SIX EYE-CATCHERS IN OUR PICTURE OF WORLD ENERGY IN 2030

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Spotting important details on a large canvas can be difficult, whether it is Suleiman The Magnificent sitting anachronistically at a table in Paolo Veronese's *The Wedding at Cana* or, in a different art form, Elon Musk's 11-second cameo in *Iron Man 2*.

Bloomberg New Energy Finance's latest forecast for global power – our 2030 Market Outlook – is a large canvas in its own right, one that we hope is worthy of even greater attention than the revered *Iron Man 2*.

It is the most ambitious forecast we have ever published, based on detailed modelling of electricity market supply and demand, technology cost evolution and policy development in individual countries and regions, and it presents 2030 as a time when modern renewables (i.e. excluding large-scale hydro) will account for a much larger share of global generation (20%, up from 5%), thanks to an average of $362bn in capital investment per year from now on, in 2014 dollars.

Inspired by the character- and symbol-rich *The Wedding at Cana*, painted in 1563, I am going to pick out six elements from the 2030 Market Outlook's complex canvas that may not be immediately obvious – but are hugely significant for the future. Below that, I will play Devil's Advocate just a little, discussing the chances of a more extreme scenario unfolding.

Emissions

My first take from the forecast concerns CO2 emissions. The last decade has seen the carbon dioxide content of the atmosphere rising inexorably, to 401.9 parts per million in May 2014, up from 380.6 in the same month of 2004. Much depends on the world's ability to bring down emissions as soon as possible.

Bloomberg New Energy Finance's projections for the power sector are not exactly reassuring in this regard, although they are a bit more optimistic than those of BP, for example, which in its latest forecast in January showed CO2 emissions growing by 29% by 2035 (and presumably continuing to increase beyond that, since there was no sign of its line changing direction).

Our numbers on emissions cover Europe, the US and China and our power mix figures are complete for all regions of the globe. We see emissions in Europe falling 56% between 2013 and 2030, while those in the US drop 13% and those in China rise 43%. Meanwhile global generation from coal will increase by 15% in TWh terms from 2013 to a peak in 2026, before slipping by 1.5% by 2030. This, combined with improved efficiency in coal plants and the retirement of some of the highest-polluting units, should mean that world power sector emissions peak sometime in the second half of the 2020s.

Of course, that will be too late, by some margin, to achieve the International Energy Agency's "450 Scenario", which would bring about a peak in the CO2 content of the atmosphere at no more than 450 parts per million, and limit the temperature increase to two degrees Celsius, according to the arithmetic of climate scientists.

It does nothing to dent the need for policy-makers to increase their efforts to clear the way for the decarbonisation of the energy system, starting with the removal of real and implicit fossil fuel subsidies. However, if we are right, the most extreme global warming scenarios look unlikely to unfold – unless there are disastrous feedback effects as warming occurs.

Coal

My second take from the forecast concerns the black stuff that has been the mainstay of the global generation mix since the Industrial Revolution. We have pointed out in previous VIP Comments, and elsewhere, that it will be very difficult to prevent coal remaining a big piece of the mix in the next couple of decades – for the simple

reason that there is a great deal of coal-firing capacity already installed and with many years of scheduled life left, and further capacity that is well into the process of development or construction, particularly in emerging economies.

Our 2030 Market Outlook shows 6GW of coal-burning capacity coming on stream in OECD countries in the calendar year 2015 and 4GW in 2020, but none at all in 2025 or 2030. That is *gross* capacity, in other words all new power stations, including any built to replace plant retirements. In non-OECD countries, on the other hand, there will be 47GW of new coal-fired capacity in 2015 (down from 66GW in 2013). This will fall to 36GW by 2020 and 22GW in 2025, but there will still be 21GW under construction in 2030.

So an important message is that we will not decarbonise the world's energy supply without new policy intervention in developing countries. That's means we cannot simply "rely on the market" to deliver the outcome – particularly in non-OECD.

Golden age of gas

Or not so golden? Fans of shale gas have enthused about what has been achieved in the US, with marketed natural gas production up 28% in the last 10 years according to the Energy Information Administration, and extrapolated similar progress in Europe, China, Latin America and elsewhere. They are not completely off target – our forecasts, for instance, show gas-fired capacity in China will increase from 47GW in 2013 to 191GW by 2030, and gas-based generation increasing from 2% to 10.5% of the total. But the latter figure will be far short both of coal, at 46.5%, and non-hydro renewables, at 20%.

In Europe, we expect no golden age of gas at all. Yes, gas-based capacity will increase from 257GW in 2012 to 280GW by 2030, but the amount of generation from that plant will fall from 696TWh in 2013 to 686TWh in 2030, as gas' role becomes more to do with balancing other sources and less to do with meeting baseload.

The reason for gas' mixed fortunes in Europe will be its stubbornly high levelised cost compared to renewables. We believe shale gas will never be as plentiful in the old continent as in the US, it will be more expensive to develop and extract because of geology, population density and local laws. In addition, what shale gas is produced will have to make up for declining conventional production, particularly on the UK Continental Shelf in the North Sea.

In the US, the age of shale will result in an increase in gas-fired generation from 1,127TWh in 2014 to 1,443TWh in 2021. However, it will decline from there, at first very slowly, and then a little more quickly because of the higher natural gas prices we expect to see in North America from 2024 onwards, reflecting the depletion of the cheapest shale fields and increased demand from heat, transport and exports.

Overall then, we have world gas-fired generation increasing between 2013 and 2030 by 47%, but still only accounting for 22% of the total generating mix at the end of that period. So it may be a gold-tipped age for gas perhaps, but certainly not 24-carat.

Technology costs

The main driver of our figures for the growth of renewables in the next 16 years is the cost trend for generation sources such as small- and large-scale PV, as well as onshore and offshore wind. These vary by region and country, for reasons that I discussed in this column two months ago. Our work on the 2030 Market Outlook has included detailed number-crunching on the future levelised costs of electricity, or LCOE, in all of the major regions.

These show that the LCOE for large-scale PV projects in China with 20% capacity factor is set to fall from $107 per MWh in 2013 to $52 by 2030, while those for 19% capacity-factor sites in the US move down from $122 to $74.

For onshore wind, the cost reduction will be less spectacular but it will still be enough, in some regions, to make it clearly cheaper per MWh than any fossil fuel alternative. Our model has the average LCOE for a European onshore wind farm at a 30% capacity factor falling from $80 per MWh in 2013 to $59 in 2030.

The cost reductions we expect for solar and onshore wind will be driven by a broad range of factors – economies of scale in manufacturing, bigger turbines, new materials, more efficient use of polysilicon, more cost-effective inverters, improvements in balance of plant and installation techniques, use of onsite intelligence to reduce operations and maintenance expense.

For offshore wind, we also see cost reductions, but as projects move to deeper water and more remote locations, these will not be sufficient to wean this technology off subsidies entirely before 2030.

One factor we expect to help renewables and hinder the construction of new fossil-fuel capacity will be the cost of capital. As subsidies for renewables fade out, and uncertainty intensifies over the possible life expectancy of any new coal plants, in particular, the cost of debt

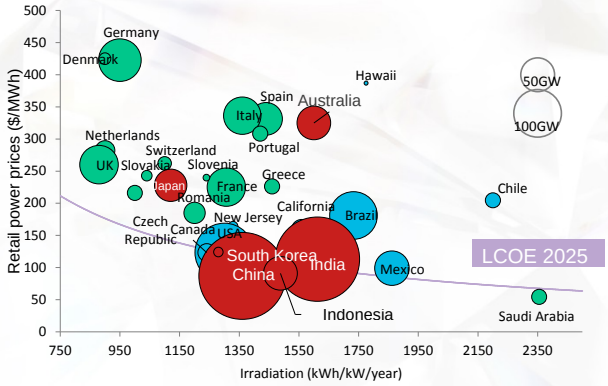
should move increasingly in favour of the cleaner options.

Small-scale solar

Rooftop PV is the joker in the pack, the power generation source that could upset all calculations for the future energy system, not to mention the business models of many incumbents. The reason is that it competes not with other generation sources in the wholesale electricity market, but with retail electricity prices. The lower all-in technology costs go for residential and small commercial solar, the more consumers will decide to generate power on their own rooftops, reducing their purchasing of grid electricity.

The chart shows that we expect improving economics for small-scale solar to "price in" the technology in many more countries by 2025 than the handful (Germany, Italy, Australia, Chile) where residential PV can undercut retail electricity prices currently. Among the new territories for unsubsidised rooftop PV will be Japan, France, the UK, half of India, most of Mexico, large parts of the US and China, most of Africa, South East Asia and Latin America.

Global residential-scale PV system economics in 2025



Source: Bloomberg New Energy Finance

We see small-scale PV expanding its generation worldwide by a factor of 13 over the next decade and a half, with a capacity increase of more than 1TW, equivalent to $1.3 trillion of investment. It sounds like an aggressive forecast, but the margin of error around it is especially large (see below).

Power demand

My sixth and final take from the 2030 Market Outlook is a more subdued projection for world electricity demand than shown by some other forecasters, or than we might have put forward a few years ago. Recent trends in OECD countries have been notably soft when it comes to electricity consumption, hinting that shifts to other heating sources, plus the use of more efficient devices and lighting may be having more effect than expected. We may also be seeing some price-elasticity of demand as consumers experience rising retail power prices.

Our model suggests that power demand in Europe will grow, but only by 16% between 2013 and 2030, while that in the US will expand by only 13%. As for developing countries, we say that Chinese power demand will double from 2013 to 2030, while that in Brazil rises 75%. But, believe it or not, these changes would represent appreciably lower growth rates than those seen in recent years (according to the IEA's World Energy Outlook 2013, published last November, Chinese electricity generation increased 632% in 1990-2011, while that of Brazil rose 139%).

India's power demand, on our figures, will treble to 2030, the same size of increase as in the longer 1990-2011 period. India will therefore take over from China as the region with the most voracious appetite for additional power capacity. One of the big questions is whether it will follow China's highly energy-intensive path to economic growth. I am hopeful (in the interests of curbing world emissions) that it will not.

Devil's advocacy

OK, so that is how Bloomberg New Energy Finance sees 2030. A world in which renewables are in the ascendancy, winning market share year-in, year-out from fossil fuel generation and nuclear, and in which efficiency measures are continuing to limit growth in electricity demand.

Of course all forecasts are destined to be wrong. We have discounted the chance of a breakthrough climate deal at the UNFCCC talks in Paris next year, resulting in a meaningful global price being put on carbon. We have discounted the chance of a sudden technology breakthrough that changes the rules of the energy sector, perhaps super-low-cost power storage, small modular nuclear reactors, or synthetic fuels made from power station exhaust flows. Much as we might long for such game-changers, time is running out for them to achieve global scale before 2030, just 15 years hence.

If I had to guess where the biggest risks lie to our forecast, I might mention improvements in fossil-fuel technology as one, a change in the global GDP growth mix leading to even lower power demand growth would be the second, and exponential growth in small-scale solar as the third, and perhaps hardest to predict.

Taking these three in turn, we have assumed broadly stable levelised costs per MWh for coal- and gas-fired generation, with technological improvements balancing out tighter emissions regulation and, in some places, increases in carbon prices or taxes. We have also

assumed very modest progress with carbon capture and storage, its various technologies held back by cost considerations and local objections. However, it is also possible to imagine greater improvements in fossil-fuel efficiency and in CCS techniques, leading to lower emissions and costs, and more generation.

Global energy demand growth in the last 20 years has owed much to China's highly capital-investment-heavy economic boom, and to the continued dominance of the internal combustion, rather than the electric, vehicle in transport. Our forecasts reflect an expectation that both influences will weaken, but that the shift will be orderly, not abrupt. More violent change is possible in either – with potentially opposite effects on world electricity demand. It is also possible that the recent surprisingly weak trends in OECD power demand prove to be just the start of a relentless trend – as successive waves of efficiency technologies wash across markets.

As for small-scale PV, our 2030 Market Outlook has presented aggressive figures for cost improvements in solar over the years ahead. But it is possible that demand for rooftop PV responds differently from our central case, and more akin to other consumer technologies such as mobile telephones or personal computers. In particular, we could move into a messy world in which decisions on generation are being made by consumers and businesses with incomplete information and facing strong peer-group influence. It is possible that PV may grow more quickly than we calculate, as customers "overbuild" what will by 2030 be a very cheap technology. If so, the impact on total grid-electricity demand (and on the businesses of incumbent generators) could be more extreme.

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