

INVESTMENT IN RENEWABLE ENERGY COMPANIES

- Investment in renewable energy companies through public markets inched up 6% to \$6 billion in 2018. This means the figure has held roughly steady for three years, but at less than half the peak for this decade set in 2014.
- Solar remained the largest sector, attracting \$3 billion, twice as much as wind. Biomass and waste stood out with a rise of 123% to \$1.3 billion, setting an all-time record, but this was driven by a single deal.
- Shares in renewable energy companies underperformed the main markets in 2018. While the S&P 500 and Nasdaq indices slipped 5% and 7% respectively, the WilderHill New Energy Global Innovation Index, or NEX, which tracks 106 clean energy and transport stocks, fell by 21%.
- Investment in renewable energy companies through venture capital and private equity rallied after three successive years of decline, rising 32% to \$2 billion, but the great majority of this took the form of expansion capital rather than early-stage money.
- Investment in research and development rose 10% to \$13.1 billion, continuing its strong growth since 2015, and setting its third consecutive annual record. Companies invested almost \$7.5 billion and governments \$5.5 billion.

For some time now, the renewable energy sector has been looking all grown up. After a decade-long adolescent growth-spurt, and several boom-and-bust crises, the industry is settling down. In the main sectors, solar and wind, manufacturing is dominated by global companies – most of which did not exist at the turn of the century – and the key technologies are well established. As a result, there is less need for venture capital and private equity than there was a decade ago, and start-ups often secure funding from utilities instead. R&D is less a matter of Eureka moments in a garden shed, and more of a relentless effort in corporate labs to make myriad incremental improvements in cost and efficiency.

Not that the sector is slowing down, however. Fierce competition among solar and wind manufacturers, and their relentless focus on capital cost and energy efficiency, means that the world secures ever more new generating capacity each year for the same money.

What it does mean, however, is that public markets tend to be quieter these days than in the past. There are fewer monster initial public offerings, or IPOs, but a steadier stream of companies returning to the markets to raise capital through secondary, private equity as public investment (PIPE), and convertible issues.

PUBLIC MARKETS

In 2018, the total investment in specialist renewable energy companies through public markets rose just 6% to \$6 billion, little changed from both 2017 and 2016, as shown in Figure 44. The combined value of IPOs fell 10% to \$1.3 billion, scarcely a tenth of its 2007 peak, while secondary issues held steady at \$2.7 billion and the 'convertible & other' category (including rights issues) jumped 29% to \$2 billion.

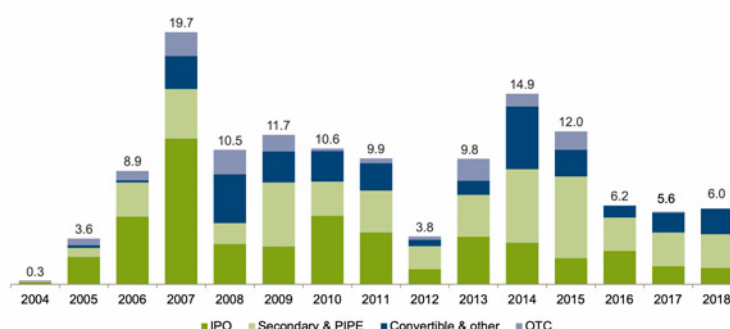
Among the sectors, solar secured the greatest investment, as usual, rising 8% to \$3 billion, while wind slumped by a third to \$1.5 billion, as shown

in Figure 45. The surprise was that biomass & waste, usually a distant fourth in the sector rankings, leapt 123% to \$1.3 billion, to run wind close for second place.

The reason, as shown in Figure 46, was a single deal, the largest of the year, from the Hong Kong-based firm China Everbright International. The company, which builds and operates waste-to-energy plants across China, and also has businesses in Germany and Poland, surprised the market with a deeply discounted rights issue to raise \$1.3 billion on the Hong Kong stock exchange. The company insisted it was not short of cash, and that 60% of the funds raised would go on new waste-to-energy projects, and 25% on R&D. In 2017, a related company, biomass generator China Everbright Greentech, mounted the year's largest renewable energy IPO, raising \$434 million.

The value of IPOs slipped 10% to \$1.3 billion in 2018, and there were not many of them: only four in the top 16 deals. In the largest, Neoen, the French solar, wind and biomass developer, raised \$808 million on the Euronext Paris exchange. The company has 2.8GW of capacity already operating or financed in 12 countries, including France, Australia, El Salvador and Zambia, and aims to raise this to 5GW by 2021.

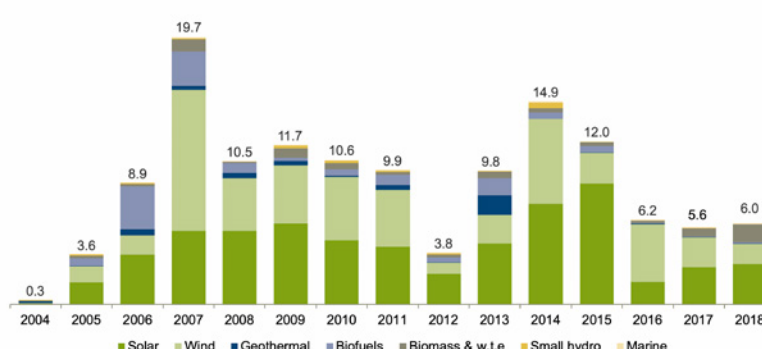
FIGURE 44. PUBLIC MARKETS NEW INVESTMENT IN RENEWABLE ENERGY BY STAGE, 2004-2018, \$BN



PIPE = private investment in public equity, OTC = over-the-counter.

Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 45. PUBLIC MARKETS INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2004-2018, \$BN



Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 46. BIGGEST PUBLIC EQUITY RAISINGS IN 2018, \$M

| Company | Location | Sector | Business model | Type of share issue | \$m |
|--------------------------------|----------------|-----------------|----------------|---------------------|------|
| China Everbright International | Hong Kong | Biomass & Waste | Developer | Convertible & Other | 1269 |
| Neoen | France | Solar | Developer | IPO | 808 |
| TerraForm Power | United States | Solar | Yieldco | Secondary & PIPE | 650 |
| Azure Power Global | India | Solar | Developer | Secondary & PIPE | 185 |
| Greencoat UK Wind | United Kingdom | Wind | Quoted fund | Secondary & PIPE | 160 |
| Jiangsu New Energy Development | China | Wind | Developer | IPO | 159 |
| Boralex | Canada | Wind | Developer | Secondary & PIPE | 158 |
| Innervex Renewable Energy | Canada | Wind | Developer | Convertible & Other | 150 |
| Greencoat Renewables | Ireland | Wind | Quoted fund | Secondary & PIPE | 130 |
| Sunpower Group | China | Solar | Manufacturer | Secondary & PIPE | 120 |

The table shows the largest deals with disclosed values.

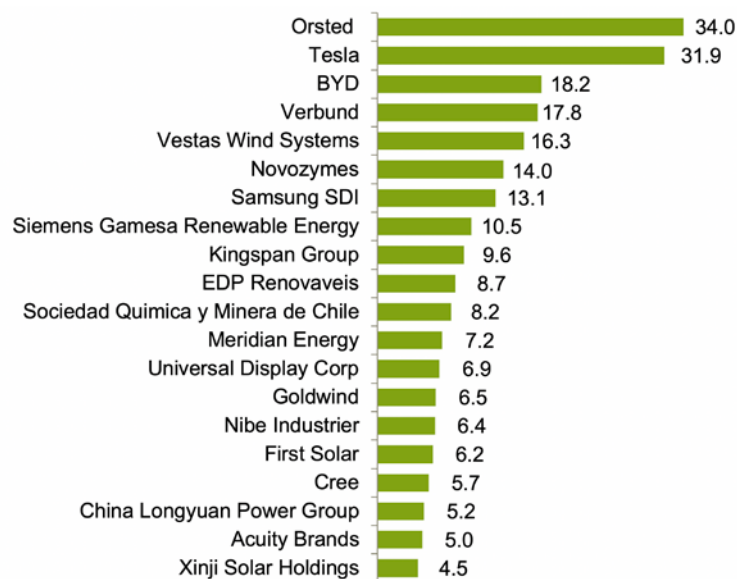
* Merger of Siemens wind business with Gamesa produced SGRE.

Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 47. NEX VS SELECTED INDICES, 1 JANUARY 2018 TO 31 DECEMBER 2018

All indices rebased to 100 on 2 January 2018.

Source: Bloomberg

FIGURE 48. LARGEST COMPANIES IN THE NEX INDEX, BY MARKET CAPITALIZATION, \$BN

Capitalization numbers on June 4, 2019.

Source: Bloomberg

The total public market investment of \$6 billion in 2018 was just 40% of the nearly \$15 billion raised in 2014 – but that peak was inflated by the boom in North American ‘yieldcos’. These investment vehicles, which own large portfolios of

generating assets, were all the rage until it became clear that investors had overestimated their dividend growth potential. Since the bubble burst, yieldcos have found it harder to raise capital.

However, TerraForm Power, now controlled by Brookfield Renewable Partners, raised \$650 million in a secondary placing in 2018, while TransAlta Renewables, a Canadian yieldco, raised \$113 million. In Europe, where quoted project funds escaped the U.S. yieldcos’ boom and bust, Greencoat UK Wind raised almost \$160 million, and its sister company Greencoat Renewables raised another \$130 million, both in secondary issues.

In share trading, the NEX index fell 21% from 1 January to 31 December 2018, compared to declines of 5% for the S&P 500 and 7% for the Nasdaq Composite, as shown in Figure 47. The NEX tracks the progress of 106 stocks, but many are in the broader clean energy and transport sector rather than strictly renewable energy – the focus of this report. Two of the three largest stocks, Tesla and BYD, are EV manufacturers, as shown in Figure 48. The largest 20 companies in the index include only three major wind manufacturers (Vestas, Siemens Gamesa and Goldwind), and just one PV module maker, First Solar. At the same time, the NEX excludes some of the world’s biggest developers and owners of renewable generating capacity, such as Enel, NextEra Energy and Iberdrola, because they also own fossil assets. These discrepancies may go some way to explaining why

the NEX has underperformed the main markets recently, despite the growth of renewable energy worldwide. Another factor has been ferocious competition on costs between manufacturers, particularly in solar.

VC/PE

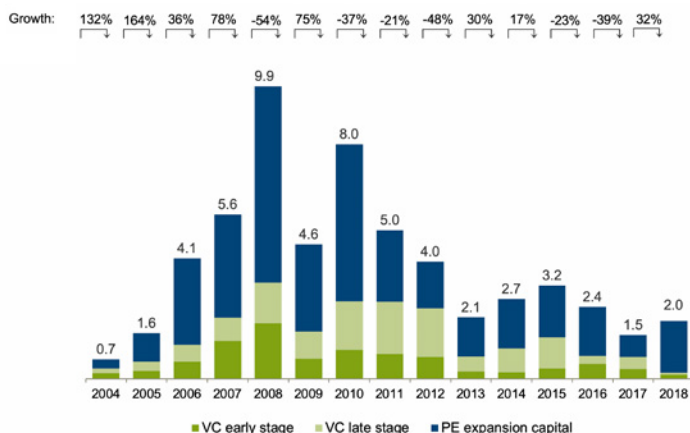
Investment in renewable energy companies through venture capital and private equity rebounded 32% in 2018 to \$2 billion. However, this increase followed a decade of near-constant declines from the \$9.9 billion peak reached in 2008.

Renewable energy is now largely a mature sector, its main technologies well established, even if the performance of the equipment continues to improve rapidly. These days, R&D is typically funded directly by large companies, and there are fewer opportunities than before for disruptive start-ups – although of course there are exceptions. Small companies often secure funding from utilities rather than venture capitalists.

As a result, 2018 saw steep declines in early- and late-stage venture capital. Early-stage fell 66% to \$148 million, while late-stage slumped 87% to \$53 million, as shown in Figure 49. These falls were almost exactly offset, however, by a more-than-doubling of private equity expansion capital to \$1.8 billion. This recovery from the previous year's slump means that category of investment has regained roughly its normal level since 2012.

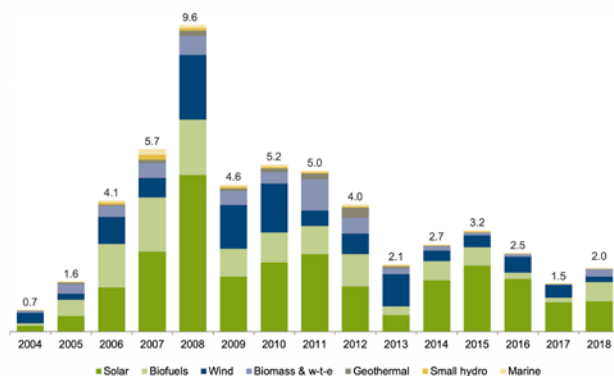
Half the VC/PE investment in 2018 went to solar, up 4%, and just a tenth went to wind, down 57%, as shown in Figure 50. The big gainers were biofuels, where investment more than quadrupled to \$598 million, and biomass & waste, where inflows jumped eleven-fold to \$241 million. The geographical breakdown given in Figure 51 shows the big gainers were China, where VC/PE soared more than fifty-fold to \$120 million; Europe, up

FIGURE 49. VC/PE INVESTMENT IN RENEWABLE ENERGY BY STAGE, 2004-2018, \$BN



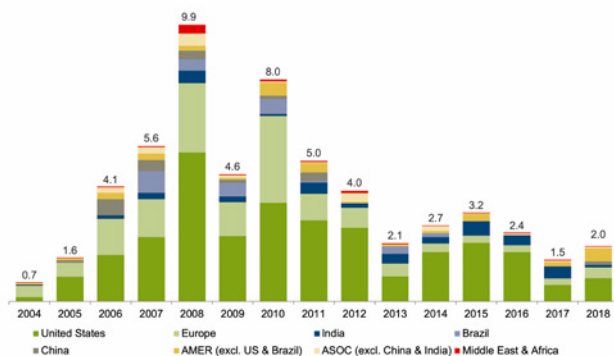
Buy-outs are not included as new investment. Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 50. VC/PE INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2004-2018, \$BN



Buy-outs are not included as new investment. Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 51. VC/PE INVESTMENT IN RENEWABLE ENERGY BY REGION, 2004-2018, \$BN



Buy-outs are not included as new investment. Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF



FIGURE 52. SOME OF THE LARGEST VC/PE EQUITY RAISINGS IN RENEWABLE ENERGY IN 2018, \$M

| Company | Location | Sector | Type | Business model | \$m |
|--------------------------------|----------------|-----------------|----------------------|--------------------|-----|
| World Energy | United States | Biofuels | PE expansion capital | Biodiesel producer | 345 |
| Enerkem | Canada | Biofuels | PE expansion capital | Waste-based fuels | 224 |
| Grasshopper Solar Corp | Canada | Solar | PE expansion capital | Project developer | 210 |
| Cypress Creek Renewables | United States | Solar | PE expansion capital | Project developer | 200 |
| Bioenergy Infrastructure Group | United Kingdom | Biomass & waste | PE expansion capital | Project developer | 196 |
| Fred Olsen CBH | United Kingdom | Wind | PE expansion capital | Project developer | 155 |
| Sunnova Energy Corp | United States | Solar | PE expansion capital | Residential solar | 100 |
| Nexamp | United States | Solar | VC early-stage | Project developer | 54 |
| Sunlight Financial | United States | Solar | PE expansion capital | Solar financing | 50 |
| Cleantech Energy Corp | Singapore | Solar | PE expansion capital | Project developer | 50 |

The table shows the largest deals with disclosed values. Other deals might have got onto this list, if their values had been disclosed.

* Merger of Siemens wind business with Gamesa produced SGRE

Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

68% to \$387 million; and Other Americas, which tripled to \$473 million. The losers were India, down 79% to \$92 million, and Other EMEA, also down 79%, to almost zero.

In private equity, seven of the 11 biggest deals with disclosed values were in solar, but the two largest were in biofuels, as shown in Figure 52.

In the largest deal, CFFI Ventures, based in Barbados, bought a minority stake in World Energy for \$345 million. World Energy is a U.S. biodiesel manufacturer with operations in the southern U.S. It has recently

expanded into California, where it also supplies bio-jetfuel to Los Angeles airport. The company said that, when its current projects are complete, it will be the largest supplier of biodiesel in North America, and the deal should speed its expansion.

In the second largest transaction, Enerkem, the Canadian biofuel producer, raised \$224 million from a group of investors including BlackRock and the National Bank of Canada. The company produces methanol and ethanol from urban waste and residual biomass through gasification. It has a plant in Edmonton, Alberta, with others planned

for Varennes in Quebec, and Rotterdam in the Netherlands. The company has signed an agreement with one of its new investors, Sinobioway, to build 100 plants across China by 2035.

In the largest solar private equity deal, Deutsche Bank bought a minority stake in Grasshopper Solar, a Canadian developer with projects in Canada, the U.S. and Japan, for \$210 million. Not far behind, Cypress Creek Renewables of the U.S. raised \$200 million.

There was also a sizeable deal in biomass and waste, as the Bioenergy Infrastructure Group raised \$196 million from investors including Helios Energy, Infracapital and Aurium Capital Markets. The British waste-to-energy company has 100GW of plants in operation or under construction

RESEARCH AND DEVELOPMENT

Research and development spending in renewable energy rose 10% to \$13.1 billion, as shown in Figure 53, continuing its strong growth since 2015, and setting its third consecutive annual record. The evidence continues to suggest this investment is paying off, as both wind and solar continue to push down the cost of renewable energy – although progress in other areas such as biofuels and marine power has been patchy.

When governments commission large amounts of renewable generation, they typically do so through auctions, and this competitive process, combined with relentless capital spending to

improve product and manufacturing efficiency, means prices continue to tumble.

BNEF analysis shows how the global levelized cost of energy for the main forms of generation has fallen dramatically over the past decade. For non-tracking solar PV, the global benchmark LCOE fell from \$304/MWh in 2009 to \$86/MWh at the beginning of 2017, and \$60/MWh by the end of 2018. For onshore wind, the equivalent figures have been \$93/MWh, \$67/MWh and \$52/MWh (see Figure 3 in the Focus Chapter).²²

At these levels, the main renewable technologies undercut fossil generation in all the main markets and generally need no subsidy. PV even undercuts new coal plants in China and India, where not long ago coal dominated capacity additions.

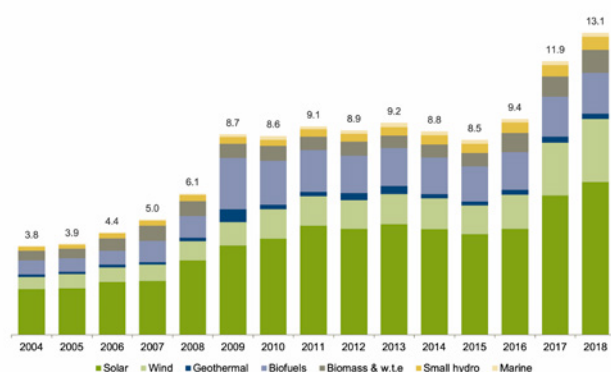
Innovation is also spreading to the auction process itself. In 2018, India pioneered 'hybrid' auctions for projects that combine solar and wind capacity. The advantage of this is that it smoothes intermittency and makes more efficient use of land and grid connections. The first hybrid auction awarded 840MW of capacity at the equivalent of \$38/MWh, and India plans five more such auctions in 2019.

At a technical level, both solar and wind are achieving incremental improvements, and are also seeing the development of new techniques aimed at achieving big leaps in efficiency and cost.

Solar

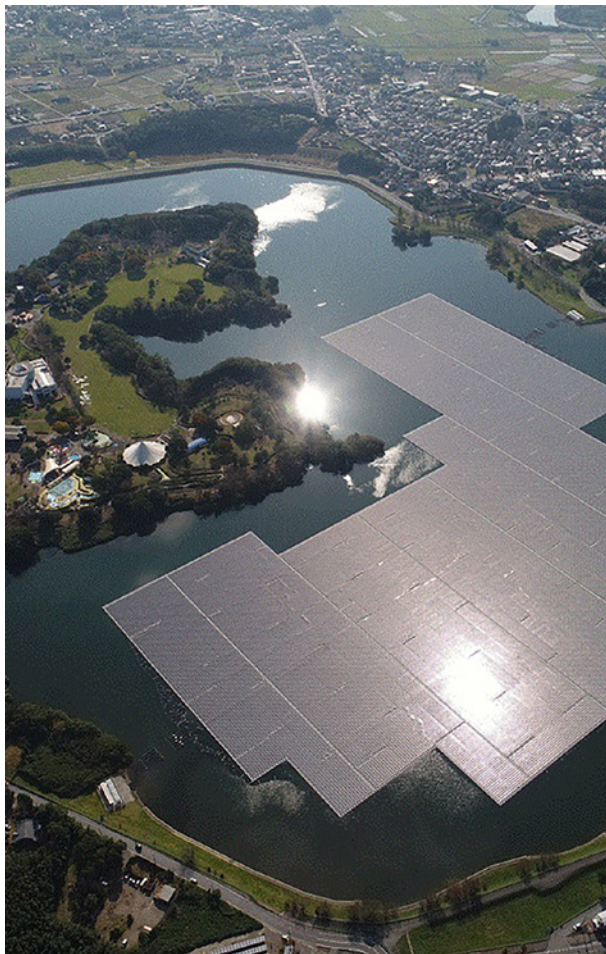
In solar, the routes to improving efficiency and cost are well established, as discussed in these pages of the 2018 Global Trends report. In the production process, one example is a much-improved method to slice the thin wafers of silicon needed to make a solar cell from the original block of material. In the last two years, almost all manufacturers have switched from the old slurry-based sawing technique to diamond wire saws. These waste much less silicon and increase the number that can be cut from a single block.

FIGURE 53. CORPORATE AND GOVERNMENT RENEWABLE ENERGY R&D BY TECHNOLOGY 2004-2018



Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

²² BloombergNEF: 1H 2019 LCOE Update, 26 March 2019 <https://www.bnef.com/core/insights/20423>



Manufacturers also continue to improve the energy efficiency of their products by switching to superior cell designs, such as passivated emitter rear contact (PERC), and by increasing the number of silver ‘busbars’ that collect the electricity from the cell. In 2016, more than 80% of cells were produced with four busbars, but in 2017, the same proportion was produced with five. Now some manufacturers are beginning to produce cells with as many as 12 busbars, which they say will increase their energy output by a further 0.1 Watt per cell.²³

Yet another advance is the ‘bifacial’ solar module, which collects reflected light on its underside to raise output by as much as 10% at little extra cost. BNEF analysts had expected production of bifacial modules to more-than-double in 2019, but then the U.S. government surprised the market by exempting these units from a major import tariff, meaning production will probably grow even faster, especially in Southeast Asia.

As a result of these kinds of advance, BNEF estimates that the production cost of the best multi-crystalline silicon modules fell from 27.8 U.S. cents per Watt to 21.8 U.S. cents/W during 2018, while that of the best mono-crystalline fell from 26 U.S. cents/W to 20.8 U.S. cents/W. The company’s analysts expect the speed of such reductions to moderate but continue over the next few years.²⁴

One strand of solar R&D that could transform the industry is the advent of cells made from perovskites – a class of materials with the same crystal structure as the mineral calcium titanium oxide. Perovskites differ from silicon – the raw material of most solar cells – in that they are easily produced from simple chemistry, and gather energy from a different part of the light spectrum. That means they are cheap to produce and can be layered on top of silicon to produce a hybrid cell, producing far more energy overall.

Perovskites have been the buzz for several years – see these pages of the 2017 Global Trends report²⁵ – but now Oxford Photovoltaics, a British company, has produced a hybrid cell with a conversion efficiency of 28%, compared to just 22% for the best silicon cells. The company raised additional funds in 2018, and also signed agreements with Meyer Burger Technology, the Swiss producer of PV manufacturing equipment, and Goldwind, the Chinese wind turbine maker, and aims to open a 250MW capacity factory in Germany by the end of 2020. On a note of caution, the technology has yet to prove that it can perform for the minimum 25 years required for a solar module, or scale up for mass manufacturing.

Wind

As with solar, R&D in wind is producing both incremental, and potentially more dramatic, gains in efficiency and cost. One major recent innovation is the development of wind turbine gearboxes that are compact enough to fit into a standard shipping container. This reduces shipping costs and gives manufacturers – such as ZF and Winergy – more choice about where they build them. Another important area of continuing innovation is big data and the ‘Internet of Things’, which can provide a wide range of benefits, from better weather and output forecasting to predictive maintenance.

²³ BloombergNEF: 2018 PV Manufacturing Overview <https://www.bnef.com/core/insights/19265>

²⁴ BloombergNEF: PV Cost Reductions Continue, But Slow Down <https://www.bnef.com/core/insights/20609>

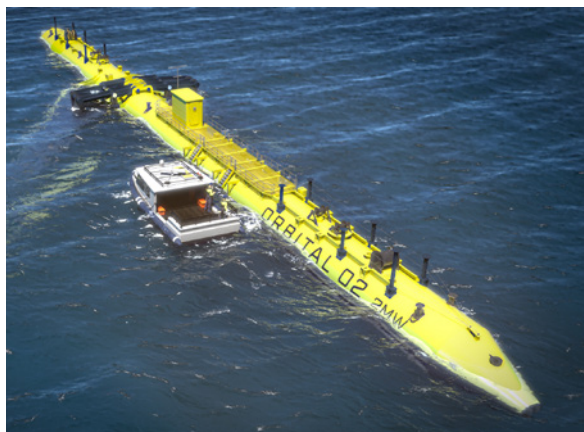
²⁵ Global Trends in Renewable Energy Investment 2017, pages 78-79

Innovations such as these continue to drive down the cost of wind turbines. BNEF analysis shows that machines delivered in 2009 cost more than \$1.8 million per MW of capacity. By the second half of 2018, the cost had fallen to scarcely \$800,000/MW.²⁶

One of the most important factors in the economics of wind turbines, however, is size. The bigger the generator, the fewer towers the developer need erect, which means large savings on steel and foundations. This is particularly true offshore. The largest commercial turbine at present is the MHI Vestas 164 machine, which can generate 9.5MW. And for several years the industry has been racing to crack 10MW.

In March 2018, however, General Electric astonished the sector by announcing it would build a 12MW prototype in 2019. The new machine will double the power of the company's largest turbine, the Haliade-X 6MW, which means the design must be entirely reworked; it is not possible to simply scale up the components. The Haliade-X 12MW will be 260 metres tall – almost three times the height of London's Big Ben – and 220 metres across the rotor. The company predicts the turbine's capacity factor – actual output as a proportion of rated capacity – will reach 63%, around 5 percentage points higher than the industry standard. The prototype is due to be tested off Rotterdam this year, and the company plans to start selling the machine commercially in 2021.

Like solar, the wind industry is also working on technologies that could be transformational in the longer term. One is floating wind turbines, which will allow developers to build wind farms in deeper waters further offshore, and which could be cheaper to install. The industry has been developing a variety of platform designs, and demonstration projects have expanded from single turbines to several: the WindFloat Atlantic project off Portugal is testing three; the Equinor project off Scotland has five. The technology is progressing steadily towards commercial viability. BNEF analysts expect that 1.2GW of floating capacity will be installed by 2030, and that France and Japan will be the biggest markets.²⁷ Japan could build a further 1.8GW at sites where developers have yet to decide between conventional or floating foundations.



Marine

Wave and tidal have been a focus for early-stage finance, including venture capital, government grants and equity investment from engineering majors, since late in the last decade. Well over \$1 billion was raised by young companies, mostly in Europe, North America and Australia. However, progress has been patchy, with many of the high-tech hopefuls going out of business during the last five or six years.

Tidal stream has seen the more success of the two marine power technologies, with the first utility-scale plant operating since 2018 – the 6MW MeyGen array, consisting of four three-bladed underwater turbines, off the north coast of Scotland. Several companies have demonstrated consistent electricity generation from tidal turbines, anywhere from 50kW up to 2MW in size, but there continues to be uncertainty over policy support in two of the key markets, the U.K. and France. One of the longest-established players (Ireland-based OpenHydro) was closed down by its French owner, DCNS, in 2018.

In wave energy, investor confidence is in short supply after a run of company failures affecting most of the enterprises that raised substantial sums in the 2005-2015 period. However, technology development continues, including via firms taking part in the power take-off, converters, materials, control systems and infrastructure programs run and funded in the U.K. by publicly owned Wave Energy Scotland.

²⁶ BloombergNEF: *1Q 2019 Global Wind Market Outlook* <https://www.bnef.com/core/insights/20441>

²⁷ BloombergNEF: *Floating Wind Drifts Towards Viability* <https://www.bnef.com/core/insights/20531>