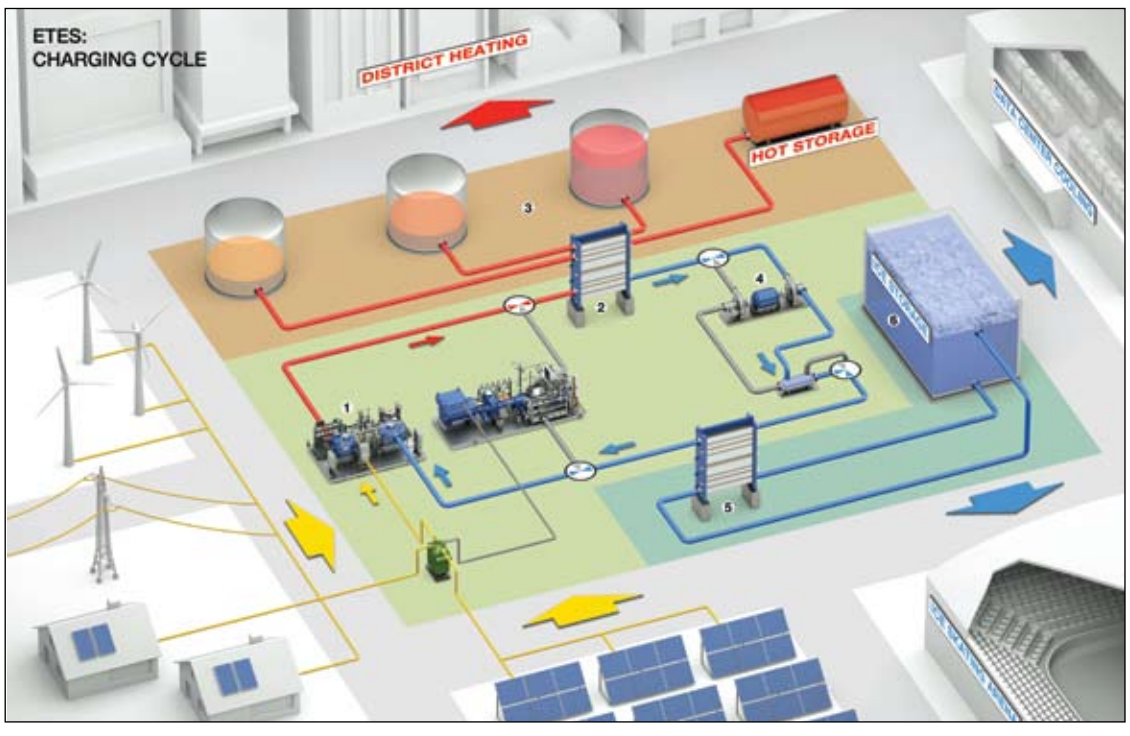
"We are sure that we have the right components and the right design," said Meli. "We have been through several design reviews and we are convinced that the system will work.

"The main challenge for us is on the customer side, and asking them to think out of the box and in a different way from what they are used to doing."

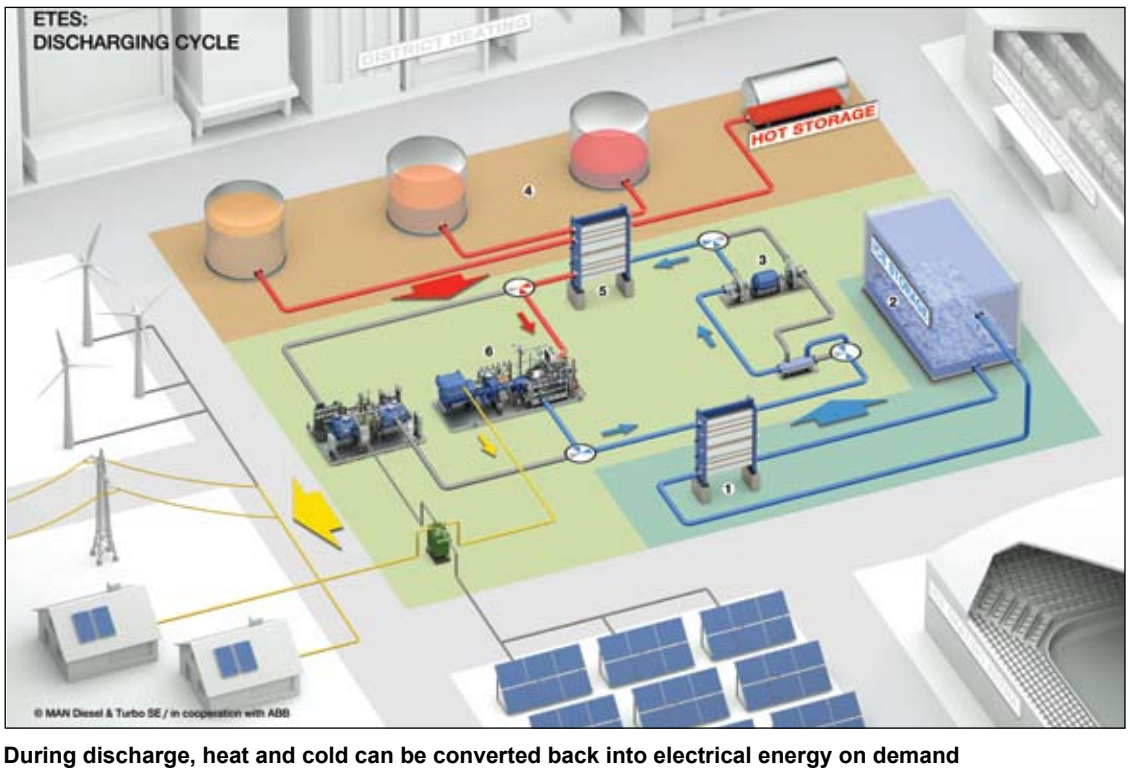
Meli added: "Following the Paris Agreement on climate change, it is no longer enough to think about your system on its own; energy users need to think about the bigger picture and ETES can help them to do this."

Potential customers can also be nervous about the use of CO_2, according to Meli, who points out when you come from a background in the oil and gas industries, working with CO_2 is nothing special. "Compressing CO_2 is not so hard," says Meli. "We are used to it."

MAN has yet to sell an ETES unit but says that it is currently in contact with a number of potential customers. "We are sure we will find a partner soon who sees the advantages of it," Meli says.



During the charging cycle the system uses surplus renewable electricity to generate heat and cold for storage



During discharge, heat and cold can be converted back into electrical energy on demand

Here comes the sun

Junior Isles

With record temperatures being set in many places around the world last month, farmers, gardeners and even the hardiest sunbathers have been praying for a little less sun and a bit more rain. For those dependent on solar power or planning to ramp up solar in the energy mix, the feelings may be a little different. These conditions are ideal for maximum solar output. And if such heat waves are likely to become more frequent due to climate change, the already bright outlook for solar perhaps just got brighter – even though global warning ultimately spells chaos.

The *World Energy Investment* (WEI) report, recently released by the International Energy Agency (IEA), makes interesting reading. After years of a strong shift from fossil fuel investment to clean energy sources, the report says that this trend could be slowing.

Michael Waldron, one of the lead authors of the report commented: "The share of fossil fuels in energy supply investment actually ticked upward from 58 per cent last year to 59 per cent in 2017. This was in stark contrast to a significant fall in previous years. Previously, this figure was up at around 68-70 per cent, indicating that there has been a pause in the shift towards the investment in clean energy."

> "There is hardly any scenario going forward, which looks at energy systems of the future with regard to decarbonisation, that doesn't give solar an extremely prominent role."

This is partly due to the rapidly declining cost of renewables. But solar PV, along with offshore wind, was one of the most notable exceptions to the trend. According to the IEA, unit costs for solar PV projects, which represent 8 per cent of total energy investment worldwide, fell by nearly 15 per cent on average, thanks to lower module prices and a shift in deployment to lower-cost regions. Investment nonetheless rose to a record level.

Technology improvements and government tendering schemes are facilitating economies of scale of new projects in some markets: in emerging economies outside of China the average size of awarded solar PV projects rose by 3.5 times over the five years through 2017.

The figures indicate that solar – at least solar PV – is not only here to stay, but looks set to play a key role in the global decarbonisation effort.

Commenting on the future of solar, Frank Wouters Director at the EU-GCC Clean Energy Network and Global Head of Solar at professional services company WorleyParsons said: "There is hardly any scenario going forward, which looks at energy systems of the future with regard to decarbonisation, that doesn't give solar an extremely prominent role. The main reason for that is because it can be applied everywhere."

Certainly solar energy can be applied in gadgets such as watches and calculators, to rooftops of houses, and over the last several years, to massive solar power plants. In a growing number of countries, falling cost is seeing solar become the cheapest from of utility scale electricity generation.

But it is not just about cost; solar PV's versatility is what makes it interesting. It should also not be forgotten that it has the potential to lift the more than 1 billion people without access to modern energy out of energy poverty – the technology that is used to charge a phone or a lamp can also be used to operate a water pump for agriculture.

Wouters noted: "When you combine it with new financial models and new models of billing, you see massive growth in places like rural Africa as well as in Asia and Latin America."

Africa has long struggled when it comes to making progress on energy access, particularly access to electricity. Nearly 675 million of the continent's population lacks access to the grid, around 600 million of which are in sub-Saharan Africa.

Waldron commented: "There is a very good reason for this; power companies in [sub-Saharan] Africa can't adequately recover their costs. They're not able to undertake reliable fixed investment to the grid and service reliable off-takers of power generation. This raises risks to investment for both the state-owned side and the private side. This is a major reason we haven't seen a pickup in demand for electricity – it is very much tied to electricity prices and the presence of subsidies in a lot of these markets."

This was echoed by Wouters. "Even in places where solar is now competitive to some extent at the wholesale level, you still need the regulatory framework. You need a level playing field in the market to make it work. In many African countries, they have a cross-subsidy in the electricity sector, where companies and people in the bigger cities usually pay a higher tariff than the rural population, which is generally poorer. It makes sense from a social development point of view but is also a blockage to, for example, developing mini-grids based on solar energy in those areas because you cannot recover your investment based on that subsidised tariff."

The ultimate effect of this is that the population remains unconnected by a grid and individuals end up paying much more through purchasing diesel or kerosene for their energy needs.

It is a problem that Wouters says has been recognised in countries like Ghana and Tanzania which now allow more flexibility on tariffs, and in doing so have increased investment.

Taking a broader look at the requirements for solar growth in various countries, Wouters added: "There's an interesting dynamic that I've observed over the last 10 years. A number of things have to be in place: you need availability of credit; a stable regulatory framework; a fair number of installers and commercial companies that offer the technology; and you need a certain level of awareness about what it can do. If all of these are in place, then markets really explode. And there's not a single market in the world that does not have that potential."

This observation is borne out by the range of countries where WorleyParsons is doing work. It is working on the 700 MW concentrated solar power (CSP) Dewa 4 project in Dubai – a $4 billion project that is the largest of its kind in the world. Wouters notes that the company is doing similar things in Chile, South Africa and other African countries.

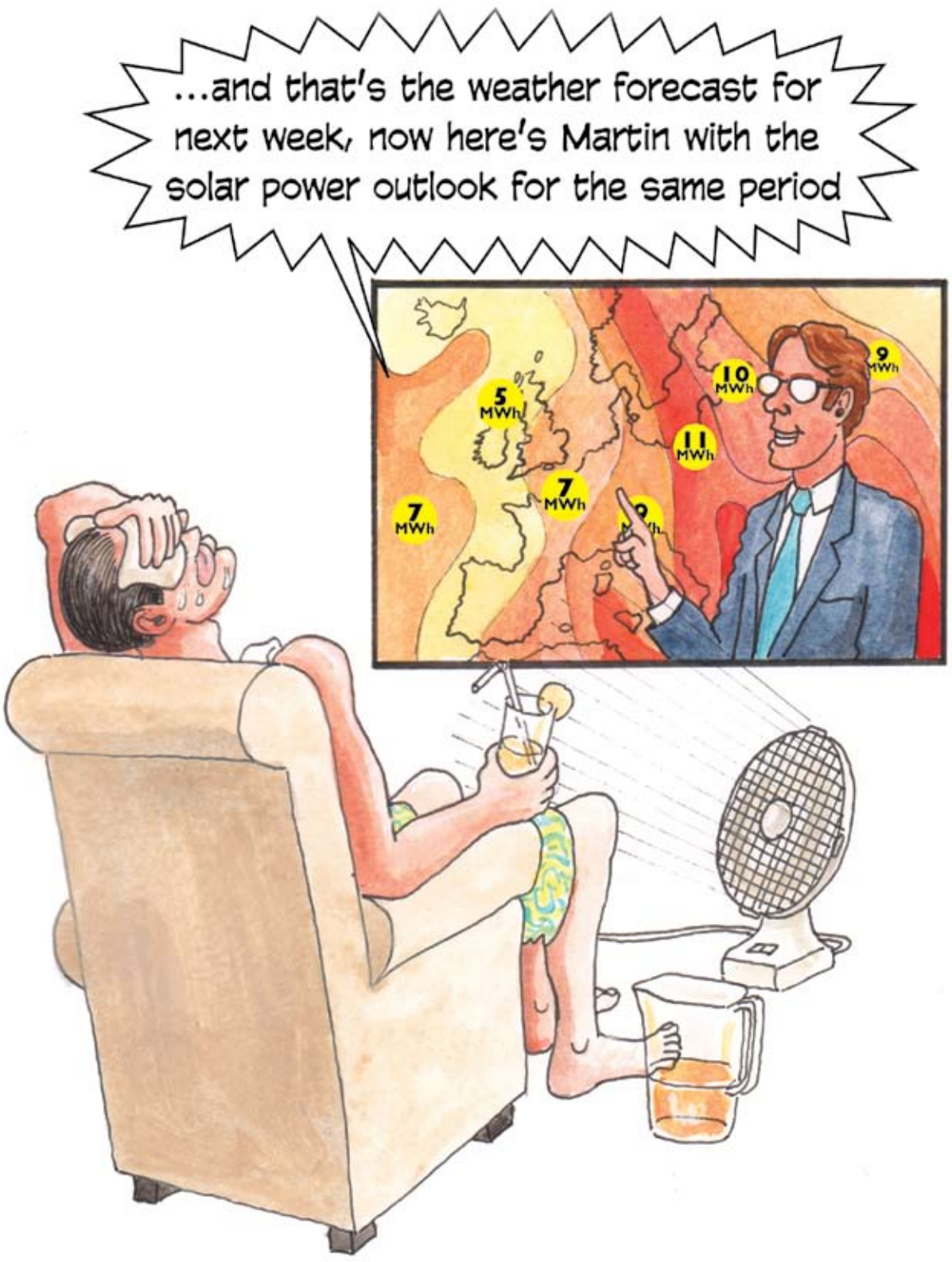
Even in parts of Europe that, current weather conditions aside, do not have the best conditions for solar, the technology is well placed to play an important role in the future energy mix. A key part of the bloc's proposed new Renewable Energy Directive going forward is the right for citizens to produce their own electricity. This will make it more difficult for member states to give priority access to bulk power producers over individual solar systems on roofs.

The solar industry has also shown that it can achieve greater efficiencies through, for example, managing supply chains and increasing scales, which will help even greater future cost reductions.

Wouters commented: "Prices at the moment are pretty accurate in the sense that solar PV has a learning rate that dictates that if you double the amount [of modules] that you produce, you go down in price by 23 per cent. And as you keep increasing the number you produce, you keep reducing the cost per kilowatt-hour of solar.

He believes the industry "has cracked it" for solar PV but still has some way to go on CSP. "Solar CSP has a much smaller footprint – about 5 GW globally compared to more than 300 GW of solar PV," he said. "It's at a much earlier stage of development so there's still a lot of work to be done – even though it's also still pretty competitive, as we've seen with Dewa 4. At night time that project provides CSP electricity at 7.4 ¢/kWh and at 3 ¢/kWh during the day with solar PV."

And if the climate scientists are right, it's a technology that will also get a little extra help from the weather. Many experts believe that these heat waves will become more frequent over time. And more sun means more solar. It is somewhat bizarre to think that here is a technology that is helped by the very phenomenon that it seeks to prevent.



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