Frankfurt School
FS-UNEP Collaborating Centre
for Climate & Sustainable Energy Finance

GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2019

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FOREWORD FROM INGER ANDERSEN, NILS STIEGLITZ AND JON MOORE

Clean energy is a cornerstone of the better future we are building for humanity. Neither the Paris Agreement nor the 2030 Agenda for Sustainable Development will be able to fulfill their full potential unless renewable energy replaces fossil fuel generation. Renewable energy avoids the greenhouse gas emissions that warm our planet. It improves air quality and therefore human health. It brings new opportunities to energy-poor communities.

Investing in renewable energy is also an economic opportunity. It is a decision that investors around the world have been increasingly making for a decade. Global Trends in Renewable Energy Investment 2019 – released ahead of the Global Climate Action Summit – shows that in 2018, investors again put hundreds of billions of dollars behind renewable energy and the energy transition we need.

The latest issue of this report – which has tracked trends and opportunities in the sector since 2004 –shows that global investment in renewable energy capacity hit $272.9 billion in 2018, far outstripping investments in new fossil fuel generation. 2018 was the fifth successive year renewables capacity investment exceeded $250 billion. Yes, the 2018 global investment figures were 12% down on the previous year, but this is not a step backwards. Renewable energy, particularly solar photovoltaics, is getting cheaper.

Looking across 2010-2019, the trend of heavy investment becomes even clearer. The report estimates that a total of $2.6 trillion will have been invested in renewable capacity (excluding large hydro) over that period. This corresponds to an estimated 1.2 terawatts of new renewable energy capacity over this decade, more than the entire electricity generating fleet of the U.S. today, and roughly quadrupling the figure of global renewables capacity commissioned at the end of 2009.

Several unexpected findings emerge from the decade perspective taken in the Focus Chapter of this report. One is the meteoric rise of solar PV to become not just the biggest renewable power technology in terms of investment – onshore wind was the number one back in 2009 – but also the most added generation source of any kind during the period. Another has been the precipitous price fall in both solar PV and wind, and a third has been the steady improvements in efficiency of those technologies.

While this demonstrates huge and lasting progress, the pace must increase. Renewables are now firmly embedded in the power generation sector, but only represent 26.3% of total electricity produced – 12.9% if we exclude large hydro. Fossil fuel subsidies, which run into the hundreds of billions of dollars each year, are slowing progress. Investors are still financing coal power plants with tens of billions of dollars each year. Equally, 1.1 billion people lack access to electricity. Providing that access to these people, through technologies such as off-grid solar, will give the Sustainable Development Goals a massive shot in the arm.

This year and next are crucial for climate action. The Global Climate Action Summit on September 23 provides an opportunity for everyone to come forward with new commitments. The final touches will be put on the Paris Agreement later this year. Everybody needs to raise their ambition levels, including investors.

With smart policies that truly value the economic and societal benefits of renewable power, we can accelerate the transition to a renewable energy economy and give people the clean energy future they deserve.

INGER ANDERSEN

Executive Director

UN Environment Programme

NILS STIEGLITZ

President

Frankfurt School of Finance and Management

JON MOORE

Chief Executive

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"Investing in renewable energy is investing in a sustainable and profitable future, as the last decade of incredible growth in renewables has shown.

"But we cannot afford to be complacent. Global power sector emissions have risen about 10% over this period. It is clear that we need to rapidly step up the pace of the global switch to renewables if we are to meet international climate and development goals."

Inger Andersen, Executive Director of the UN Environment Programme

"The technologies to use wind, sun or geothermal energy are available, they are competitive and clean. Within 10 years, Germany will produce two-thirds of its power based on renewables. We are demonstrating that an industrial country can phase out coal and, at the same time, nuclear energy without putting its economy at risk. We know that renewables make sense for the climate and for the economy. Yet we are not investing nearly enough to decarbonize power production, transport and heat in time to limit global warming to 2C or ideally 1.5C. If we want to achieve a safe and sustainable future, we need to do a lot more now in terms of creating an enabling regulatory environment and infrastructure that encourage investment in renewables."

Svenja Schulze, Germany's Federal Minister for the Environment,
Nature Conservation and Nuclear Safety

"It is important to see renewables becoming first choice in many places. But now we need to think beyond scaling up renewables. Divesting from coal is just one issue within the broader field of sustainable finance. Investors increasingly care whether what they do makes sense in the context of a low-carbon and sustainable future."

Nils Stieglitz, President of Frankfurt School of Finance and Management

"Sharp falls in the cost of electricity from wind and solar over recent years have transformed the choice facing policy-makers. These technologies were always low-carbon and relatively quick to build. Now, in many countries around the world, either wind or solar is the cheapest option for electricity generation."

Jon Moore, Chief Executive of BloombergNEF

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METHODOLOGY AND DEFINITIONS

All figures in this report, unless otherwise credited, come from BloombergNEF, or BNEF, which maintains the world's most comprehensive database of investors, projects and transactions in clean energy.

The BloombergNEF database at www.bnef.com collates all organizations, projects and investments according to transaction type, sector, geography and timing. It covers many tens of thousands of organizations (including start-ups, corporate entities, venture capital and private equity providers, banks and other investors), projects and transactions.

METHODOLOGY

The BNEF database seeks to cover the following types of asset: all solar, biomass and waste-to-energy, geothermal, and wind generation projects of more than 1MW; all hydropower projects of between 1MW and 50MW; all wave and tidal energy projects; all biofuel projects with a capacity of one million litres or more per year.

Where deal values are not disclosed, BNEF assigns an estimated value based on comparable transactions. Deal values are rigorously back-checked and updated when further information is released about particular companies and projects. The statistics used are historical figures, based on confirmed and disclosed investment.

Annual investment is estimated for small-scale commercial and residential projects such as rooftop solar. These figures, referred to in the investment charts of the report as 'small distributed capacity', are based on annual installation data provided by industry associations and governments.

This report does not cover larger hydro-electric dams of more than 50MW, except for brief mentions in Chapters 1 and 3.

The BNEF database also covers all deals in the following categories: equity raising by specialist renewable energy companies from venture capital and private equity funds and public market investors; all acquisitions of specialist renewable energy companies or strategic stakes in those; and all acquisitions and refinancings of renewable energy projects and assets.

Figures on research and development by specialist renewable energy companies are collated annually from the Bloomberg Terminal and other sources. Those on government R&D are estimated annually using a variety of official and third-party sources.

All of this is a dynamic process: as the sector's visibility grows, information flow improves. New deals come to light and existing data are refined, meaning that historical figures are constantly updated.

This 2019 report contains revisions to a number of investment figures published in the 2018 edition of Global Trends in Renewable Energy Investment. Revisions reflect improvements made by BloombergNEF to its data during the course of the last 12 months, and also new transactions in 2017 and before that have since come to light.

DEFINITIONS

Investment categories in this report are defined as follows:

Capacity investment: all money invested in renewable energy generation projects, large or small. It covers both **asset finance of utility-scale projects**, whether from internal company balance sheets, from loans, or from equity capital, and the financing of **small-scale solar systems** of less than 1MW.

Research and development (R&D): all money invested in early-stage renewable energy technologies and techniques, whether financed out of government budgets or from the balance sheets of specialist renewables companies.

Venture capital and private equity (VC/PE): all money invested by venture capital and private equity funds in the equity of specialist companies developing renewable energy technology. Investment in companies setting up generating capacity through special purpose vehicles is counted in the asset financing figure.

Public markets: all money invested in the equity of specialist publicly quoted companies developing renewable energy technology and clean power generation.

Total renewable energy investment: this brings together all of the above categories – capacity investment, R&D, VC/PE and public markets. It also incorporates an adjustment for **re-invested equity** (generally when money raised from VC/PE or public markets are then re-invested in renewable energy assets). The adjustment prevents double-counting.

Mergers and acquisitions (M&A): the value of existing equity and debt purchased by new corporate buyers, in companies developing renewable energy technology or operating renewable power and fuel projects. Includes refinancing. M&A is not included in total renewable energy investment because it is money changing hands, rather than new money coming into the sector.

In the 2019 Global Trends report, capacity investment is the main topic of the Focus Chapter (A Decade of Renewable Energy Investment), and of Chapters 1, 3, 4 and 5. Total renewable energy investment is covered in Chapter 2, while R&D, VC/PE and public markets are discussed in detail in Chapter 6. M&A is the subject of Chapter 7.

Commonly used terms in the report are defined in the Glossary after the end of Chapter 7.

REN21's annual Renewables Global Status Report (GSR) was first released in 2005. The Global Status Report is the sister publication to UNEP Global Trends in Renewable Energy Investment, and its latest edition was released in June 2019. It grew out of an effort to capture comprehensively, for the first time, the full status of renewable energy worldwide. Over the years, the GSR has expanded in scope and depth, in parallel with tremendous advances in renewable energy markets and industries. The report has become a major production that involves the amalgamation of thousands of data points, hundreds of reports and other documents, and personal communications with experts from around the world.

KEY FINDINGS

ABOUT THE DECADE 2010-2019:

- The years 2010-2019 will have seen $2.6 trillion invested in renewable energy capacity (excluding large hydro), more than treble the amount invested in the previous decade. Solar is set to have attracted the most in 2010-2019, at $1.3 trillion, with wind securing $1 trillion and biomass and waste-to-energy $115 billion.

- China will be the top country by far in terms of the sums invested in renewables capacity during the current decade. It committed $758 billion between 2010 and the first half of 2019, with the U.S. second on $356 billion and Japan third on $202 billion.[1]

- Europe as a whole invested $698 billion in 2010 to first-half 2019, with Germany contributing the most, at $179 billion, and the U.K. $122 billion. India is an increasingly important investor in renewables, and had committed $90 billion by the end of the first half of this year.

- The decade has seen a spectacular improvement in the cost-competitiveness of renewables, with the levelized cost of electricity for solar photovoltaics [2] down 81%, for onshore wind down 46% and for offshore wind down 44%. One or other renewables technology is now the cheapest option for new generation in many countries around the world.

- Behind these cost reductions in solar and wind have been a combination of economies of scale in manufacturing, fierce competition along the supply chain – intensified by the introduction of auctions in many countries – record-low costs of finance, and improvements in the efficiency of generating equipment.

- There will have been more solar capacity installed during the decade than any other generating technology, fossil or renewable. Solar's additions, of some 638GW during 2010-2019, is a remarkable figure given that there were only 25GW of solar power capacity worldwide at the end of 2009.

- The 2010-2019 period is set to have seen a net 2.4 terawatts of power capacity of all sorts installed, with solar first, coal second, and wind narrowly beating gas for third place. Nevertheless, the stock of fossil fuel power already installed, and those added this decade, has meant that global power sector emissions are likely to have risen by at least 10% between the end of 2009 and 2019.

ABOUT 2018:

- Global investment in renewable energy capacity in 2018 was $272.9 billion, the fifth successive year in which it has exceeded $250 billion, but down 12% compared to 2017 – due in large part to a policy change that hit the financing of Chinese solar in the second half of the year.

- The global investment figure for 2018 was achieved despite continuing falls in the capital cost of solar and wind projects. Solar kept its position as the technology attracting the most capacity investment, at $133.5 billion, although this was down 22% on 2017. Wind secured $129.7 billion, up 3%.

- Renewable energy capacity investment was more spread out across the globe than ever, with 29 countries each investing more than $1 billion in 2018, up from 25 in 2017 and 21 in 2016. China invested the most, at $88.5 billion, down 38%, with Europe on $59.9 billion, up 45%, and the U.S. on $42.8 billion, down 6%.

- Spain, Vietnam, Ukraine and South Africa were among the countries in the "$1 billion-plus club" that saw capacity investment jump by more than fivefold in 2018. There were also increases of 100% or more in investment in the Netherlands, Sweden, Morocco, Russia and Taiwan.

- Investment in renewables capacity in 2018 was about three times global investment in coal and gas-fired generation capacity combined. This came despite further reductions last year in the average capital cost per MW of solar and wind projects.

- The world added a record 167GW of new capacity of renewables excluding large hydro in 2018, with solar additions hitting their own record of 108GW. This helped renewables excluding large hydro to raise its share of global electricity generation, from 11.6% in 2017 to 12.9% in 2018, helping the world to avoid an estimated 2 gigatonnes of carbon dioxide emissions.

- Other types of investment in renewables showed increases in 2018. Government and corporate research and development was up 10% at $13.1 billion, while equity raising by specialist companies on public markets was 6% higher at $6 billion, and venture capital and private equity investment was up 35% at $2 billion. Overall renewable energy investment, including these categories as well as capacity investment, was down 11% at $288.3 billion in 2018.

[1] Excluding large hydro. All renewable energy investment totals in this report also exclude large hydro.

[2] Without a tracking system to follow the sun. Systems with tracking have seen similar-sized cost reductions.

A DECADE OF RENEWABLES INVESTMENT

- At the dawn of this decade, in January 2010, wind and solar were dots on the horizon of the world power system, accounting for only 4% of global generating capacity and much less of total electricity produced. They were also relatively expensive, and reliant on subsidies.
- A startling transformation has since taken place. By the end of the decade of 2010-2019, in a few short months' time, the two leading renewable energy technologies are expected to account for some 18% of global generating capacity, after the investment of some $2.4 trillion in new projects over the 10 years.
- The cost comparison has also changed out of all recognition. Since the second half of 2009, the benchmark global levelized cost of electricity[3] for solar photovoltaics without tracking systems has fallen by 81%, the equivalent for onshore wind by 46% and offshore wind by 44%. In many countries, the cheapest source of new generating capacity in 2019 is either solar or wind.
- Overall, including other renewable energy technologies but not large hydro, capacity investment over the 2010-2019 period is set to reach $2.6 trillion. The biggest investing country, by far, during the decade is set to be China, which committed $758 billion between the beginning of 2010 and mid-year 2019. Europe as a whole invested $698 billion in that time, and the U.S. $356 billion.
- Interest rates at record lows in major economies during the decade have been an important factor in making this possible. A much higher proportion of lifetime costs for wind and solar are incurred in advance rather than during the operating phase than for coal and gas. This upfront capital has to come from equity providers and lenders.
- Few would have dreamt at the start of 2010 that solar would see more capacity added during the decade ahead, at 638GW, than any other generating technology – renewable, fossil fuel or nuclear. However, the greening of the electricity system still has a very long way to go. The 2010-2019 period will have seen more than 500GW of new coal plants added worldwide, pushing up overall power system emissions.

DAWN OF THE DECADE

In the first decade of the Twenty-First Century, it was far from clear whether non-hydro renewables would ever be competitive with fossil fuel generation. New renewables were routinely called "alternative energy", and regarded as a small niche. It was also uncertain which of the new technologies would be important in the decades ahead, or how difficult it might be for grids to absorb more than a tiny proportion of electricity from variable generation sources such as wind and solar. The electricity system was familiar with juggling large, centralized coal, gas, oil, nuclear and hydro generating units.

However, in that 2000-2009 period, at least there was a rise in interest in renewable energy technology on the part of governments, investors and the public. That, together with climate change

[3] Levelized cost of electricity, or LCOE, for any generating technology includes the cost of project development and construction, lifetime operating and maintenance expenses, feedstock costs and finance costs.

worries, was leading by the turn of the decade to sharp increases in the amount of investment going into sectors such as wind, solar and biofuels. In 2009, the world invested a record $147 billion in new renewable energy capacity (excluding large hydro-electric projects).

For a while, early in the current decade, it looked as if the rise of renewables might come to an end. Slow economic growth after the 2008-2009 financial crisis, particularly in developed countries, helped to limit demand for energy, and the shale gas boom in North America introduced a significant new source of both gas and oil into the markets. Energy prices fell, with for instance the Newcastle coal contract halving between a peak in early 2011 and its low in 2016, and the Henry Hub gas price in the U.S. averaging $3.30 per million British thermal units in the current decade compared to $5.85 during the 2000s. And in late 2014, the world oil price crashed.

There was also pressure on renewables from a political direction, as consumers protested about rising electricity bills. In most countries, subsidies for green power were only one of several reasons for higher charges per kilowatt-hour – but governments in many cases had under-estimated the take-up of wind and solar, and therefore the cost of their support. Some politicians argued for renewables-friendly policies to be abandoned. There were retroactive cuts in subsidies for existing projects in a number of European countries. Eventually and more positively, governments in Europe followed the example of developing countries such as Brazil and moved toward auctioning as a means of trying to ensure that additional capacity got built at the lowest practicable cost.

The renewable energy manufacturing sector, meanwhile, had its own problems. Over-expansion and cut-price competition led to falling share prices and – in the solar photovoltaic sector – to a stream of bankruptcies and closures, particularly in 2012-2014.

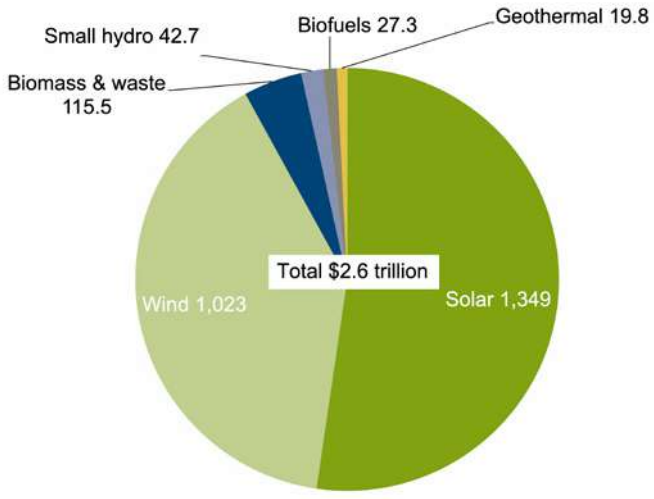
THE MONEY FLOWS

From the middle of this decade onward, the ongoing cost reductions in solar PV and both onshore and offshore wind have become more obvious to policy-makers, investors and incumbent energy companies, and this has engendered a new environment in which the growing importance of low-cost renewables is widely recognized. At the same time, wind and solar projects have sprung up in an increasing number of countries, notably in the developing world. New ways of integrating their variable generating output have emerged, including more flexible grids and the deployment of batteries and other forms of energy storage.

The current decade, if you define it as 2010 to 2019, is not quite over at the time of writing this report, but approximate figures for investment in 2019 can be estimated on the basis of published numbers for the first half of the year.[4]

In Figure 1, we estimate that the 2010s, when they end in December 2019, will have seen a total of $2.6 trillion of investment in renewable energy capacity, excluding large hydro. The chart also shows the extent to which investment will have been dominated by just two sectors – solar, with $1.3 trillion, or 52% of the total;

FIGURE 1. RENEWABLE ENERGY CAPACITY INVESTMENT OVER THE DECADE, 2010-2019, $BN

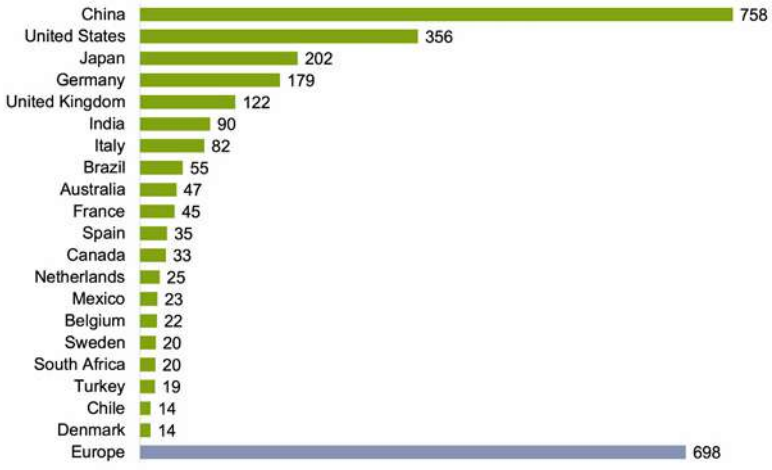


Includes an estimate for 2019, based partly on provisional first-half data.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

[4] We make an assumption that the eventual total for the year will be two times the originally published first-half figure – this is likely to be a conservative estimate, since in every one of the last five years, the eventual full-year total has been significantly more than double the originally published first-half figure. See the box at the end of Chapter 1 for more on the investment in 1H 2019.

and wind, with $1 trillion, or 41% (note that the sum of the two rounds up to $2.4 trillion). The only other sector to attract three figures of billions over the decade is set to be biomass and waste-to-energy, with $115 billion invested, or 4% of the total. Small hydro capacity got commitments of $43 billion, biofuels $27 billion, geothermal $20 billion and marine less than $500 million.

FIGURE 2. RENEWABLE ENERGY CAPACITY INVESTMENT FROM 2010 TO 1H 2019, TOP 20 COUNTRIES, $BN

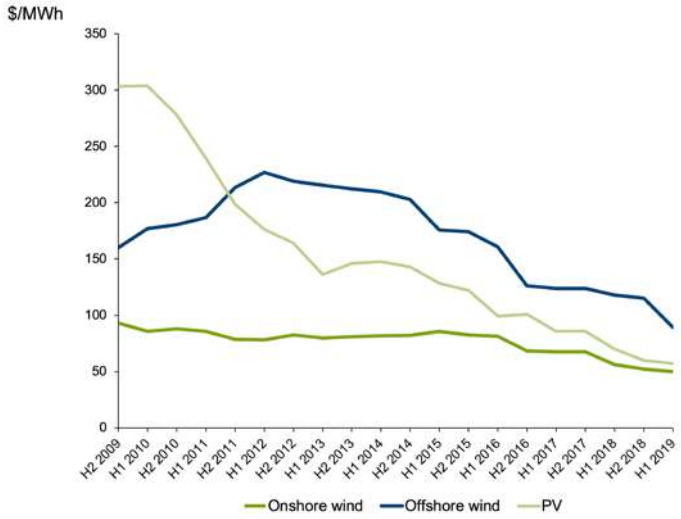


Includes first-half data for 2019, but not an estimate for the second half.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

Figure 2 shows the amount invested in renewable energy capacity in the top 20 markets up to the end of the first half of 2019 (it does not include an estimate for the second half of this year). All of them have spent more than $14 billion on renewables excluding large hydro. The runaway leader in the 2010s has been China, with investment of $758 billion, nearly 31% of the global total, with the U.S. second on $356 billion, or 14%.

There are eight European countries in the top 20, headed by Germany with $179 billion and the U.K. with $122 billion, and Europe as a whole has accounted for investment over the period from 2010 to the first half of 2019 of about $698 billion, some 28% of the global total. Some

FIGURE 3. LEVELIZED COST OF ELECTRICITY, BY MAIN RENEWABLE ENERGY TECHNOLOGY, 2009 TO 2019, $/MWH



PV is crystalline silicon with no tracking
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

Figure 3 shows the transformation in costs achieved over the decade by the three leading green power sources – solar photovoltaics, onshore wind and offshore wind. BNEF's levelized cost of electricity (LCOE) model, which distills data on development, construction, operations and maintenance and finance costs from actual projects around the world, shows that the global benchmark for solar PV without tracking has tumbled by 81%, from $304 per megawatt-hour in the second half of 2009 to $57 per MWh in the first half of 2019. The equivalent figure for onshore wind has been a 46% fall, from $93 per MWh, to $50; and for offshore wind a 44% drop, from $160 per MWh, to $89.

These moves have been the result of several factors: fierce competition among manufacturers and developers to cut overheads, the influence of renewable energy auctions in driving that competition, improving technology that has added incrementally to efficiency (the number of megawatt-hours of energy coming from the same number of megawatts of capacity), and a strong downward trend in finance costs.

This last factor is often overlooked. Renewable energy technologies all involve significant upfront capital expenditure and, in the cases of wind and solar, ongoing running costs are very low by comparison. That makes the cost of the equity and debt used to finance new capacity highly influential in calculating the total LCOE of new green power projects. Record-low official interest rates in many countries during the 2010s, and increasing competition among investors and banks to participate in renewable energy deals, has driven down the cost of both equity and debt. To take one example, the all-in cost of debt for a German onshore wind farm dropped from 6% at the end of 2009, to 2.2% in the first half of 2018.[6]

The result is that, as the decade draws to a close, either wind or solar (or both) find themselves to be cheaper options for new generating capacity than fossil fuel sources in an increasing number of countries.

European nations have experienced booms and busts in capacity investment during the decade – Germany and Italy, for instance, seeing their annual total touch $30 billion or more in at least one year between 2009 and 2011 as developers rushed to build solar systems to take advantage of generous feed-in tariffs.

The top 20 includes a number of developing countries, led by India with $90 billion, with most of the others in the latter part of the list. However, in most cases, developing economies have only broken into their stride on renewables investment since solar and wind costs came down to competitive levels in mid-decade, so we could expect to see them taking up higher positions in a list for 2015-2025, for instance.

THE COST REVOLUTION

The decade opened with non-hydro renewables widely seen as expensive relative to conventional generation sources – unless you assumed a high carbon price to reflect the pollution and greenhouse gas effects of fossil fuel power. As recently as January 2014, the Economist published an article entitled "Why Is Renewable Power So Expensive?"[5]

[5] The Economist: *Why Is Renewable Energy So Expensive?* https://www.economist.com/the-economist-explains/2014/01/05/why-is-renewable-energy-so-expensive
[6] BloombergNEF: *2018 Asset Finance Outlook for European Renewables* https://www.bnef.com/InsightDownload/18373

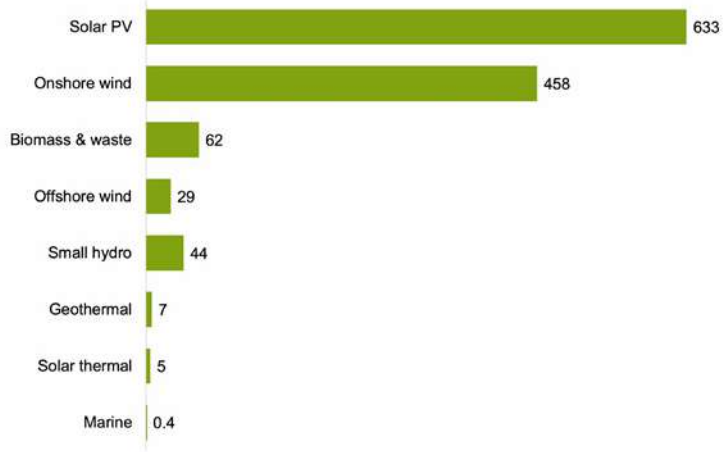
A DECADE'S ADDITIONS

Figure 4 highlights the estimated gigawatt capacity added for the different renewable power technologies over 2010-2019.[7] It breaks down solar into its two main varieties, PV and solar thermal, and wind into onshore and offshore, to provide further insight. The greatest amount of new capacity added over the decade by far will have been in PV, at 633GW, multiplying the amount installed at the end of 2009 by 27 times.

Onshore wind was more established than PV at the turn of the decade, so its addition of 458GW since the end of 2009 is "only" a fourfold increase. Offshore wind, however, which was expensive and relatively immature when the decade dawned, will have added 29GW over the period, multiplying its installed capacity by 15.5 times. Biomass and waste will have nearly doubled its fleet, by adding 62GW. The other technologies have managed more modest increments.

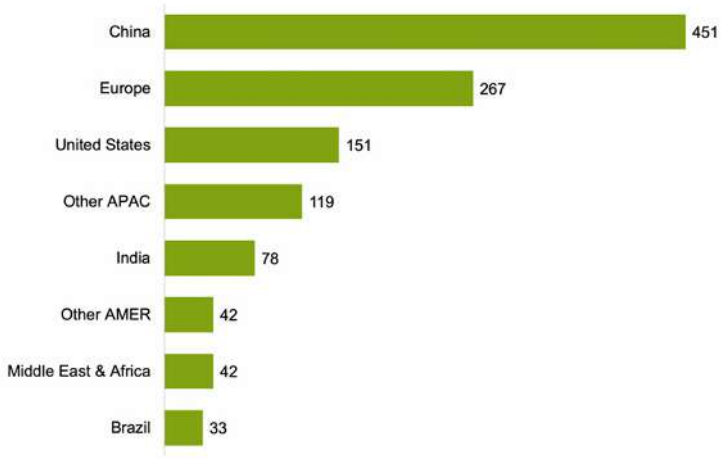
A regional analysis of the capacity additions (Figure 5) shows that China will have installed by far the highest amount of new capacity of renewables excluding large hydro over the 10 years, at about 451GW, or 36% of the world total. Europe is set to come second, with 267GW added, and the U.S. third with 151GW. The steepest expansion in capacity in proportionate terms will have come in Middle East and Africa, with a 15-fold rise from 3GW to 45GW.

FIGURE 4. CAPACITY ADDED IN RENEWABLE POWER TECHNOLOGIES OVER THE DECADE, 2010-2019, GW



Figures are estimated based on actual data to 2018, and forecasts for 2019.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 5. RENEWABLE ENERGY CAPACITY ADDED OVER THE DECADE, 2019 VS 2009, BY REGION, GW

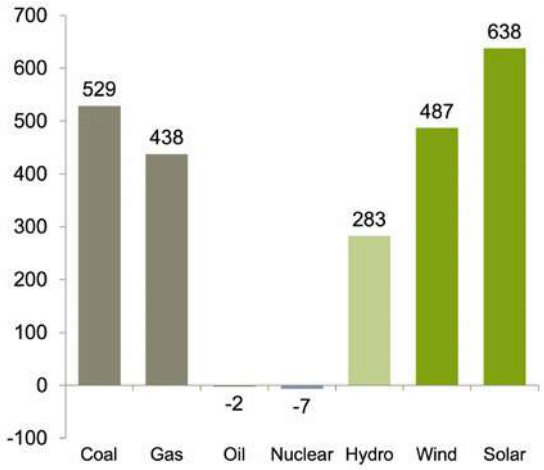


Figures are estimated based on actual data to 2018, and forecasts for 2019. The sum of the additions by region falls short of the total of additions by sector in Figure 4. This is because a small proportion of renewable power additions have yet to be confirmed in terms of location.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

Figure 6 is thought-provoking in both a positive and a negative way. It shows the global capacity added not just in renewables but in fossil fuel and nuclear also. Solar is set to have been the most heavily installed generation technology in the 2010s, with some 638GW added worldwide (including solar thermal as well as PV) – an astonishing result for a power source that could boast only 25GW of global capacity at the end of 2009.

[7] These totals are made up of estimates of BNEF's sector analysts for 2010 to 2018, based on hard data from its project database, plus its forecasts for 2019 based on expected progress on project pipelines.

FIGURE 6. NET CAPACITY ADDED IN MAIN GENERATION TECHNOLOGIES OVER THE DECADE, 2019 VS 2009, GW



Figures are estimated based on actual data to 2018, and forecasts for 2019. Oil and nuclear saw capacity closed more than offset new capacity commissioned.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

Solar is on course to have a significant lead, of more than 100GW, over the next-most installed technology. But, worryingly, that is set to be coal, with some 529GW added – despite all the global concerns about climate change and the earnest declarations made at international conferences such as COP-21 in Paris in December 2015.

China has seen by far the largest participant in the build-out of both solar and coal, adding more than 200GW of each during the 2010s. Otherwise, solar's growth has been well spread through much of the globe. By contrast, coal has seen strong expansion in emerging markets far more than offsetting nearly 100GW of closures in the U.S. and Europe.

Third place among the most installed power sources is relatively close between wind and gas, but BNEF's figures suggest that wind will have the edge once a full tally is done at the end of 2019, with 487GW added during the 2010s compared to 438GW for gas-fired generation. Wind will have seen China and Europe add nearly 300GW between them. Gas will have seen significant expansion in the U.S., on the back of the shale gas boom, but also elsewhere, partly due to rising international trade in liquefied natural gas, or LNG.

Fifth place looks set to be taken by hydro-electric (large and small), with 283GW added, helped by

the commissioning of a number of megaprojects such as the 13.9GW Xiluodo dam in 2014.[8] Two other technologies, oil-fired generation and nuclear, look likely to see a small net shrinkage in their global gigawatt capacity as closures more than offset openings.

One other point is crucial when it comes to the sustainability of the addition of different power sources cited above. Although solar is set to have beaten coal in the 2010s in terms of new capacity, it will not have done so in terms of new electricity generation. This is because the capacity factor of solar globally is in the 11-35% range, reflecting the availability of sunlight, whereas coal-fired power stations have the potential to generate electricity round the clock and throughout the year. In practice, coal's capacity factor around the world is often much lower than this because of operating problems or electricity prices at times too low to justify generation. But the point is that even though there was a lot of solar and wind capacity installed in the latest decade, its impact on the electricity mix has been gradual, not dramatic.[9]

The result is that power sector greenhouse-gas emissions have continued to rise despite the impressive growth of renewables, and despite international climate commitments. And this will continue to be the case until the growth of renewable electricity generation can outpace the growth in demand for power.[10]

[8] See Figure 25 in Chapter 2 for the size of large hydro investment relative to other renewables, and the box at the end of Chapter 3 for discussion of large hydro activity in 2018.

[9] This is shown in Figure 15 in Chapter 1.

[10] See Figure 17 in Chapter 1.

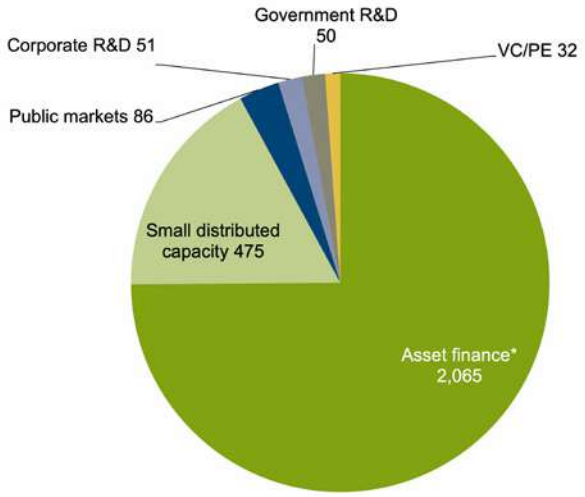
OVERALL RENEWABLES INVESTMENT

The chapter so far has focused on capacity investment in renewables and other generation technologies. However, as discussed in Chapter 2, capacity investment is only part of the picture in terms of the new money coming into the renewable energy sector. Also important are research and development, and equity raising by specialist renewable energy companies on public markets and from venture capital and private equity investors.

These other areas of investment were particularly vital to the emergence of the sector in the first decade of this century. They remain important – but not to the same degree as a decade ago. The mix between these different sources of finance for technologies and companies has also evolved. Venture capital funding has become less significant than it was in 2010, for instance, while annual corporate R&D (taking place in large companies, both specialist and diversified) has almost doubled since then.

Overall, corporate R&D will have amounted to about $51 billion during the decade as a whole, with government-funded R&D very close to that, as Figure 7 shows. Public markets investment will have totaled about $86 billion, and VC/PE financings about $32 billion. Together with asset finance of utility-scale projects and the funding of small-scale projects, these elements will take overall investment in renewable energy over the whole decade to $2.8 trillion.

FIGURE 7. TOTAL RENEWABLE ENERGY INVESTMENT OVER THE DECADE 2010-2019, BY CATEGORY, $BN



Asset finance adjusts for re-invested equity, VC/PE = venture capital and private equity. Figures for 2019 are estimated by doubling the provisional first-half figures for each category. The exception is R&D, which is only calculated annually. We have assumed that it totals the same in 2019 as it did in 2018.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

RENEWABLES CAPACITY GROWTH IN 2018

- Investment in new renewable energy capacity (excluding large hydro-electric projects) was $272.9 billion worldwide in 2018, down 12% on the previous year, the fifth successive year in which the total has exceeded $250 billion.
- The main reasons for the decline in the global figure were a downturn in solar financings in China in response to a tightening in government policy, and lower average capital costs per megawatt for both solar and wind in most parts of the world.
- Solar attracted the most capacity investment globally, at $133.5 billion, although this was 22% down on 2017, while wind secured $129.7 billion, up 3%, and biomass and waste-to-energy $6.8 billion, up 61%.
- China led the regions in terms of dollars invested in 2018, at $88.5 billion, but this was down 38% on the previous year. Europe saw $59.9 billion of new capacity investment, up 45%, while the U.S. brought in $42.8 billion, down 6%. Middle East and Africa showed the sharpest increase, of 61%, to $16.1 billion.
- A record 167GW of renewable power capacity (excluding large hydro) started production in 2018, up from 160GW in 2017. This made up almost 68% of all the net new generating capacity (fossil fuel, nuclear and renewable) added last year.
- As a result, renewables excluding large hydro increased their share of world electricity generation from 11.6% in 2017 to 12.9% in 2018. Were it not for this green power, world carbon dioxide emissions last year would have been an estimated 2 gigatonnes greater.

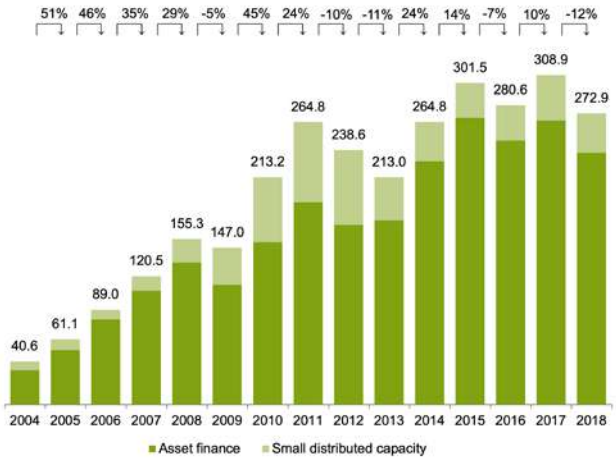
This chapter highlights the high-level trends in renewable energy capacity investment in the year of 2018. It identifies the sectors that attracted financing, the regions and countries that hosted that investment, and also the gigawatts of new capacity that was installed in 2018 as a result of money committed in that year – or earlier. It also puts that activity in renewables in the context of what was happening in the power generation sector as a whole, and the implications for the trend in carbon dioxide emissions. Finally, the chapter has a brief look at capacity investment in the first half of 2019.

Total investment in renewables (including non-capacity funding such as research and development and venture capital financing) is discussed in Chapter 2, before the report returns specifically to look at capacity investment in more detail in Chapters 3, 4 and 5. Chapter 3 focuses on the types of transactions done and the mechanisms that helped to make them possible. The trends in capacity investment in developing countries are examined in Chapter 4, and those in developed economies in Chapter 5.

DOLLARS DEPLOYED

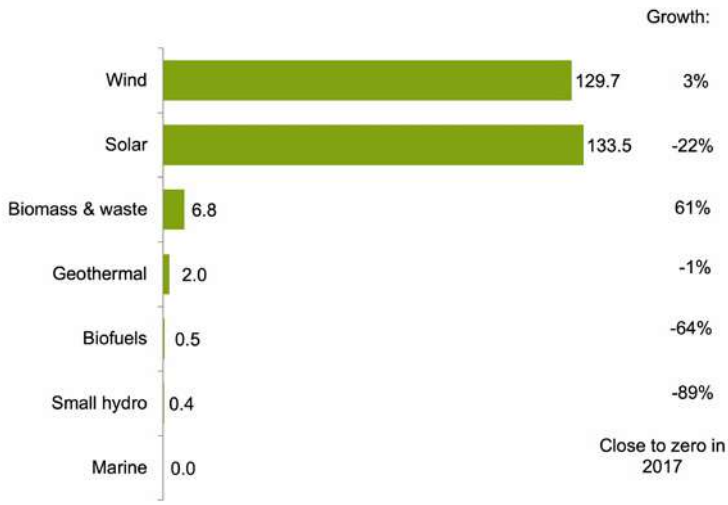
Figure 8 shows that investment in renewable energy capacity excluding large hydro-electric projects totaled $272.9 billion in 2018, some 12% down on the previous year but still high enough to stay in the $250 billion-plus range it has occupied for the last five years. The overall figure in 2018 was made up mainly of $236.1 billion of utility-scale asset finance for projects such as wind farms, solar parks and biomass plants, which was down 11% year-on-year. The remainder was the financing of small-scale solar capacity of less than 1MW, at $36.8 billion, down 14% compared to 2017.

FIGURE 8. GLOBAL RENEWABLE ENERGY CAPACITY INVESTMENT, 2004 TO 2018, $BN



Total values include estimates for undisclosed deals
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 9. GLOBAL INVESTMENT IN RENEWABLE ENERGY CAPACITY BY SECTOR IN 2018, AND GROWTH ON 2017, $BN



Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

The prime reason for the decline in overall renewable energy investment in 2018 was a sharp setback in solar funding, at least in dollar terms, as Figure 9 makes clear. Investment in solar capacity slipped 22% to $133.5 billion, while that in wind actually increased by 3% to $129.7 billion. Activity in the smaller sectors was mixed last year, with biomass and waste-to-energy attracting $6.8 billion, up 61% year-on-year, but geothermal saw a 1% decline to $2 billion, biofuels a 64% drop to $481 million and small hydro an 89% fall to $359 million.

Looking at the sectors in turn, the decline in solar investment had two main causes. One was the continued reduction in capital costs for photovoltaic installations, with the global benchmark for systems without tracking down from $1.03 million per megawatt in 2017 to an average of $820,000 per MW in the second half of 2018.[11] It has become the case that, in the most competitive markets, large solar PV projects are being built for much less than $1 million per MW – a striking example came with Iberdrola's announcement in 2019 that it was building a 500MW PV park at Nunez de Balboa in Spain, at a cost of 290 million euros ($328 million).

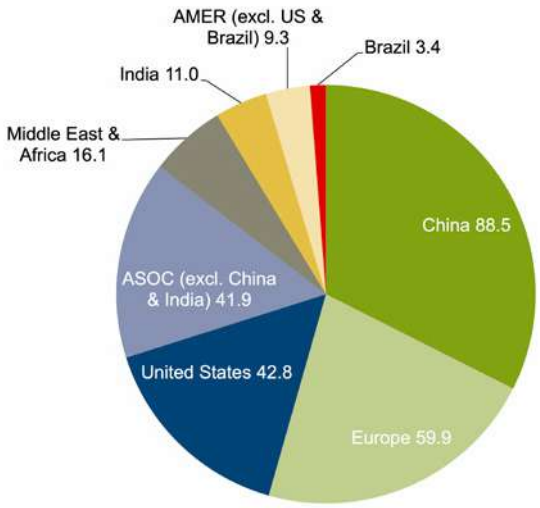
The second reason was that the world's biggest solar market – China – experienced a sudden weakening from around the middle of 2018. The country saw a runaway solar boom in 2017, with

[11] BloombergNEF: *2H 2018 Global LCOE Update* https://www.bnef.com/InsightDownload/19559/excel

some 53GW installed (more than half the world total in that year) and many developers going ahead with projects in the expectation, not certainty, that they would subsequently be approved for government-set feed-in tariffs.

In June 2018, faced with a growing deficit on its account that finances the feed-in tariff, the Chinese government announced that it was restricting the number of new solar installations that would qualify for support. This led to a dramatic fall-off in solar investment in China, with the second-half total for 2018 estimated at $15.4 billion, compared to $22.4 billion in the first half of the same year, and $35.3 billion in the final six months of 2017.

FIGURE 10. INVESTMENT IN RENEWABLE ENERGY CAPACITY BY REGION, 2018, $BN



Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

Solar capacity investment also declined 11% in the U.S. to $20.3 billion, but elsewhere it generally continued at similar levels to 2017 – or increased. In Europe, it bounced 87% to $19.2 billion, thanks to a jump in PV financings in Spain, while it gained 19% to $10.1 billion in Middle East and Africa, and 14% to $31.8 billion in Asia excluding China and India.

The dynamics in wind were very different, with capacity investment in China down only 3% to $50.5 billion, bolstered by the financing of a stream of offshore arrays, and the U.S. market seeing a 4% rise to $22 billion as developers continued to press ahead with large projects in order to qualify for the Production Tax Credit before its scheduled expiry around 2020. In Europe, wind financings climbed 26% to $36.7 billion. It was a busy year for offshore wind investment in the North Sea and for onshore wind in Scandinavia, and although capital costs per MW in both onshore and offshore were much less in 2018 than a few years earlier, the size of projects more than made up for this.

Last year's rebound in capacity investment in biomass and waste-to-energy came about thanks to the financing of a series of new-build plants (and one coal-to-biomass conversion) in two major markets, the U.K. and Japan. However, activity in

FIGURE 11. INVESTMENT IN RENEWABLES CAPACITY BY TOP 30 COUNTRY/MARKET 2018, AND GROWTH ON 2017, $BN

		% growth on 2017
China	88.5	-38%
United States	42.8	-6%
Japan	17.6	-17%
India	11.0	-15%
Australia	9.2	36%
United Kingdom	8.8	36%
Spain	7.5	859%
Germany	6.3	-52%
Vietnam	5.2	809%
Netherlands	4.9	197%
Sweden	4.5	122%
France	4.1	-8%
South Africa	4.1	3493%
Mexico	3.8	-38%
Brazil	3.4	-44%
Belgium	3.1	312%
Morocco	3.1	173%
Ukraine	2.1	539%
Turkey	2.0	-33%
Italy	2.0	92%
Argentina	1.9	15%
Russian Federation	1.9	371%
Taiwan	1.8	163%
Denmark	1.7	69%
Kenya	1.4	0 in 2017
Korea (Republic)	1.4	-37%
Chile	1.3	-38%
Norway	1.1	15%
Finland	1.0	193%
Egypt	1.0	-71%

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

the sector globally remained well below the levels in the first half of this decade, when investment was running at an average of $15 billion per year.

Figures 10 and 11 highlight the geographical diversity of renewable energy capacity investment in 2018. China remained by far the largest market, but the 38% retreat in its dollar investment total to $88.5 billion narrowed substantially its lead over Europe, up 45% at $59.9 billion. As far as individual countries were concerned, the U.S. was in clear second place once again last year, with $42.8 billion invested, down 6%. Japan and India retained their positions in third and fourth, but were down 17% and 15% in dollar terms to $17.6 billion and $11 billion respectively.

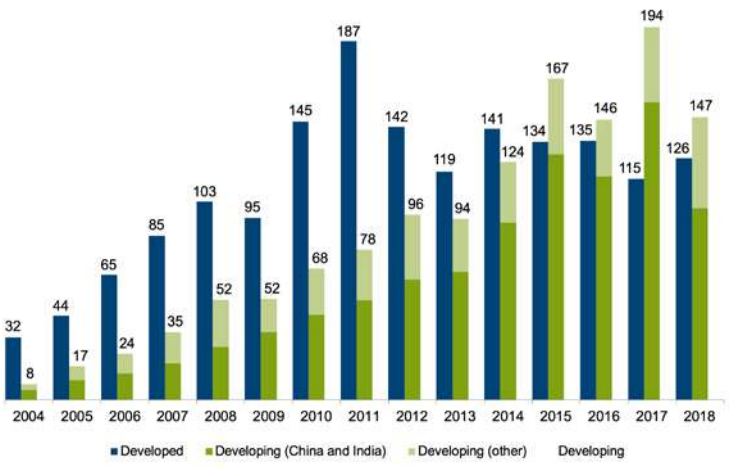
One of the messages from Figure 11 is how spread-out investment in renewables capacity has become. In 2018, there were 29 countries that committed more than $1 billion,[12] compared to 25 in 2017 and 21 in 2016. In 2018, there were an additional 14 countries that invested between $500 million and $1 billion.

Particularly sharp increases in investment in 2018 were recorded in Spain, Vietnam, South Africa and Ukraine. These and other country-level changes are explored in depth in Chapters 4 and 5.

Another way of looking at the trends in investment geographically is to split the world into developed and developing economies. Generally speaking, developed countries were the first to embrace non-hydro renewables, back in the last decade, offering subsidies to encourage deployment. However, the sharpest increases in electricity demand, by far, are taking place in developing countries. Figure 12 shows that up to 2014, the majority of renewable energy capacity investment was in the developed world, but that every year since then, emerging economies have been dominant.

In 2018, developed economies invested $125.8 billion, some 10% more than in the previous year, while developing countries committed $147.1 billion, down 24%. However, the different shades of green in the chart reveal that the latter change was entirely due to China and India. Investment in those two giants, taken together, fell 36% to $99.6 billion, while that in "other developing economies" rose 22% to a record $47.5 billion.

FIGURE 12. INVESTMENT IN RENEWABLE ENERGY CAPACITY, DEVELOPED VS DEVELOPING COUNTRIES, 2004-2018, $BN



Total values include estimates for undisclosed deals.
Developed volumes are based on OECD countries excluding Mexico, Chile, and Turkey.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

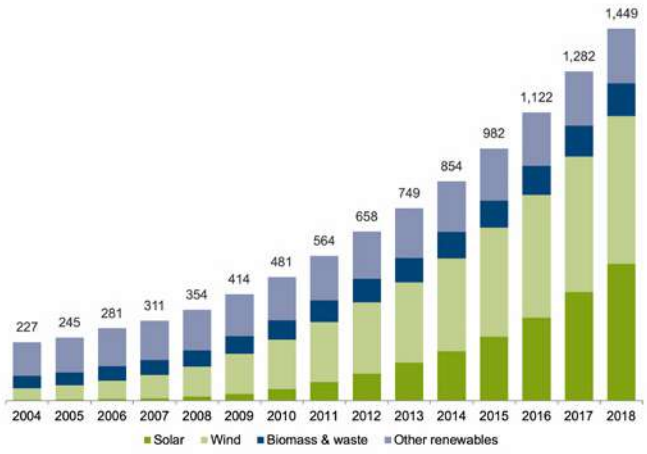
[12] Egypt's total is rounded to $1 billion in the table, but was actually a little below this mark, at $967 million.

CAPACITY ADDED

Dollars invested is only one side of the build-out of new renewable energy capacity. The other is the number of actual gigawatts that are installed as a result. Figure 13 shows that global capacity in renewable power (excluding large hydro-electric projects) reached almost 1.45 terawatts by the end of 2018, up from 414GW at the end of the last decade and 227GW at the end of 2004.

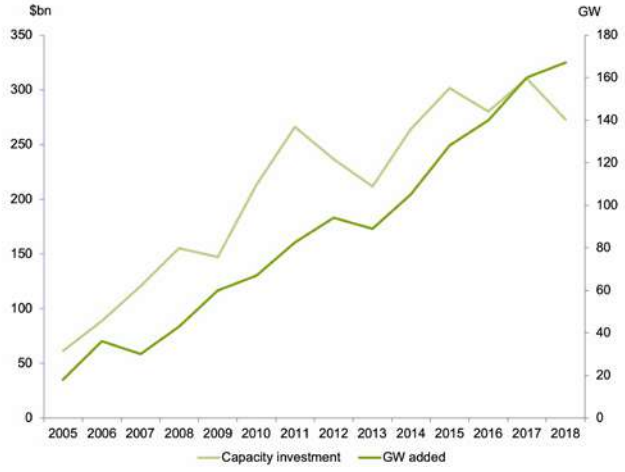
Wind was still slightly ahead of solar in terms of installed capacity at the close of 2018, at some 577GW compared to 532GW, but the gap has been closing for many years and 2019 could be the year when the fleet of solar systems globally exceeds the size of the equivalent for wind. Biomass and waste-to-energy capacity reached an estimated 126GW last year, and "other renewables" (including small hydro as well as geothermal and a small amount of marine power, but excluding 50MW-plus hydro-electric dams) came to 214GW. Note that "other renewables", notably small hydro, had significant capacity already installed by 2004 and that mainly explains their relative prominence all along the time series in the chart.

FIGURE 13. GLOBAL CAPACITY IN RENEWABLE POWER, 2004-2018, GW



"Other renewables" does not include large hydro-electric projects of more than 50MW.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

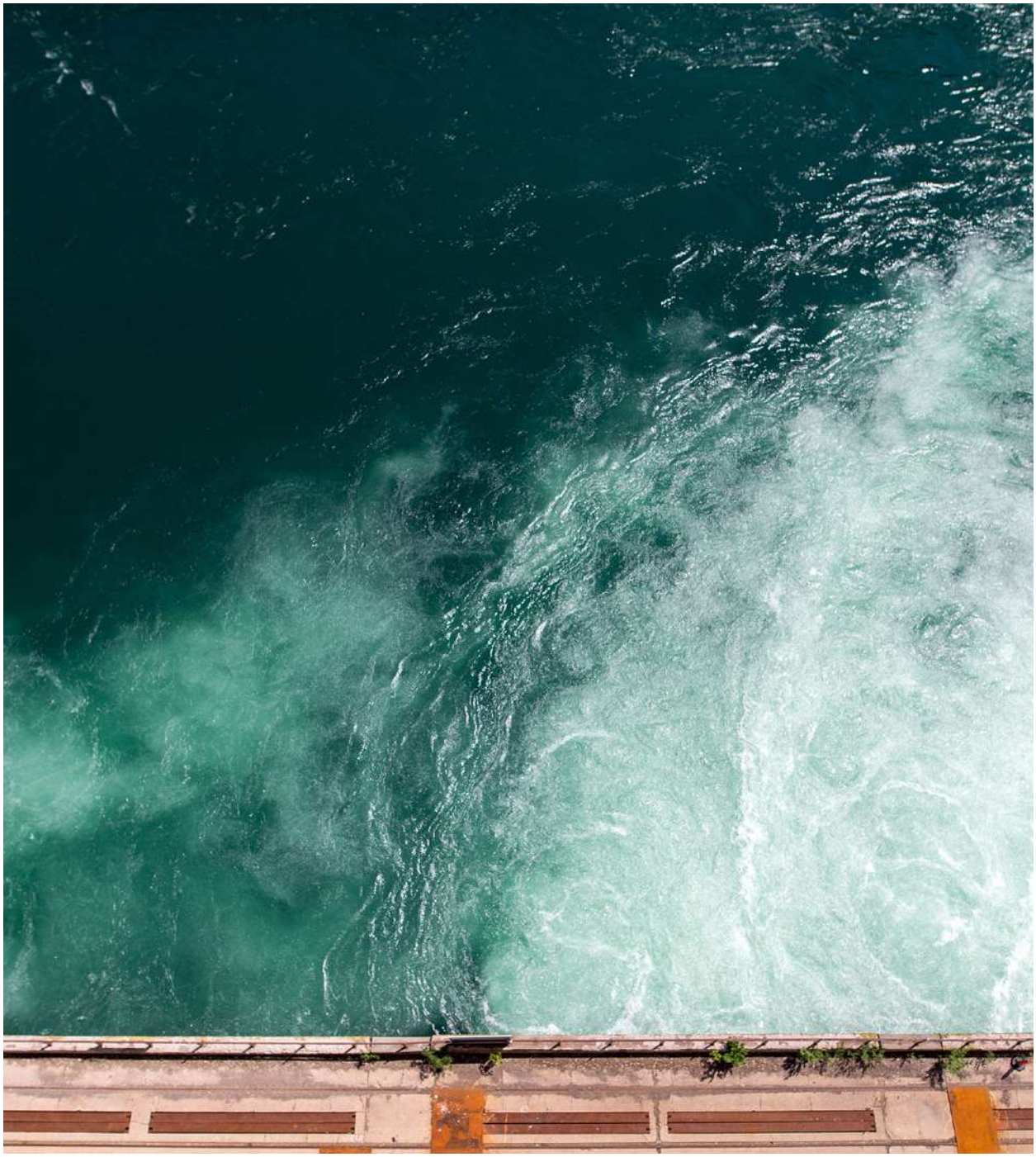
FIGURE 14. RENEWABLE ENERGY CAPACITY INVESTMENT IN $BN VS GW CAPACITY ADDED, 2005-2018



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

The almost unbroken rising trend in year-on-year additions of renewable power is shown in Figure 14. Last year, an estimated 167GW of green power capacity joined the global generating fleet, the highest to date, and up from 160GW in 2017. The chart shows the annual gains in capacity mapped against year-by-year dollar investment, and the message from this is that gigawatts added have carried on rising even though the money invested has been yo-yoing roughly sideways since 2015. This reflects reductions in costs per megawatt.

An important caveat should be mentioned in relation to Figure 14. There is not an automatic read-off between the amount invested in a particular year and the number of gigawatts added, enabling the reader to divide one by the other. This is for two reasons. One is that there is a lag between the date of 'final investment decision' on a project (this is the moment when BNEF data record the full value of the investment) and the commissioning of that plant. This varies from 3-6 months in the case of solar photovoltaics, to six



months to a year for onshore wind, to 2-4 years for offshore wind, solar thermal, geothermal and biomass and waste-to-energy. Therefore a project financed in 2018, for example, may not actually join the ranks of commissioned capacity until 2019, 2020 or even later.

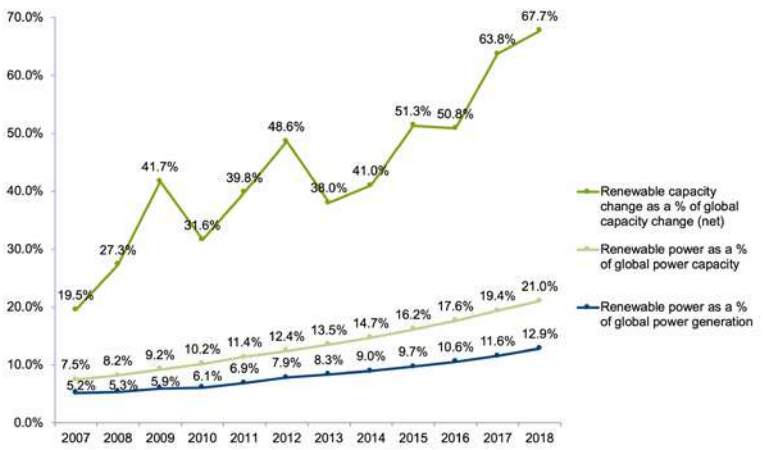
The second reason is that the technology mix changes from year to year, and that affects the dollar investment total too. For instance, a year with a relatively large number of offshore wind gigawatts financed could be expected to see more dollars invested, other things being equal, than one in which there were much less offshore capacity financed but the difference was made up with the equivalent number of additional onshore wind gigawatts. Generally speaking, solar PV and onshore wind are the cheapest in capital-cost terms, with the other technologies significantly more expensive, at least in upfront expense.

RENEWABLES IN PERSPECTIVE

Activity in renewables matters not just in itself, but also in comparison with that in fossil fuel and nuclear energy, and in terms of the changing overall generating mix and the trend in world power sector carbon dioxide emissions. Figure 15 highlights how the investment trends discussed in this report are impacting the profile of the global electricity system.

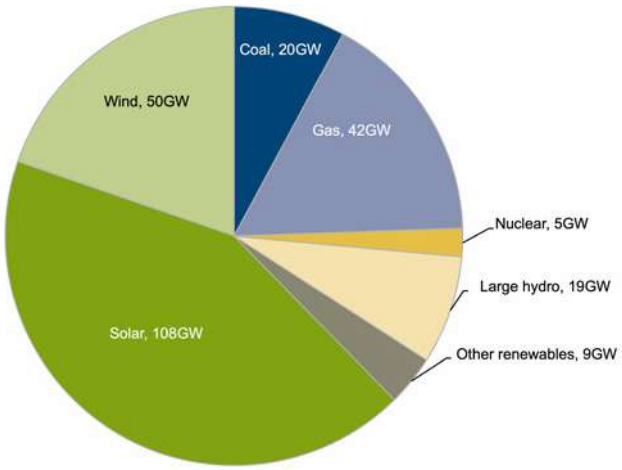
In 2018, nearly 68% of the net new generating capacity added worldwide was renewable (excluding large hydro). This was the highest proportion ever recorded, and compared to 64% in 2017 and 51% in 2016.[13] The impact in terms of electricity generated was less dramatic, with the share of renewables excluding large hydro rising to 12.9% in 2018, from 11.6% in 2017 and around 6% at the start of the decade.

FIGURE 15. RENEWABLE POWER GENERATION AND CAPACITY AS A SHARE OF GLOBAL POWER, 2007-2018, %



Renewables figure excludes large hydro. Capacity and generation based on BloombergNEF totals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 16. NET POWER GENERATING CAPACITY ADDED IN 2018 BY MAIN TECHNOLOGY, GW



The chart does not show the negative figure from net closure of oil-fired capacity in 2018
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

This gradual but not spectacular increase in the share of green electricity is a function of the fact that there is a huge installed fleet of power stations already, much of it fired by fossil fuels, and shifting the mix of electrons generated therefore inevitably happens in incremental steps. It is also the case that wind and solar are dependent on weather and sunlight and so tend to produce fewer megawatt-hours of electricity over the year relative to their nominal, megawatt capacity than, for instance, coal-fired or nuclear plants.

Figure 16 reinforces the message from the Focus Chapter (A Decade of Renewable Energy Investment) that solar has become the most added generating technology worldwide. In 2018, a record 108GW of solar, almost all photovoltaics, are estimated to have been added worldwide, up from 99GW in 2017. The second-highest net addition of capacity was in wind, with 50GW added onshore and offshore.

The story on coal and gas-fired capacity is more complicated because, in both, there were a significant number of gigawatts taken out of service as well as built. The chart shows that the net addition – the difference between additions and 'retirements' – is estimated to have been 20GW for coal-fired plants globally, and 42GW for gas generators.

[13] The equivalent figures in previous Global Trends reports have been revised in this report, to reflect new information.

These net additions mean that, if average running hours and efficiency remain similar, then world power sector emissions will rise, even though the world is adding more renewables than fossil capacity.

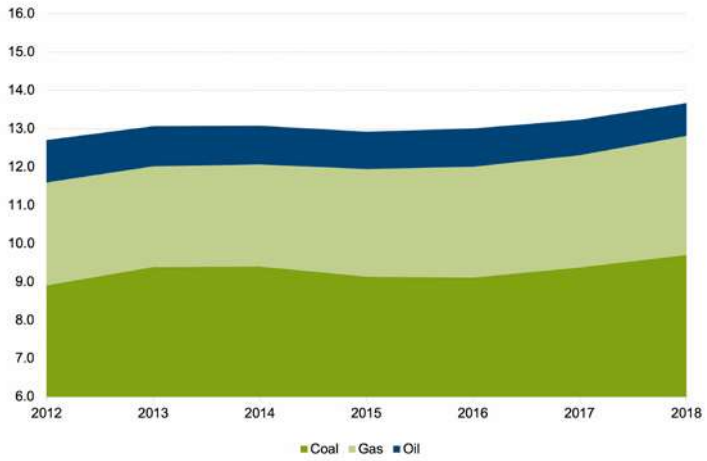
More dollars have been invested in renewables than in fossil fuel and nuclear power for many years, and that has enabled the proportion of green electricity to carry on rising. The gap, however, has become a large one: investment in renewable power capacity (excluding large hydro and also biofuels) was $272.4 billion in 2018. BNEF does not collect figures for investment in older established generation sources with the same accuracy, but its estimates are that these attracted $123 billion in total last year – consisting of $41 billion for coal plants, $49 billion for gas-fired capacity, and $33 billion for nuclear. If the comparison is just with fossil fuel power, then renewables attracted three times as much capacity investment in 2018.

One positive way of looking at the impact of renewables on the wider power system is to think of the volume of carbon dioxide emissions that they saved, compared to what would have been the case if the same electricity had been generated by other technologies. This report estimates that world power sector emissions would have been 2 gigatonnes, or 15%, higher in 2018, were it not for the investment in 'new renewables' over recent years.[14]

Nevertheless, Figure 17 shows the extent of the emissions challenge persisting in the power sector. Carbon dioxide emitted has continued to increase in recent years, albeit not in a straight line and not rapidly in percentage terms, but emissions from coal-, gas- and oil-fired power stations are estimated to have been 13.7 gigatonnes in 2018, up from 12.7 gigatonnes in 2012.[15]

Meanwhile, the proportion of CO2 in the atmosphere has increased from 394 parts per million in 2012 to an average of 408.5ppm last year, according to the U.S. National Oceanic and Atmospheric Administration measurement at Mauna Loa, Hawaii.

FIGURE 17. GLOBAL POWER SECTOR EMISSIONS, BILLIONS OF TONNES OF CO2 EQUIVALENT, 2012-2018



Source: BloombergNEF's New Energy Outlook 2019

[14] This is estimated by taking BloombergNEF's figure for power sector emissions, and assuming that the 12.9% of world electricity generated by renewables excluding large hydro was instead generated by the same mix as the remaining 87.1% of the mix. If so, emissions in 2018 would have been 2 metric gigatons higher.

[15] BloombergNEF: *New Energy Outlook 2019* https://www.bnef.com/core/insights/20917

INVESTMENT SO FAR IN 2019

Capacity investment in renewables excluding large hydro was a provisional $109.4 billion in the first half of 2019, down 17% compared to the same period in 2018. Contributing most to the fall was an estimated 60% shrinkage in Chinese capital investment compared to a year earlier. The U.S. was down 12% in the first half of this year, and Europe down 11%.

The first half figures suggest that full-year 2019 is likely to struggle to match 2018's total for capacity investment of $272.9 billion. However, the eventual total may end up closer to last year's number than would appear likely given the provisional first-half tally, because new information on the progress of projects over recent months will come in during the rest of the year. In addition, a solar auction taking place over the summer is expected to lead to a renewed rush of project financings in China.

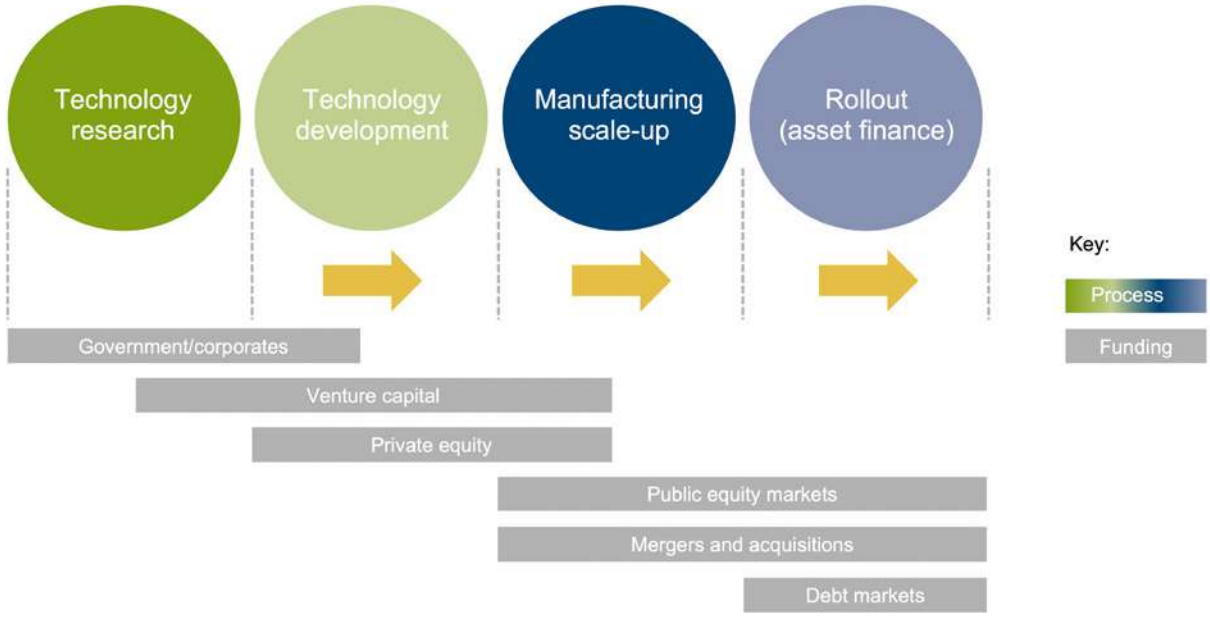
Highlights of the first-half 2019 investment included the financing of multibillion-dollar projects in two relatively new markets – a solar thermal and photovoltaic complex in Dubai, at 950MW and $4.2 billion, and two offshore wind arrays in the sea off Taiwan, at 640MW and 900MW and an estimated combined cost of $5.7 billion. The Dubai deal in late March, for the Mohammed bin Rashid Al Maktoum IV project, is the biggest financing ever seen in the solar sector.

Other sizeable project deals in the first half included the go-ahead for the 300MW Dalian Zhuanghe II offshore wind farm in Chinese waters, at $741 million, and two waste-to-energy plants in the U.K., Lostock and Rookery South, totaling between them 125MW and $1.2 billion. In the new market of Cambodia, Gideon Group financed the 135MW Kandal PV plant for $488 million.

TOTAL RENEWABLE ENERGY INVESTMENT

- This chapter looks not just at the capacity investment discussed in Chapter 1, but at the overall flow of capital into all parts of the renewable energy value chain – what the Global Trends report calls the 'financing continuum'.
- Total investment in renewable energy worldwide, including early-stage and corporate-level funding as well as the financing of new capacity, was $288.3 billion in 2018. This was 11% down on 2017's record $325 billion.
- The fall was entirely due to the decline in investment in new capacity, as discussed in Chapter 1. The main causes of this were lower equipment costs globally, and China's switch to a more restrictive allocation of feed-in tariffs for solar projects.
- Non-capacity types of investment all rose in 2018. Corporate research and development was up 12% at $7.6 billion, and government R&D 8% higher at $5.5 billion. Equity raising by specialist renewable energy companies on public markets increased 6% to $6 billion.
- Venture capital and private equity investment in renewables businesses jumped 35% to $2 billion last year, but remained far below the peak figures recorded around the turn of the decade.

FIGURE 18. THE FINANCING CONTINUUM



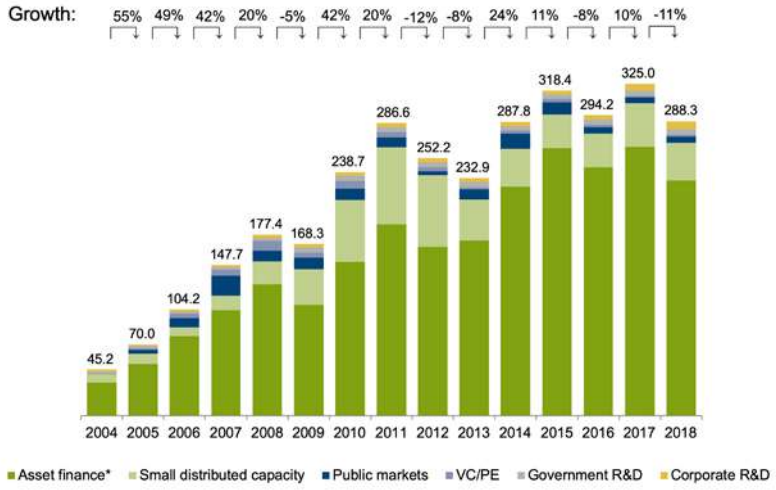
FINANCING CONTINUUM

The Global Trends in Renewable Energy Investment report has, over the years, tracked the flow of finance into the sector along a 'financing continuum'. This is shown in Figure 18. At the left-hand side of the diagram, there is pure technology funding. Some of this is extremely early-stage and often financed by government research and development programs, or in the R&D budgets of large companies. An important additional element is paid for by start-ups and young companies, in turn drawing their resources from the purchase of new shares by venture capital and private equity investors.

The private equity element, in particular, takes growing companies specializing in renewable energy into the next phase, which is scaling-up either of manufacturing or of service offerings, including project development. This stage also sees an important role for investors on public stock markets, providing new capital via share issues by specialist renewable energy companies.

In the 'rollout' phase, on the right of the diagram, are the asset finance of utility-scale renewable energy projects such as wind farms, solar parks and biofuel plants, and the funding of 'small distributed capacity' (solar systems of less than 1MW in capacity). Asset finance, the largest element of the continuum by far, relies on-balance-sheet capital from large developers such as utilities; and a mix of equity and debt from infrastructure investors and banks. This second type is known as 'non-recourse project finance' because the equity and debt is provided directly to the project, and its risk lies with the performance of the project not with the fortunes of the developer.

FIGURE 19. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY ASSET CLASS, 2004-2018, $BN



*Asset finance volume adjusts for re-invested equity. Total values include estimates for undisclosed deals

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

Acquisition activity, both of companies and of projects, is another important element in the financing continuum since it enables money to be recycled into new opportunities in the renewable energy sector. It is shown in the bottom right of Figure 18.

This chapter looks at the shifting volumes of finance going into these different elements of the continuum. Other chapters look in more detail at each of those elements – capacity investment (the rollout stage in Figure 18) has been introduced in Chapter 1, and will be examined more comprehensively in Chapters 3, 4 and 5; earlier-stage investment (on the left and centre of Figure 18) is covered in Chapter 6; the acquisition stage (on the far right of the continuum) is explored in Chapter 7.

Looking at the different stages of the continuum is important in order to understand the dynamics of overall investment. The growth of renewable energy can be put in jeopardy if capital dries up in any stage of the continuum – for instance the funding of new technology or the recycling of finance via acquisitions.

OVERALL INVESTMENT

Figure 19 shows the total flow of new money into renewable energy each year since 2004. It shows the contribution from the different categories of investment, with the exception of mergers and acquisitions, which do the important job of recycling capital but do not introduce brand new money to the sector. As explained in Chapter 1, this report defines renewable energy as including small hydro-electric projects of 50MW or less, but excluding larger dams.

This measure of 'total new investment' in renewable energy came to $288.3 billion in 2018, down 11% from the record figure of $325 billion attained in 2017. This decline was in fact entirely due to a fall in investment in new capacity, as discussed in Chapter 1.

Indeed, other stages of the financing continuum were more resilient last year. Taking them in turn, corporate R&D advanced by 12% to a record $7.6 billion worldwide, while government R&D rose 8% to $5.5 billion, also the highest in any year to date, although by only a narrow margin over the previous record set in 2009.

Public markets investment in renewable energy companies increased 6% to $6 billion, but was below the five-year average of $8.9 billion and far below the most recent high, of $14.9 billion reached in 2014.

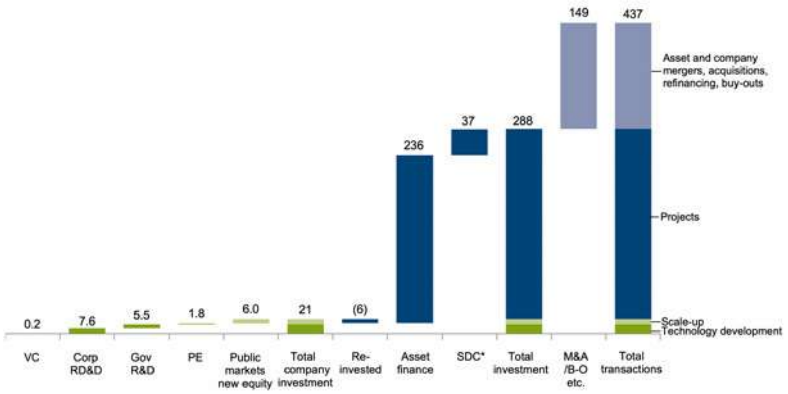
Venture capital and private equity investment in renewables rallied 35% to $2 billion in 2018, but this was also below the five-year average and far less than in the peak years around the turn of the decade. The reasons for the changes in financial flows to these types of investment are discussed in Chapter 6.

Last year marked a pause in one long-term trend, which has been the increasing dominance of the 'rollout' phase (asset finance of utility-scale

projects and the funding of small distributed capacity) within overall new investment in renewables, reflecting the ever-increasing maturity of the sector, particularly wind and solar technologies. Since 2010, the 'rollout' phase has increased its share of that total from 85% to 93% – despite a fractional move downwards in 2018.

Also evident in Figure 20 is the scale of acquisition activity – mergers and acquisitions, buy-outs, refinancings and asset purchases. This amounted to $149 billion in 2018, up 4% on 2017. Together with the new investment categories discussed above, it took total transactions in renewables to $437 billion.

FIGURE 20. GLOBAL TRANSACTIONS IN RENEWABLE ENERGY, 2018, $BN



SDC = small distributed capacity. Total values include estimates for undisclosed deals. Figures may not add up exactly to totals, due to rounding.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

Figure 21 is a regular fixture of the Global Trends Report: a convenient breakdown of total renewable energy investment since 2004, by type, by sector and by region. It shows the compound annual growth rate for each item. Some of the most impressive CAGRs over the 2004-2019 period are for investment in China and that in the Middle East and Africa, at 30% and 27% respectively, and that for project acquisition and refinancing, at 25%.

At the other end of the scale, some corners of renewable energy investment have seen negative annual growth rates over the 15 years to 2018.

FIGURE 21. GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2018 DATA TABLE, $BN

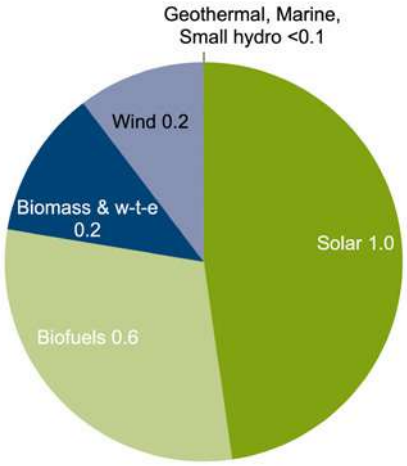
Category / Year / Unit	2004 $bn	2005 $bn	2006 $bn	2007 $bn	2008 $bn	2009 $bn	2010 $bn	2011 $bn	2012 $bn	2013 $bn	2014 $bn	2015 $bn	2016 $bn	2017 $bn	2018 $bn	2017-18 Growth %	2004-18 CAGR %
1 Total Investment																	
1.1 New investment	45.2	70.0	104.2	147.7	177.4	168.3	238.7	286.6	252.2	232.9	287.8	318.4	294.2	325.0	288.3	-11%	14%
1.2 Total transactions	53.7	96.3	137.7	204.7	235.7	230.0	295.9	361.4	318.5	300.3	374.6	424.1	428.1	468.2	437.4	-7%	16%
2 New Investment by Value Chain																	
2.1 Technology development																	
2.1.1 Venture capital	0.4	0.6	1.2	2.1	3.3	1.6	2.6	2.6	2.4	0.8	1.0	1.4	0.8	0.7	0.2	-73%	-4%
2.1.2 Government R&D	1.9	2.0	2.2	2.7	2.8	5.4	4.9	4.8	4.7	5.2	4.5	4.4	5.1	5.1	5.5	8%	8%
2.1.3 Corporate R&D	1.9	1.9	2.2	2.3	3.3	3.3	3.8	4.3	4.1	4.0	4.3	4.1	4.3	6.8	7.6	12%	10%
2.2 Scale-up																	
2.2.1 Private equity expansion capital	0.3	1.0	2.9	3.5	6.7	3.0	5.3	2.4	1.6	1.3	1.7	1.8	1.7	0.7	1.8	140%	13%
2.2.2 Public markets	0.3	3.6	8.9	19.7	10.5	11.7	10.6	9.9	3.8	9.8	14.9	12.0	6.2	5.6	6.0	6%	25%
2.3 Projects																	
2.3.1 Asset finance	32.5	51.0	80.0	106.6	133.1	112.4	152.4	189.7	168.5	172.6	227.8	268.8	247.4	266.0	236.1	-11%	15%
Of which re-invested equity	-0.1	-0.2	-2.2	-3.1	-4.4	-3.8	-1.8	-2.1	-2.9	-1.2	-3.6	-6.7	-4.4	-2.9	-5.7	97%	33%
2.3.3 Small distributed capacity	8.0	10.1	9.0	13.9	22.2	34.7	60.9	75.1	70.0	40.4	37.1	32.7	33.1	42.9	36.8	-14%	11%
Total Financial Investment	33.3	56.0	90.8	126.8	149.1	124.9	169.2	202.5	173.3	183.3	241.8	277.2	251.7	270.2	238.4	-12%	15%
Gov't R&D, corporate RD&D, small projects	11.9	14.0	13.4	18.9	28.4	43.4	69.5	84.1	78.9	49.6	45.9	41.2	42.5	54.8	49.9	-9%	11%
Total New Investment	45.2	70.0	104.2	147.7	177.4	168.3	238.7	286.6	252.2	232.9	287.8	318.4	294.2	325.0	288.3	-11%	14%
3 M&A Transactions																	
3.1 Private equity buy-outs	0.8	3.7	1.8	3.3	5.1	1.9	1.9	2.9	3.0	0.5	4.1	3.6	3.2	10.6	12.5	18%	22%
3.2 Public markets investor exits	0.4	2.3	2.6	3.9	0.9	2.4	4.8	0.2	0.4	1.7	1.6	1.5	6.4	2.8	0.1	-97%	-9%
3.3 Corporate M&A	2.2	7.6	10.1	19.8	16.5	22.4	18.7	29.6	9.3	16.2	11.2	17.2	30.2	13.3	15.7	18%	15%
3.4 Project acquisition & refinancing	5.1	12.6	18.9	30.0	35.7	35.2	31.8	42.1	53.6	49.0	70.0	83.4	94.1	116.4	120.8	4%	25%
4 New Investment by Sector																	
4.1 Wind	18.9	27.3	36.3	59.1	73.9	73.3	98.3	84.7	77.9	83.2	110.7	121.5	124.9	129.7	131.5	1%	15%
4.2 Solar	10.7	15.3	21.5	37.5	60.3	63.4	101.7	158.8	142.9	121.4	148.0	176.2	146.3	180.0	141.1	-22%	20%
4.3 Biofuels	3.9	9.8	26.2	26.4	17.6	9.4	10.1	10.4	7.7	5.1	5.5	3.6	2.1	3.2	3.0	-9%	-2%
4.4 Biomass & w-t-e	7.9	9.3	12.0	15.9	16.2	13.4	17.3	20.9	15.4	14.6	12.9	10.3	13.6	5.7	9.3	62%	1%
4.5 Small hydro	2.8	7.4	6.8	6.4	7.6	5.9	8.2	7.7	6.3	5.7	7.4	4.0	4.4	3.8	0.9	-75%	-7%
4.6 Geothermal	1.1	0.8	1.3	1.7	1.7	2.5	2.8	3.8	1.7	2.7	2.9	2.5	2.7	2.3	2.3	-2%	5%
4.7 Marine	0.0	0.1	0.1	0.7	0.2	0.3	0.3	0.3	0.3	0.2	0.4	0.2	0.2	0.2	0.2	9%	14%
Total	45.2	70.0	104.2	147.7	177.4	168.3	238.7	286.6	252.2	232.9	287.8	318.4	294.2	325.0	288.3	-11%	14%
5 New Investment by Geography																	
5.1 United States	6.0	11.4	28.6	30.5	34.7	23.0	34.6	50.0	39.7	35.8	37.9	47.0	45.2	48.5	46.5	-4%	16%
5.2 Brazil	0.7	2.4	4.1	9.9	11.1	6.9	7.2	10.2	7.8	3.9	7.7	6.4	5.7	6.2	3.4	-46%	12%
5.3 AMER (excl. US & Brazil)	1.7	3.7	3.5	4.8	5.6	5.0	12.0	11.7	10.2	12.9	14.9	11.5	6.5	13.2	10.2	-23%	14%
5.4 Europe	24.3	32.5	41.6	64.6	78.9	77.1	112.0	130.0	90.3	57.0	69.1	61.3	71.1	44.7	62.2	39%	7%
5.5 Middle East & Africa	0.6	0.8	1.2	1.8	2.2	1.5	4.0	3.1	9.7	8.8	8.0	11.6	7.5	10.1	16.1	60%	27%
5.6 China	2.4	8.5	10.5	17.2	25.8	36.6	42.5	45.5	56.5	63.3	89.4	121.7	105.2	147.2	93.2	-37%	30%
5.7 India	2.7	3.0	4.8	6.1	5.3	4.3	8.1	12.8	7.6	5.2	7.7	8.3	13.0	13.5	11.4	-16%	11%
5.8 ASOC (excl. China & India)	6.8	7.7	9.9	12.8	13.8	13.9	18.3	23.3	30.4	46.2	53.1	50.6	40.1	41.7	45.4	9%	15%
Total	45.2	70.0	104.2	147.7	177.4	168.3	238.7	286.6	252.2	232.9	287.8	318.4	294.2	325.0	288.3	-11%	14%

New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

Investment in biofuels, for instance, climbed strongly to a peak in 2006, but then slumped so that its total for last year was less than that in 2004. Small hydro investment has also tended to decline after peaking in 2010 – although it is possible that its 2018 Figure may be revised up in due course, when more information on projects becomes available. Venture capital funding of renewables is a third line in the table to have showed a negative CAGR over the period, as its high point in 2008 gave way to a record low by 2018.

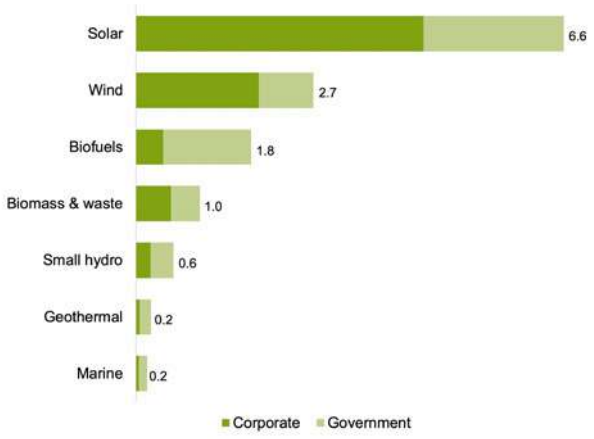
Figure 21 also reveals some interesting movements at the level of sub-categories of investment. For instance, while private equity expansion capital was relatively buoyant in 2018 at $1.8 billion, the highest for three years, venture capital financing was just $201 million, the lowest in any year covered by BloombergNEF data. VC funding has tended to decline in recent years, reflecting the fact that the dominant technologies in renewables (wind and solar) are now mature, and the scope for breakthroughs by start-up companies is much more limited than it was.

FIGURE 22. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2018, $BN



VC/PE new investment excludes PE buy-outs. Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 23. R&D INVESTMENT IN RENEWABLE ENERGY BY SECTOR 2018, $BN



Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

THE SECTOR DIMENSION

This section looks at time series for the categories of investment mentioned above, and how different renewable energy sectors contributed to the changes.

The rise in venture capital and private equity funding in 2018 was from a low base – because the 2017 figure, at $1.5 billion, was the smallest since 2004. So although last year saw a 35% bounce to $2 billion, that was still the second weakest total since 2005 and a far cry from the $9.9 billion record of 2008 or the $8 billion number of 2010.

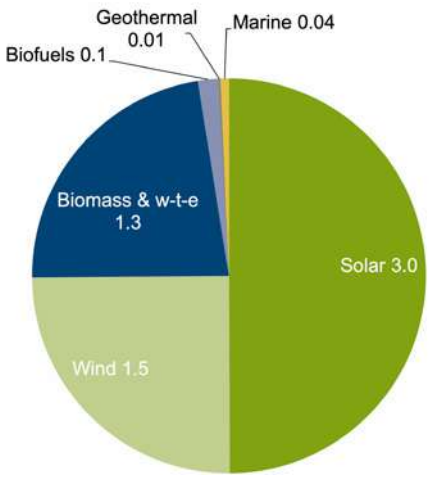
Biofuels accounted for the two biggest deals in VC/PE funding for renewables in 2018, with several transactions in solar and one each in wind and in biomass and waste-to-energy making up the list of those above $50 million. Overall, solar was the largest sector for venture capital and private equity raising, as Figure 22 shows. More detail on the individual deals and the sector and region is contained in Chapter 6, later in this report.

Research and development spending by companies and governments continues to play an important role in nurturing new green energy technologies. Last year, solar made up the majority of the activity, at $6.6 billion, as Figure 23 indicates.

Wind came second at $2.7 billion, with biofuels at $1.8 billion and biomass and waste at $1 billion.

The relative importance of corporations and governments in R&D dollars spent has changed subtly over the years. Governments accounted for the lion's share of spending during the "green stimulus" period after the 2008 financial crisis, and their lead over companies stayed in place right up to 2016. In the last two years, however, corporations have pulled ahead in terms of commitments, and the 2018 total of $7.6 billion was a clear record.

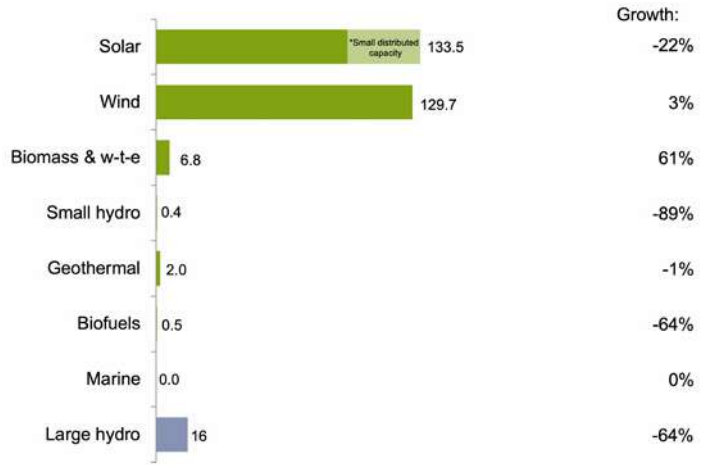
FIGURE 24. PUBLIC MARKETS NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2018, $BN



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

Public markets investment (see Figure 24) tends to come into play at a somewhat later stage in corporate evolution, either when a manufacturer is looking to raise money to scale up output and improve its products, or when a renewable energy developer is aiming to roll out a new wave of projects. In 2018, as Chapter 6 highlights, almost all of the sizeable public market issues in renewables were by developers, mostly of wind or solar projects, but including one large Chinese biomass and waste-to-energy project firm.

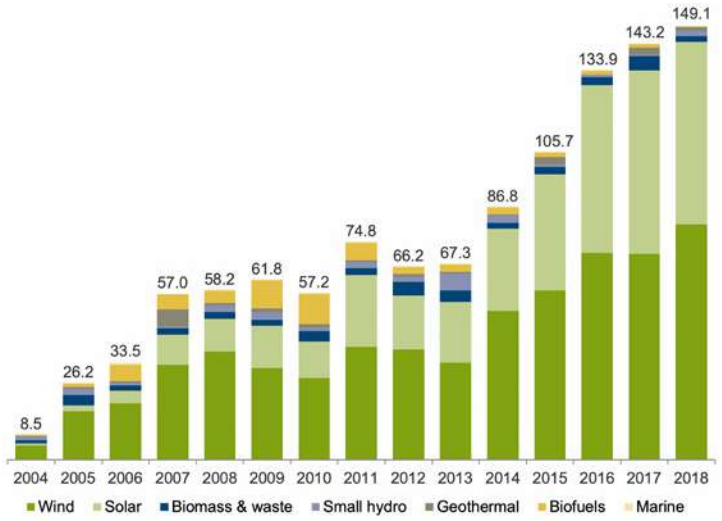
FIGURE 25. RENEWABLE ENERGY ASSET FINANCE AND SMALL DISTRIBUTED CAPACITY INVESTMENT BY SECTOR, 2018, AND GROWTH ON 2017, $BN



Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

Figure 25, on capacity investment, illustrates just how dominant wind and solar have become in renewable energy. Even large hydro, which is outside the scope of most of this report, found itself dwarfed in 2018 – with final investment decisions of around $16 billion, down 64%, compared to $100 billion-plus totals for wind and solar. The other two sectors to see capacity investment of more than $1 billion were biomass and waste-to-energy, and geothermal.

FIGURE 26. ACQUISITION TRANSACTIONS IN RENEWABLE ENERGY BY SECTOR, 2004-2018, $BN



Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

The previous section of this chapter mentioned acquisition activity as being an important element in the recycling of capital through the sector, and in enabling investors to crystallize their returns. Figure 26 reveals just how much upward momentum acquisitions have had over recent years. After a fairly flat period from 2007 to 2013, the volume started to take off, and 2018's figure of $149.1 billion was more than double that of 2013.

The growth in acquisition activity over the last five years has been logical, in that much of it has been the purchasing and sale of wind and solar projects – and those assets have multiplied in number and scale as their sectors have added more and more capacity during this decade. More gigawatts installed or under development equals more gigawatts that can be transferred to new owners, at the right price.

Overall, wind and solar played by far the largest roles in acquisition activity in renewables in 2018, contributing $81 billion and $62.7 billion respectively to the overall total of $149.1 billion. The wind figure was up 15% on the previous year, but solar was down 1%.

CAPACITY INVESTMENT – GLOBAL

- Global investment in renewable energy capacity (excluding large hydro-electric projects) fell 12% in 2018 to $272.9 billion. That total was made up of the asset finance of utility-scale projects, at $236.1 billion, down 11%, and financing of small-scale projects at $36.8 billion, down 14%.
- Within the asset finance category, wind was the largest sector, with commitments up 3% at $129.7 billion. Onshore wind attracted the great bulk of this, at $104.2 billion, up 1%, while offshore wind took $25.6 billion, up 11% and its second highest year ever.
- Solar secured $96.7 billion of asset finance in 2018, down 25% on the previous year. Within this, photovoltaics got $95.4 billion, some 24% lower, while solar thermal projects received just $1.3 billion of investment, down 48% and the lowest figure in any year since 2005.
- Some 61% of renewable energy asset finance in 2018 took the form of on-balance-sheet funding by utilities, developers and others, against 38% that were done using non-recourse project finance with banks. A proportion of the first category subsequently get refinanced with bank debt or bonds.
- Out of the 15 largest projects reaching final investment decision last year, 10 were in offshore wind, either in Europe's North Sea, or off China's coast. The other five were in onshore wind, in South Africa and the U.S., in solar PV in Morocco, biomass in the U.K and solar thermal in Chile.
- Government-held auctions had their second-highest year ever, and corporate power purchase agreements hit a new record, for the amount of new renewable energy capacity they supported in 2018. These mechanisms have emerged as important ways for developers to secure fixed electricity prices, now that feed-in tariffs are disappearing.
- Small distributed capacity investment slipped in 2018, due in large part to the further decline in solar capital costs. The cost of a 4kW PV system in Australia, for instance, fell 21% between 2017 and 2018, while the Chinese multi-module price reached an average of just 30 U.S. cents per kW.

Chapter 1 provided some of the main highlights of renewable energy capacity investment in 2018, and put it in context in terms of the amount of new capacity added, and also the comparison with fossil fuel power sources.

This chapter explores renewables capacity investment in more detail at the global level, at the sub-sector level in the context of, the trends in financing and tariff support and small-scale system costs. Chapters 4 and 5 will look at the geographical patterns and the largest deals of the year, starting with developing economies and then developed economies.

Figure 8 in Chapter 1 showed the breakdown in 2018 between the two forms of renewable energy capacity investment – asset finance of utility-scale projects such as wind farms, solar parks and biofuel plants; and the financing of small-scale systems, all solar, of less than 1MW. Asset finance accounted for $236.1 billion, nearly 87% of the total capacity investment in that year of $272.9 billion, while small distributed solar made up the remaining $36.8 billion, or 13% of the total.

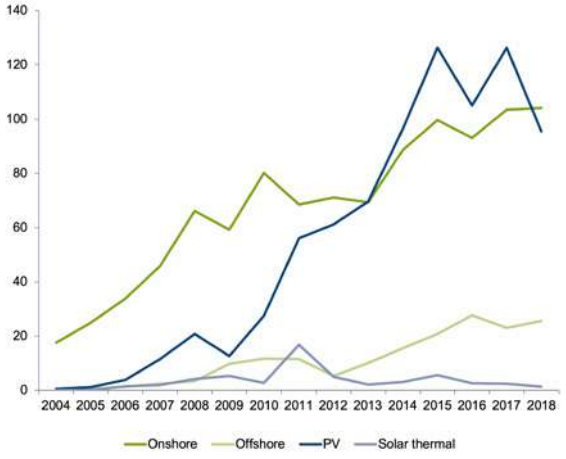
ASSET FINANCE

Of last year's $236.1 billion of asset finance, down 11% on 2017, the biggest shares were predictably taken by wind and solar. Wind asset finance totaled $129.7 billion, up 3% on the previous year, while that for solar was $96.7 billion, down 25%. The setback in solar owed much to events in China (discussed more fully in Chapter 4), and lower capital costs per megawatt.

Figure 27 displays how these financial commitments have played out at the sub-sector level of wind and solar. Onshore wind was for many years the dominant sub-sector, and it won this position back in 2018 thanks to a 1% rise in asset finance to $104.2 billion at a time when its main rival, solar PV, fell back. Offshore wind has seen its importance increase over time, but its curve has seen some dips along the way. In 2018, it attracted $25.6 billion, up 11% on 2017 but some $2.1 billion less than in the record year of 2016.

The sub-sector trends in solar have been much more jagged, with PV soaring to hit record levels of asset finance in 2015 and 2017 before suffering a reverse in dollar terms in 2018, while solar thermal projects peaked way back in 2011 in terms of the capital committed and have tended to become ever more sparse in recent years. Last year, $96.7 billion of utility-scale PV projects

FIGURE 27. ASSET FINANCE OF WIND AND SOLAR PROJECTS WORLDWIDE, BY SUB-SECTOR, 2004-2018, $BN

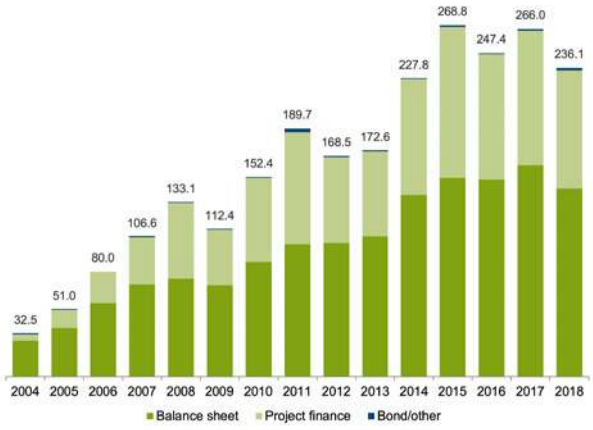


Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

received financing, down 24% on 2017, while only $1.3 billion of solar thermal sites reached the same stage, down 48% and the lowest figure since 2005.

The way renewable energy assets are financed to construction is explored in Figure 28. There are two main methods – on-balance-sheet funding by utilities, developers or other investors, in which all the cost of the project is met by their owners; and non-recourse project finance, in which the project itself receives a mixture of equity and debt finance. For the latter, the typical mix in developed economies is 60-80% debt, and the remainder equity.

FIGURE 28. ASSET FINANCE INVESTMENT IN RENEWABLE ENERGY BY MODE OF FINANCE, 2004-2018, $BN



Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

In 2018, global asset finance consisted of $143.9 billion of on-balance-sheet transactions, $90.4 billion of non-recourse project finance, and $1.9 billion of bond and other deals, including leasing. The proportions of each in the total remained relatively steady, at 61% for on-balance-sheet, 38% for project finance and 1% for bond/other.

These numbers do not tell the full story of how renewable energy is funded globally. That is because many projects receive more than one financing package. The first will typically take a wind farm, solar park or other asset to the point of 'final investment decision', when BNEF records the project in its investment data. A second package, or refinancing, often takes place either near the start of construction, or once the project is operating. That enables the initial developer to share the capital costs, or to recycle cash back into other projects. Refinancings are counted as part of acquisition activity in this report, and are discussed in Chapter 7.

Figure 29 lists the 15 largest renewable energy asset finance deals in 2018, for which capital costs have been disclosed, or estimated by BNEF. One message that emerges clearly from the table is the dominance of offshore wind in the big-ticket list. This technology tends to involve projects that are large, in some cases around the

FIGURE 29. LARGEST ASSET FINANCE DEALS IN RENEWABLE ENERGY IN 2018

Project	Country	Technology	MW	Estimated cost ($bn)
Moray Firth	United Kingdom	Offshore wind	950	3.3
Triton Knoll	United Kingdom	Offshore wind	860	2.6
NOORm Midelt	Morocco	PV	800	2.4
Borssele III & IV	Netherlands	Offshore wind	732	1.7
Vattenfall Kriegers Flak	Denmark	Offshore wind	605	1.5
Guangdong Baolihua New Energy Shanwei Lufeng Houhu	China	Offshore wind	500	1.5
Otary Seamade	Belgium	Offshore wind	487	1.5
EGP South Africa Portfolio	South Africa	Onshore wind	706	1.3
SPIC Jieyang Huilai Shenquan Phase I	China	Offshore wind	400	1.2
Jiusi Nantong Rudong Jiangjiasha H2	China	Offshore wind	300	1.2
CGN Huizhou Huidong Gangkou Phase I	China	Offshore wind	400	1.2
Xcel Rush Creek	United States	Onshore	600	1.0
EIG Atacama 1	Chile	Solar thermal	110	1.0
Drax Biomass Cofiring Phase IV	United Kingdom	Biomass	645	0.9
Three Gorges Nanao Yangdong	China	Offshore wind	300	0.8

The table shows the largest deals on the basis of disclosed values, or BNEF estimates.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

1GW mark, but also the capital cost per megawatt is significantly higher than for onshore wind or PV. This higher capital cost ratio is offset to some extent by the fact that offshore wind arrays tend to produce more electricity during the year per MW of capacity than either onshore wind or PV: this measure, known as 'capacity factor' or 'load factor', can be as high as 40-50% for the latest offshore wind projects, but is likely to be 20-40% for onshore wind, and 11-35% for solar PV.[16]

Both European and Chinese offshore wind projects made it into the top 15 transactions in 2018. EDP Renovaveis' 950MW Moray Firth array, which tops the list, was the fifth largest transaction in offshore wind on record in terms of dollars committed, and larger than any financing in any other renewable energy sector (excluding large hydro) up to that point.[17]

BECOMING 'BANKABLE'

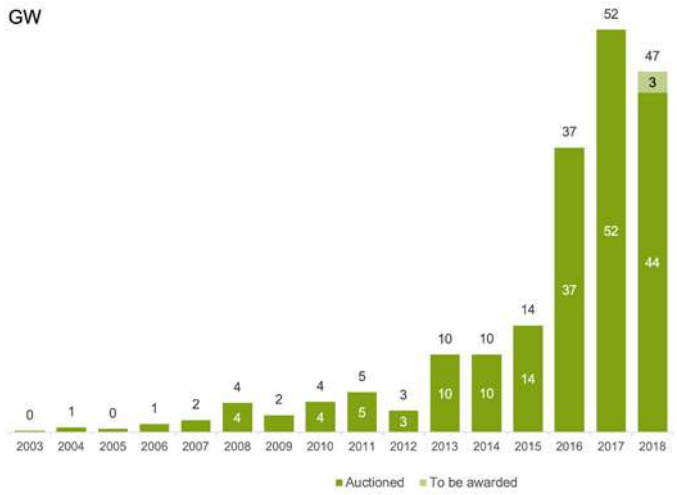
Key to whether renewable energy projects get beyond the drawing board, or the permitting process, is what is known in the sector as 'bankability'. All the green power technologies involve heavy upfront capital expenditure. In the case of wind and solar, the balance between capital costs and operating costs of a plant are particularly heavily tilted toward the former, since the expense of keeping installations going once built is modest. For coal, gas, nuclear and biomass plants, operating-stage and feedstock costs make up a higher share of total lifetime costs.

The money to cover upfront capital expenditure needs to be raised. Getting that funding, whether from the developer's own balance sheet (and therefore board of directors) or from outside equity

[16] Biomass, waste-to-energy and geothermal projects also tend to have high capital costs per megawatt, but also high capacity factors, signalling their ability to generate through most of the year.

[17] In 2019, it was surpassed by the $4.2 billion Al Maktoum IV solar financing in Dubai.

FIGURE 30. GLOBAL AUCTIONED RENEWABLES CAPACITY, 2003-2018 GW



Excludes 60.8TWh of renewable electricity auctioned in Chile between 2006 and 2018, because it was not allocated on a GW basis.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

Figure 30 shows that the capacity of renewable energy projects subject to auctions each year worldwide grew exponentially, from just 3GW in 2012 to 52GW in 2017, before slipping back slightly to 47GW in 2018 (including just under 3GW for which the auction is believed to have occurred but the winners have not yet been disclosed). The small setback last year does not appear to be the start of a new, weaker trend – by late July, 2019 had already seen 43GW of auction capacity awarded, with a further 53GW announced as scheduled to take place before year-end.

Among the highlights in terms of low pricing from the auctions in 2018 were a Saudi Arabian round for 400MW of onshore wind, which produced an indexed contract price of $26.43 per MWh, and a 600MW round by SECI in India for solar that produced a fixed (non-indexed) contract price equivalent to $35.42 per MWh. In offshore wind, the second German transitional auction round produced a 20-year euro price for 1.6GW equivalent to $54.99 per MWh. None of these prices were quite all-time record lows for their technologies, but that may reflect developers thinking that they were overly aggressive in bidding in some of the 2016 and 2017 rounds.

investors and banks, will depend on whether those involved have a high level of confidence that the project will make adequate returns.

That level of confidence, in turn, hinges on the price that the project will achieve for its electricity over the 10-15 years ahead. Market electricity prices are volatile and hard to predict, so almost all non-hydro renewable energy projects built have gone ahead thanks to some sort of contract securing the electricity selling price that their owners would receive.

For most of the first two decades of this century, and in most countries, that has taken the form of a government-set contract – either a feed-in tariff, which guarantees the full electricity price, or a certificate that can go up and down in value but can be sold to provide a second stream of income alongside the wholesale market electricity price.

However, in recent years, countries have increasingly moved move away from these arrangements, toward auctions – which bring in a strong element of initial competition among developers to secure capacity. The auction mechanism, combined with falling technology costs, has led to much lower electricity prices for wind and solar projects, in particular, than pertained earlier in the decade.

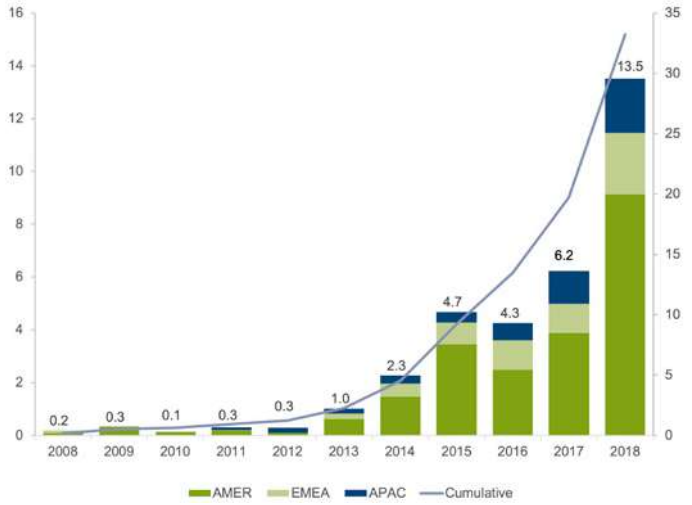
The other way for a developer to achieve 'bankability' for a project is to bypass government-run processes, and to agree a long-term power purchase agreement, or PPA, with a credit-worthy private sector electricity buyer. The latter can be a utility, but recent years have also seen an increasing number of PPAs signed directly with corporate energy users.

Figure 31 reveals just how powerful this momentum was in 2018. New corporate PPAs signed shot up from a then-record of 6.2GW globally in 2017, to 13.5GW in 2018, taking the cumulative total agreed in the decade to nearly 33GW. The 2018 total included 2.1GW of deals in Asia-Pacific (mainly India and Australia), 2.3GW of transactions in Europe, Middle East and Africa (mainly for wind in Sweden and Norway, and solar in Spain), and a remarkable 9.1GW in the Americas (mainly the U.S.).

Much of the impetus comes from large electricity-consuming companies that have set targets to switch their operations to 100% green power by a particular date – partly to demonstrate their sustainability to customers and employees. More than 190 of these organizations have joined RE100, a club set up for those with such targets. Some other companies have gone down the PPA path only partly for sustainability reasons, and at least as much to lock in a long-term, low electricity price for their operations.

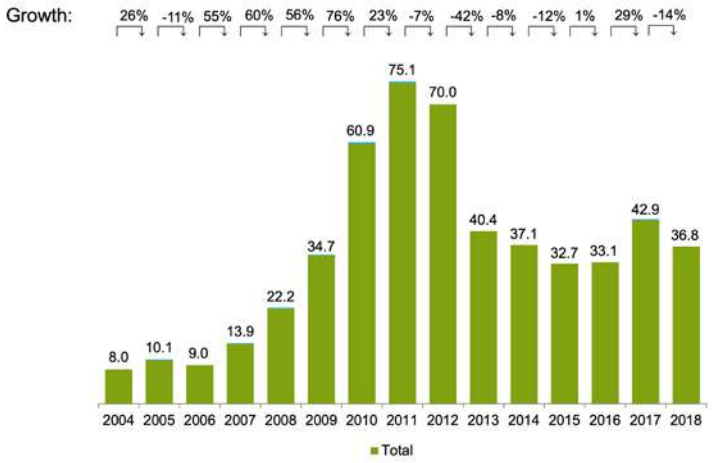
In 2018, the company that signed the largest volume of PPAs worldwide was Facebook, with 2.1GW of solar deals and 551MW of wind deals. AT&T followed, with 820MW of wind PPAs, with Walmart third, at 138MW of solar and 533MW of wind. Industrial firms also figured in the top 10 worldwide, including Norsk Hydro (667MW of wind) and ExxonMobil (325MW of wind and 250MW of solar).

FIGURE 31. GLOBAL VOLUME OF CORPORATE POWER PURCHASE AGREEMENTS SIGNED, BY REGION, 2008-2018 GW



Onsite PPAs with captive installations not included. APAC number is an estimate. Pre-market reform Mexico PPAs are not included. The cumulative total is shown on the right-hand axis.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 32. SMALL DISTRIBUTED CAPACITY INVESTMENT, 2004-2018, $BN



Represents investments in solar PV projects with capacity below 1MW
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

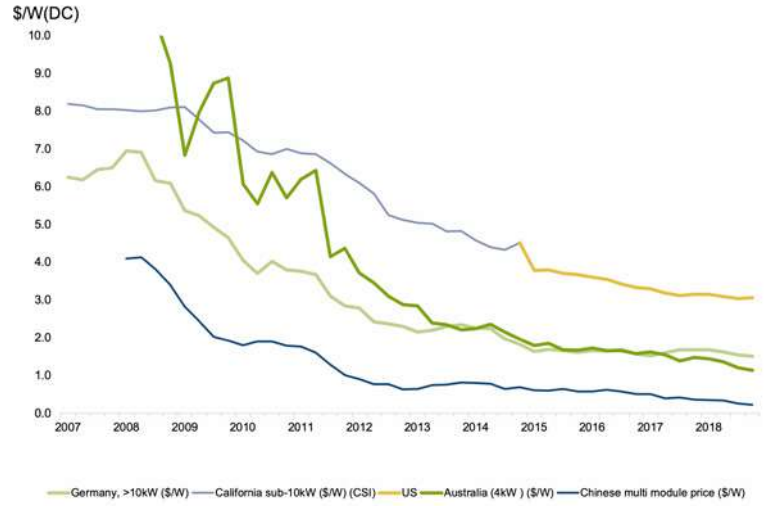
SMALL-SCALE SOLAR SYSTEMS

More than four-fifths of investment in renewable energy capacity in 2018 took the form of utility-scale projects of more than 1MW in size. The rest consisted of the financing of small-scale solar systems of less than that capacity – some of it in the hundreds of kilowatts, serving businesses or small localities, and some of it in the single-digit or tends of kilowatts, serving individual households.

The year-by-year totals for this small distributed capacity investment worldwide is shown in Figure 32. What emerges is the lack of an obvious trend – this category of capital spending peaked in 2011 at $75.1 billion, fell to $32.7 billion in 2015, rallied to $42.9 billion in 2017, and then fell 14% last year to $36.8 billion.

The explanation owes much to rapidly falling costs of solar equipment. The years 2010-2012 saw heavy expenditure on small-scale PV, at high prices per kW, especially in European countries such as Germany and Italy that offered attractive feed-in tariffs. Those booms subsided, and although Japan and the U.S. have been strong players in small-scale solar in recent years, unit costs have been lower and previous years' totals have not been matched.

FIGURE 33. SMALL PV SYSTEM COST IN GERMANY, THE U.S. AND AUSTRALIA, AND TREND IN CHINESE MODULE PRICES, $ PER W



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

In 2018, the largest markets for small-scale solar activity were the U.S., with an estimated $8.9 billion invested, down 15% on the previous year, Germany with $2.8 billion, up 103%, Australia with $2.1 billion, up 40% on the previous year, China at $1.9 billion, down 90% due to the cutbacks in its feed-in tariff, and Japan with $1.7 billion, some 8% more than in 2017. The rest of global small-scale solar investment was spread thinly through developed and developing economies, much of it on business or residential rooftops.

The cost dimension is illustrated in Figure 33, with the capital expenditure costs of small-scale solar systems in Germany, the U.S. and Australia shown (excluding labor costs in installation, and tax). Also in the chart is the Chinese multi module price. The longest series with sufficient data points is that for German systems: this shows a slide from the euro equivalent of $6.35 per Watt in 2007 all the way to an average of $1.59 during 2018. This decline, of 75%, is less than the 90%-plus reduction in Chinese module prices in that time, for the reason that the system cost series contain more than just modules – they also include inverters, racks and other balance of plant.

Small-scale systems, by their nature, tend to attract less fanfare than city-sized solar parks in the desert or giant offshore wind arrays with 200-meter turbines. However, many interesting small-scale projects proceeded during 2018.

To name just a few that made the news, BayWa completed a 288kW rooftop PV installation for livestock cooperative Pastores Grup Cooperativo in Spain, the Southern Railway put 4.8kW of solar panels on seven carriages of a train in Tamil Nadu, India, and Kenya installed a 500kW project at Moi International Airport, the first such installation at an African air travel hub. Puerto Rico's Hospital del Nino put in a microgrid system based around 200kW of solar panels and 475kWh of batteries, Greater Cairo Utility Data Centre in Egypt added a 60kW rooftop PV plant, and Wildhorse Golf Club in Davis, California put in a 246kW solar array on a shaded parking structure. Siemens installed a hybrid power plant on the island of Isabela in the Galapagos archipelago, including a 952kW PV system, while packaged food company Lonbisco in the Philippines signed up for 100kW of rooftop solar.

LARGE HYDRO-ELECTRIC PROJECTS

As shown in Figure 25, in Chapter 2, final investment decisions for large hydro-electric projects of more than 50MW was an estimated $16 billion in 2018, down 64% on the 2017 total of $45 million. The sharp drop reflected the absence of a mega-project getting the go-ahead last year, in contrast to 2017's start of full construction on the giant 16GW, $28 billion Baihetan dam in China.

Large hydro's tally of $16 billion of investment in 2018 puts it more than $100 billion behind the two leading renewable power sectors of wind and solar. Hydro was by far the biggest segment of renewables until the mid-2000s, when wind overtook. The amount of investment it attracts has tended to falter in recent years, partly because of concerns on the part of development banks and others about the biodiversity and social sustainability of some projects, and partly because most of the mega-projects have now been done.

Nevertheless, last year saw a number of large hydro dams reach milestones, including government permission for the 743MW Bala project in China, the agreement of loans for the 450MW Souapiti development in Guinea, and other finance packages for the 900MW Arun 3 dam in Nepal and the 300MW Balakot Mansehra in Pakistan. Money was raised for a second, 600MW phase of the Rogun complex in Tajikistan, and for the 480MW Hoa Binh expansion in Vietnam.

Large hydro is not included in the main investment figures in this report, for two main reasons. One is that it is a long-established technology, dating back a century or so, and therefore does not share the same dynamics as "new renewable" technologies such as wind, solar and biomass. The other is that investment is hard to estimate with any precision, since big projects tend to unfold over many years, even a decade or more, will often stop and start, and may be part-financed at different times.

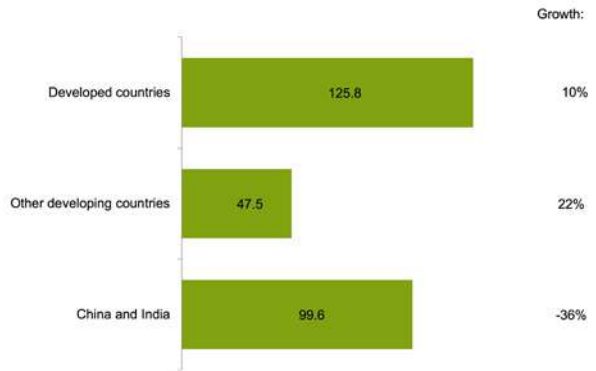
CAPACITY INVESTMENT – DEVELOPING COUNTRIES

- Renewable energy capacity investment in developing economies out-weighed that in developed countries for the fourth year running in 2018, but the gap was much smaller than in 2017 due to a sharp drop in spending in China.
- Capacity investment in "other developing countries" (outside China and India) reached $47.5 billion in 2018, some 22% up on the previous year and the highest figure on record. Developed economies enjoyed a 10% rise to $125.8 billion.
- China saw capacity investment fall 38% to $88.5 billion, with solar down a massive 56% to $37.9 billion and wind just 3% lower at $50.5 billion. Part of the drop in solar was due to lower unit costs per MW, but the main cause was Beijing's move in the middle of the year to restrict feed-in tariffs for new projects.
- Capacity investment in India slipped 15% to $11 billion, with solar down 19% at $6.9 billion and wind 8% lower at $4.1 billion. Indian PV projects had among the lowest capital cost figures per MW worldwide, reflecting the cut-price competition in its auction program.
- The Middle East and Africa region saw capacity allocations jump 61% to $16.1 billion in 2018, easily the highest ever. There was a rebound in financings of projects in South Africa, and Morocco and Kenya also easily exceeded the $1 billion barrier.
- Vietnam was one of the most spectacular performers among developing countries in 2018, with a ninefold jump in capacity investment to $5.2 billion. In the Americas region, Mexico saw a 38% decline to $3.8 billion and Brazil a 44% fall to $3.4 billion.

Figure 12 in Chapter 1 showed that renewable energy capacity investment in developing economies as a whole fell 24% in 2018 to $147 billion. However, this was certainly not indicative of a generalized retreat. Figure 34 shows that, while investment fell by 36% to $99.6 billion combined in China and India, it actually increased by 22% in the rest of the developing countries, taken together.

The total for "other developing economies", at $47.5 billion, was in fact the highest ever and almost

FIGURE 34. CAPACITY INVESTMENT IN RENEWABLES: DEVELOPED COUNTRIES, CHINA AND INDIA, OTHER DEVELOPING ECONOMIES, 2018, AND GROWTH ON 2017, $BN



Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 35. RENEWABLE ENERGY CAPACITY INVESTMENT IN CHINA BY SECTOR AND SUB-SECTOR, 2018, AND CHANGE ON 2017, $BN

	2018	% growth on 2017
Biofuels		
Biomass & waste	**0.2**	**-72%**
Geothermal		
Marine		
Small hydro		**-100%**
Solar	**37.9**	**-56%**
(of which PV)	37.6	-56%
(and solar thermal)	0.2	-84%
Wind	**50.5**	**-3%**
(of which offshore)	11.9	-9%
(and onshore)	38.6	-1%
Total	**88.5**	**-38%**

Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

double the equivalent for 2010 – despite the much reduced costs per MW of both solar and wind during the ensuing years. Other developing economies accounted for 17% of investment globally in 2018, up from 13% in 2017. There was a 10% increase in capacity investment in developed economies to $125.8 billion, as detailed in Chapter 5 of this report.

CHINA

China has been by far the largest country for investment in renewable energy excluding large hydro in every year since 2012, and it maintained its lead last year, its financing of new capacity, at $88.5 billion, being more than twice the equivalent for the U.S., which deployed $42.8 billion.

However, the Chinese total in 2018 was 38% down on the 2017 record, and that country's lowest since 2014. Figure 35 shows that most of this decline last year was due to the solar sector, which saw investment more than halve to $37.9 billion.

Two factors lay behind the $49 billion plunge in solar capacity commitments in China between 2017 and 2018 – a change that was the largest single influence on the global comparison between those two years. One factor was that solar got cheaper, as it did everywhere else. BNEF data indicate that the capital cost in China per MW of a PV installation without tracking declined by 25% between the first half of 2017 and the first half of 2019.[18]

[18] BloombergNEF: *1H 2019 LCOE Update.* https://www.bnef.com/core/insights/20423

The bigger effect, however, came from a sudden switch in the policy environment in China, from one in which developers felt confident that any new PV capacity they built would qualify for the country's feed-in tariff, to one in which access to that tariff was much more tightly controlled by government. The reason for this policy shift was alarm in Beijing at the way the public sector's liabilities were mounting as a result of the obligation to pay these guaranteed tariffs to project owners.

Solar investment, which had been running at a hectic average of more than $20 billion per quarter in 2017, slipped to an average of $11.2 billion per quarter in the first half of 2018, and then to $8.8 billion in the third quarter and just $6.6 billion in the fourth.

The amount of new PV capacity added in China fell less steeply, from the 53GW record in 2017 to an estimated 44.3GW in 2018. The fact that this was a smaller decrease than for investment was partly due to the lower average capital costs per MW and partly due to some developers rushing to build in the two months after the policy change. They were nursing a false hope that the government would allow for a grace period and allocate more subsidy.

Among the big Chinese solar plants reaching final investment decision in 2018 were a group of PV 500MW projects by Huanghe Hydropower Hainan Gonghe, at an estimated $465 million each; and the Zhangjiakou Zhangbei Poverty Alleviation plant, also at 500MW and an estimated $465 million. There was one significant deal in solar thermal, with the go-ahead of the 50MW Jiuquan Dunhuang project, at $246 million.

Wind investment in China was much more resilient, at $50.5 billion, down just 3%. Onshore

wind took $38.6 billion, down 1%, while offshore wind accounted for $11.9 billion, down 9% from 2017's record. The main reason for the modest decline in dollars committed was simply the timing of deals – in fact there was more onshore wind commissioned in 2018 than in 2017, and 2019 is likely to be higher again. Predictably, the largest deals last year were in offshore, reflecting that technology's higher cost per MW, with the largest of the year being the 500MW CGN & Guangdong Baolihua Shanwei Lufeng Houhu array, at about $1.5 billion.

Onshore, one of the top transactions was the Huaneng Puyang wind farm, at $636 million for 500MW. Beijing announced during 2018 a shift from feed-in tariffs to auctions, prompting some developers to accelerate construction to ensure their projects qualified for the former, and others to scale back the size of projects in order to make that task easier. Overall, BNEF estimates that China installed 19.3GW of onshore wind in 2018, up from 16.8GW in 2017. There is normally a lag of at least six months between the financing of an onshore wind project, and its commissioning.

Other sectors in China were subdued in 2018. Figure 35 shows small hydro capacity investment at zero last year, having averaged $2.2 billion a year in the rest of the decade. Activity in small hydro in China has been decreasing as the larger sub-50MW sites have become scarcer, but it is likely that the 2018 total will be revised up as more information on projects comes through. In biomass and waste-to-energy, Figure 35 shows capacity investment of just $224 million, also well down on recent years. This may also be revised up in due course, particularly due to the amount of activity going on in waste incineration. China has a problem with waste pollution and inadequate landfill capacity, and it has an official target to raise its cumulative installations of waste-to-energy plants from 4.7GW in 2015 to 7.5GW by 2020.[19]

INDIA

Figure 36 shows the breakdown of renewable energy investment in India in 2018. In total, the country committed $11 billion, down 15% on 2017, but slightly above its five-year average of $10.3 billion. Solar investment was $6.9 billion, some 19% lower, mainly due to falling capital costs, while wind investment was $4.1 billion, down 8%. Other renewable energy sectors recorded zero figures, as they did in 2017. However, some of these may be revised up if new information becomes available.

India remains committed to an ambitious target to reach 175GW of renewable energy capacity (excluding large hydro) by 2022, with solar making up some 100GW of that. The latter number compares to cumulative PV capacity installed in the country by the end of 2018, of 32GW.

Commissioning of new photovoltaic capacity in India was some 11GW last year, up from 10.3GW in 2017, but lower capital costs per MW helped to prevent the dollar value from increasing. There were also reasons for caution on the part of investors. The Indian government's decision in July 2018 to impose a 25% safeguard duty on PV modules and cells imported from China and Malaysia created a period of uncertainty for developers constructing solar projects at tariffs

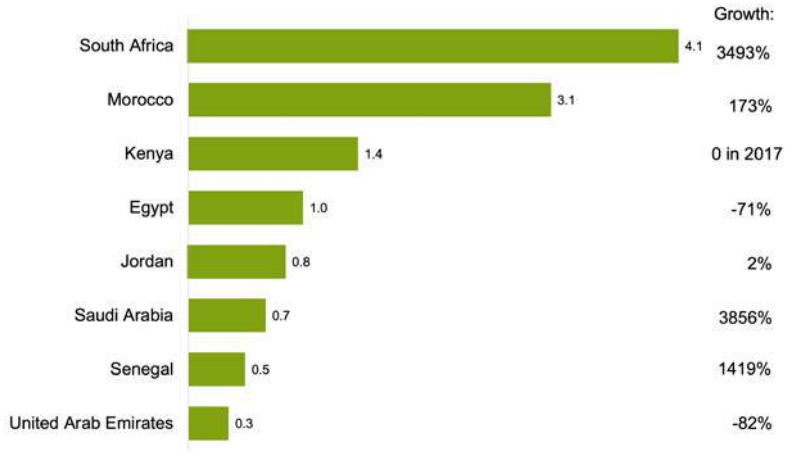
FIGURE 36. RENEWABLE ENERGY CAPACITY INVESTMENT IN INDIA BY SECTOR AND SUB-SECTOR, 2018, AND CHANGE ON 2017, $BN

	2018	% growth on 2017
Biofuels		
Biomass & waste		
Geothermal		
Marine		
Small hydro		
Solar	**6.9**	**-19%**
(of which PV)	6.9	-20%
(and solar thermal)	0.0	0 in 2017
Wind	**4.1**	**-8%**
(of which offshore)		
(and onshore)	4.1	-8%
Total	**11.0**	**-15%**

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

[19] BloombergNEF: *Ugly Duckling of Clean Energy Has Chance to Make Splash.* https://www.bnef.com/core/insights/18887

FIGURE 37. RENEWABLE ENERGY CAPACITY INVESTMENT IN MIDDLE EAST AND AFRICA BY COUNTRY, 2018, AND CHANGE ON 2017, $BN



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

awarded prior to the announcement of the new duty. There was also a 16% depreciation of the rupee against the dollar in the first 10 months of 2018, putting up the costs of imported equipment.

Highlighting the ultra-competitive nature of the Indian solar market were some of the capital costs attributed to the largest projects financed in 2018. The NLC Tangedco PV plant, for instance, accounted for only $498 million for its 709MW, while the Adani Karnataka portfolio came in at an estimated $242 million for 350MW.

In onshore wind, a transition from feed-in tariffs to auctions as the main method for securing electricity prices caused the amount of new capacity added to slip 44% to 2.3GW. Auctions in 2017 and 2018 delivered highly competitive tariffs for wind projects in Gujarat and Tamil Nadu, and the commissioning of these from 2019 onward is expected to expand the market to 5-6GW annually.

India is starting to emerge as an offshore wind market, with the government eyeing up to 1GW of projects along the coast of Gujarat. The country has targets for offshore wind of 5GW by 2022 and 30GW by 2030, but investors are waiting for more clarity over the power offtake mechanism, the amount of subsidy, and what the conditions will be for site permissioning.

MIDDLE EAST AND AFRICA

Some of the most promising markets for renewables, and solar in particular, are in the Middle East and Africa, given plentiful insolation and fast growth in electricity demand in most countries. Sure enough, that region produced a 61% rise in green energy capacity investment in 2018, to a record $16.1 billion. Solar took the lion's share of the total, at $10.1 billion, up 19%, but there was also a fivefold jump in wind investment.

Most of the investment in new capacity ($12.6 billion) came in the form of utility-scale projects, but there was also an estimated $3.4 billion of financing of small-scale solar systems, the highest in any year to date.

Figure 37 shows the detail by country. The biggest contributor to the surge in investment in region was, ironically, an established market that suffered a slump in investment in 2016-2017: South Africa. The country attracted $4.1 billion of capacity investment in 2018, up 35-fold, and back roughly to its average in the 2012-2015 period. Wind took $2.7 billion of last year's total, and solar $1.3 billion.

Behind the rebound was the belated signing of power purchase agreements, or PPAs, by the electricity utility, Eskom. These had been held up during the latter stages of the Zuma presidency in South Africa, even though the projects concerned had won capacity in renewable energy auctions, but there was a change of mind under the new political leadership. The biggest wind financing in the country in 2018 was the Enel Green Power wind portfolio, at $1.3 billion for 704MW, and in solar, $396 million for the 258MW Scatec PV portfolio.

Morocco has been a strong feature in renewables in Middle East and Africa for several years, with the size of the investment total in each year depending on the timing of particular deals. In 2018, it secured $2.6 billion of solar financings, more than double the previous year, a tally dominated by the 800MW NOORm Midelt PV

portfolio at $2.4 billion. Wind investment was $439 million, up from zero the previous year.

Kenya saw investment of $1.4 billion in 2018, the highest on record, and split almost equally between geothermal at $486 million, wind at $476 million and solar at $467 million. The largest deals were $366 million for the 83MW Kengen Olkaria 1 geothermal plant, unit 6, and $333 million for the 100MW Actis Kipeto wind farm.

One market that has come from nowhere in recent years is Egypt. Its total of $967 million marked a big decline from $3.4 billion in 2017, but this reflected the timing of financings that come out of auction rounds, rather than any underlying problem. The country has a target to reach 20% of electricity production from renewables by 2022, and 41% by 2035.

The two largest asset financings in Egypt last year were the third phase of the NREA Gabal El Zayt wind farm, at an estimated $202 million for 120MW, and the Acciona and Swicorp Benban PV portfolio, at $180 million for 186MW.

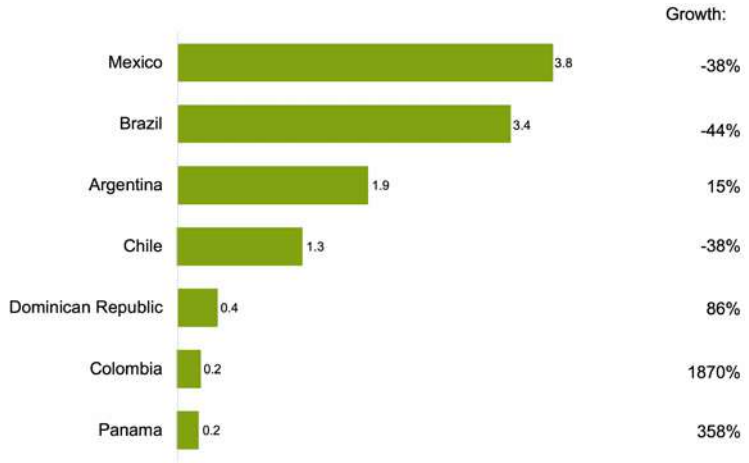
Among the countries not breaking the $1 billion investment barrier in 2018, Saudi Arabia was the most spectacular riser, achieving its highest total to date, at $651 million, thanks entirely to solar projects. United Arab Emirates, which saw $1.9 billion of solar financings in 2017 and then hosted in early 2019 the largest solar deal ever worldwide (at $4.2 billion), had an investment lull in the year in between.

LATIN AMERICA

This region had a quieter 2018, with three of the major four markets seeing investment slide. New investment in renewable energy capacity in Latin America was $12.1 billion, down by more than 30% in 2018 compared to the previous year, a decline primarily driven by Brazil and Mexico. In a historic first, solar led the way with $7.3 billion of investment, up 12%, mostly directed to Mexico and Chile. Wind, which had been the biggest sector for financings since taking over from biofuels in 2011, came second last year with $4.3 billion of investment, down 57%. The only other sectors to see financings in 2018 were biomass and waste, and small hydro, both at around $200 million.

Looking at individual countries, Figure 38 shows that Mexico was once again the leader in the region, although its total was down 38% at $3.8 billion. The jump in the value of investment in 2017 reflected projects that had won capacity in earlier auctions reaching financial close, and this influence was less powerful in 2018. Nevertheless, there were several big deals, including the 493MW Acciona and Tuto Puerto Libertad PV plant, at an estimated $404 million, and the 306MW EnerAB Mesa La Paz wind farm, at $405 million.

FIGURE 38. RENEWABLE ENERGY CAPACITY INVESTMENT IN LATIN AMERICA BY COUNTRY, 2018, AND CHANGE ON 2017, $BN



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

Brazil suffered a 44% drop in capacity investment to $3.4 billion, the lowest for that country since way back in 2005. Solar attracted $1.8 billion, down 24%, while wind slipped 61% to $1.3 billion. The Enel Sao Goncalo PV portfolio was the largest financing in that country in 2018, at $390 million for 388MW.

The fall in Brazilian investment was mostly a reflection of the fact that no auctions for new capacity were held between November 2015 and December 2017. Investment levels may pick up in the near term as a result of four auctions held over 2017 and 2018 that contracted 2.8GW of wind and 1.8GW of solar, to be commissioned between 2021 and 2024.

Argentina registered an increase in capacity investment of 15% in 2018 to a record $1.9 billion, thanks largely to the financing of projects awarded in the RenovAr auction held in 2016-2017, as well as the launch of a renewable energy corporate PPA market. The vast majority of money ($1.3 billion) went into wind projects, with solar accounting for $518 million. One of the largest deals of the year was an estimated $180 million for the 122MW Petroquimica Comodoro Rivadavia del Bicentenario wind portfolio.

Chile saw a decrease of 38% in new investments to $1.3 billion, below the country's five-year average of $1.9 billion. However, within this, solar attracted $1.2 billion, up 106%, while wind slumped 96% to less than $100 million. Both technologies were affected by worries about curtailment and delays to transmission expansion projects, but the solar number was bolstered greatly by the estimated $1 billion financing of the 110MW EIG Atacama 1 parabolic trough thermal plant.

EMERGING ASIA EXCLUDING CHINA AND INDIA

Figure 39 shows the leading eight developing countries in Asia in 2018 in terms of investment in renewables excluding large hydro (apart from the two giants of China and India discussed above). Vietnam soared to lead the list by a long distance, its record annual tally of $5.2 billion being nine times that of the previous year.

Most of the activity ($4.6 billion), up 25-fold, came in solar, with wind contributing a more modest $599 million, up 63%. There were some 10 PV projects of 100MW or more financed in 2018, led by the first phase of the 420MW Tieng Reservoir Tay Ninh plant, for an estimated $402 million, and the 351MW Hong Phong Binh Thuan Bac Binh undertaking, for about $326 million.

The rush of investment in solar reflected pressure on developers to get their projects commissioned and connected to the grid by June 30, 2019 to be eligible for the feed-in tariff rate of 9.35 U.S. cents per kWh for 20 years.

Vietnam also had a 142MW offshore wind farm financed in 2018, for some $392 million. The third phase of the Cong Ly Bac Lieu project will, like earlier phases, be built in shallow waters just off the coast and accessible by bridge from shore.

Taiwan enjoyed a 163% leap in renewable energy investment last year, to $1.8 billion, thanks in greatest part to small-scale solar funding, which came to some $900 million in 2018, the highest to date. The year also saw the island's first big offshore wind financing, of an estimated $627 million for the 120MW Formosa 1 Miaoli array. The latter project was interesting in an Asian context, in that it involved Danish developer Orsted, Australian investor Macquarie and a club of European, Australian, Japanese and Taiwanese banks.

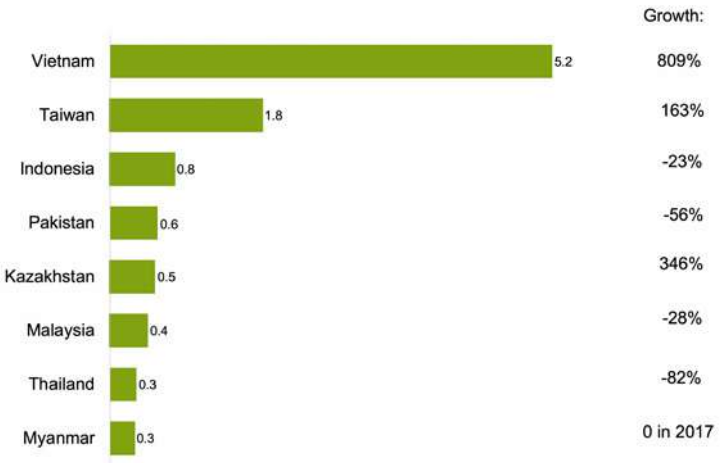
Indonesian investment slipped 23% to $771 million in 2018, close to that country's five-year average. As in many other years, the main activity was in geothermal, with the estimated $701 million financing of the 91MW Supreme Rantau Dedap by Engie, Marubeni and a consortium of banks.

The country's state-owned utility, PLN, issued a new procurement plan in 2018, shaving the overall additions to reflect weaker-than-expected electricity demand growth, but sticking with coal-fired generation as the main technology choice.

Pakistan was the other Asian developing economy to see renewables capacity investment of more than half a billion dollars in 2018, although in its case the total was only a little above this level, at $563 million, down 56% and the lowest since 2012. Small-scale solar systems made up the majority of Pakistan's investment last year.

The decline in the country's overall total should be treated with caution, since previous years' figures for Pakistan have often been revised up as information has emerged with a delay. In addition, there has been a stream of projects in both solar and wind seeking tariff approval from the regulator, and these are likely to reach financing in 2019-2020. Tariffs have mostly been set on a cost-plus basis by the regulator, but the authorities have been working on a possible competitive bidding system to encourage investment.

FIGURE 39. RENEWABLE ENERGY CAPACITY INVESTMENT IN NON-OECD ASIA (EXCLUDING CHINA AND INDIA), 2018, AND CHANGE ON 2017, $BN



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

CAPACITY INVESTMENT – DEVELOPED COUNTRIES

- Renewable energy capacity investment increased by 10% in developed economies in 2018, reaching $125.8 billion, but still below the five-year average of $130 billion and the all-time peak of $186.7 billion reached in 2011.
- The U.S. was, as usual, by far the largest investor among developed countries. Its allocations to new green power capacity in 2018 amounted to $42.8 billion, down 6% on the previous year but still the third-highest figure on record. Developers continued to bring projects forward to qualify for federal tax reliefs before these expire after 2020.
- Europe saw investment in renewables capacity rising 45% to $59.9 billion in 2018, close to its average for the last five years. Commitments to wind increased 26% to $36.7 billion, but the star performance was from solar in Europe, with an 87% jump to $19.2 billion.
- Among individual European countries, the U.K. was the largest investor last year, with $8.8 billion going to new renewables capacity, up 36% on 2017 thanks to final investment decisions on several large offshore wind parks and biomass and waste-to-energy plants.
- The most spectacular year-on-year change in Europe, however, came from Spain. Investment there jumped 859% to $7.5 billion, as a new generation of low-cost solar and wind projects got the go-ahead on the back of auctions or private sector power purchase agreements.
- Among other developed countries, Australia lifted investment in new capacity by 36% to a record $9.2 billion, while Japan experienced a 17% fall to $17.6 billion. The latter figure was Japan's lowest since 2012 and reflected both lower capital costs per MW in solar and an underlying cooling in capacity additions.

Developed economies saw $125.8 billion committed to new renewable energy capacity in 2018, up by a tenth on the 2017 total.[20] This was still far below the record reached in 2011, when the European tally was boosted by solar booms in Germany and Italy at relatively high capital cost per MW and by the latter stages of a 'green stimulus' program under the Obama administration in the U.S.

However, there were plenty of bright spots in the developed economy capacity investment picture in 2018, ranging from onshore wind financings in the U.S. to surging activity in a number of European countries that had been relatively dormant in previous years.

UNITED STATES

U.S. investment in renewable energy capacity continues to be influenced heavily by the schedule for the expiry of the Production Tax Credit for wind, and the Investment Tax Credit for solar. These two federal incentives are becoming less generous year-by-year and are due to expire completely after 2020. A decision by Congress to extend them beyond that point remains possible, but most developers and investors are not betting on that outcome. Instead, the imperative is getting as many projects as possible to the start-of-construction stage so that they can qualify for the PTC or ITC while they still exist.

[20] The split in the global total between developed and developing countries can be seen in Figures 12 and 34 of this report.

This line of thinking has ensured a healthy flow of utility-scale project financings, particularly in wind, over the last two years. Figure 40 shows that overall U.S. investment in renewable energy capacity slipped 6% to $42.8 billion. However, this was still the third-highest total on record and some way above the average for the last five years, of just under $40 billion.

FIGURE 40. RENEWABLE ENERGY CAPACITY INVESTMENT IN THE U.S. BY SECTOR AND SUB-SECTOR, 2018, AND CHANGE ON 2017, $BN

	2018	% growth on 2017
Biofuels	**0.4**	**-71%**
Biomass & waste	**0.1**	**-36%**
Geothermal	**0.2**	**-33%**
Marine		
Small hydro		**-100%**
Solar	**20.3**	**-11%**
(of which PV)	20.3	-11%
(and solar thermal)		
Wind	**22.0**	**4%**
(of which offshore)		
(and onshore)	22.0	4%
Total	**42.8**	**-6%**

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

Wind investment rose 4% to $22 billion, a record. There were no new financings in offshore wind in 2018, although activity continued in several states along the eastern seaboard, and some large final investment decisions appear likely to happen in the next two years. Instead, there was a fresh wave of onshore projects reaching the go-ahead, led by the 600MW Xcel Rush Creek wind farm, at $1 billion, and the 478MW Hale County installation, at $769 million.

However, this was just the tip of the iceberg. There were some 47 wind financings in the U.S. in 2018 with estimated capital costs of $200 million or more. Many of these involved European utilities such as EDP Renovaveis, Innogy or E.ON, or alternatively large American independent power producers such as NextEra Energy or MidAmerican Energy, part of Warren Buffett's Berkshire Hathaway conglomerate.

The trend in U.S. solar was somewhat weaker in dollar terms, even if capacity added grew

modestly to some 11.7GW. Overall investment fell 11% to $20.3 billion, the lowest since 2013. Commitments to utility-scale solar dipped 9% to $11.4 billion, but there was a 15% drop to $8.9 billion in the financing of small-scale systems of less than 1MW. Both of these figures were influenced by the continuing falls in global PV capital costs per MW, and by uncertainty produced by the Trump administration's tariffs on imported solar equipment from China.

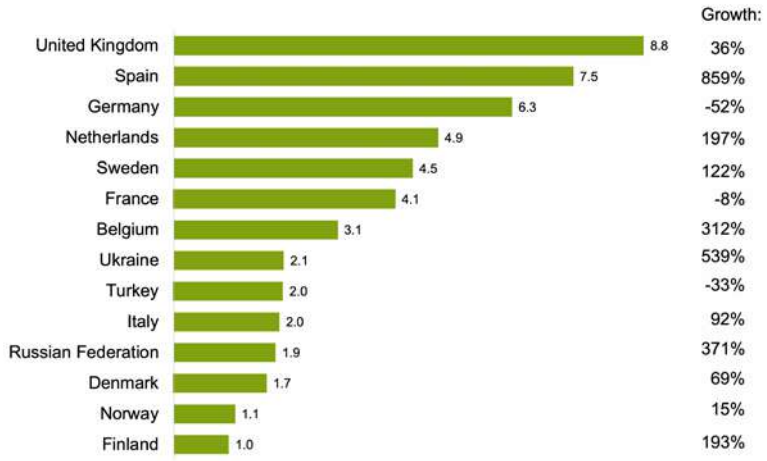
Among the significant projects reaching final investment decision in 2018 were the first, 324MW phase of the giant Misae PV project, at an estimated $301 million, and the 315MW Innergex Phoebe Winkler PV park, at $397 million. Both Misae and Phoebe Winkler are in Texas. A second, 680MW phase of the Misae complex is also under development and is likely to reach "notice to proceed" during 2019, according to the developer, LAE American Energy.

FIGURE 41. RENEWABLE ENERGY CAPACITY INVESTMENT IN EUROPE BY SECTOR AND SUB-SECTOR, 2018, AND CHANGE ON 2017, $BN

	2018	% growth on 2017
Biofuels	**0.1**	**0 in 2017**
Biomass & waste	**3.2**	**175%**
Geothermal	**0.6**	**-13%**
Marine		
Small hydro	**0.1**	**-4%**
Solar	**19.2**	**87%**
(of which PV)	19.2	87%
(and solar thermal)		
Wind	**36.7**	**26%**
(of which offshore)	12.6	29%
(and onshore)	24.1	25%
Total	**59.9**	**45%**

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

FIGURE 42. RENEWABLE ENERGY CAPACITY INVESTMENT IN EUROPE BY COUNTRY, 2018, $BN, AND GROWTH ON 2017



Countries investing more than $1 billion in 2018.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

As Figure 40 shows, activity in other renewable energy sectors was subdued in 2018, with biomass and waste-to-energy, and geothermal both showing less than $200 million worth of investment and declines from 2017 levels. Biofuels also slipped back, but to a slightly higher figure of $355 million, thanks to the financing of two bioethanol production plants.

EUROPE

Figure 41 shows the detail of capacity investment in Europe in 2018. Both the main renewable power sectors enjoyed sharply higher flows of capital, with wind up 26% at $36.7 billion and solar 87% higher at $19.2 billion. From a much smaller base, biomass and waste also saw a jump in investment, of 175% to $3.2 billion.

There were sector trends at work in these changes, but even more important were the shifts at a national level. Figure 42 shows that no fewer than 14 European countries attracted capacity investment of $1 billion or more in 2018.

The U.K. heads the list, with a 36% rise in financings to $8.8 billion, but still far below the peak of $23.1 billion reached in 2015. The 2018 total was dominated by two offshore wind farms that

won support in the 2017 Contract-for-Difference auction round – the 950MW Moray Firth array, at an estimated $3.2 billion, and 860MW Triton Knoll project, at $2.6 billion. Both these huge projects are being developed and built by European utilities, and secured non-recourse loans from clubs made up of a dozen or more European and Asian commercial banks.

There were also several deals in U.K. biomass and waste-to-energy, the largest being an estimated $903 million for the conversion of the fourth unit at the giant Drax power station from coal to biomass. Several smaller transactions in waste-to-energy went ahead, helped by relatively high 'gate fees' on offer for incinerators taking fixed amounts of garbage per year.

Spain marked its return to the major investing countries in Europe, after a long period of depressed activity following the retroactive cuts to tariff support earlier this decade. Investment there leapt 859% to $7.5 billion, the highest total since its runaway solar boom in 2008-2010.

Behind the rebound in Spanish green power construction has been the fall in capital costs, together with the Madrid government's determination to meet its 2020 renewable energy targets. Spain has plentiful resources of both sunshine and wind, enabling developers to bring forward projects with high capacity factors (high percentages of electricity output compared to maximum potential during the year) into the country's auction program for new capacity. The largest wind project financed in 2018 was the 446MW Enel Green Power Portfolio, at an estimated $749 million, while the list in solar was led by the 494MW Cobra Mula PV park, at $417 million. No fewer than nine of the largest 12 solar financings in Europe in 2018 were in Spain.

Germany saw capacity investment of $6.3 billion in 2018, down 52% on the previous year, and the lowest total for that country in the whole of the period since 2004. The year was the first for a decade not to see a significant offshore wind financing, and in onshore wind there was a halving of investment to $3.1 billion, the lowest since 2013, as permitting delays affected many of the projects

that won capacity in 2017-2018 auctions. However, solar investment in Germany picked up 66% to $2.9 billion, the highest since 2013.

Highlights from the other European countries shown in Figure 42 included the financial close for the Borssele III and IV offshore wind farm in Dutch waters, at 731.5MW and $1.7 billion, with a smaller project, Fryslan, of 380MW and $578 million, also helping the Netherlands to record a near-trebling of its investment volume to $4.9 billion.

The driver of Sweden's 122% increase in capacity investment to $4.5 billion was different. The country has become a magnet for large onshore wind projects, taking advantage of the country's good wind resources, its green certificate program for renewables, and the popularity there of corporate power purchase agreements.

An example was the 353MW Blakliden and Fabodberget project cluster, financed for an estimated $317 million by Vattenfall, Vestas Wind Systems and Danish pension fund PKA. As part of the package, Norsk Hydro agreed to buy 60% of the wind farms' expected annual output for 20 years, the latest such power purchase deal by the aluminum maker in Scandinavia.

Ukraine and Russia both saw significant projects financed in 2018, underlining how investment in non-hydro renewables has expanded to new corners of Europe over recent years.[21] In Ukraine, the largest deal was for the 246MW DTEK and CMEC Nikopol PV plant, at an estimated $282 million, while Russia played host to the financing of three onshore wind farms, each of about 200MW and with estimated capital costs of more than $300 million. Overall, Ukrainian capacity investment jumped 539% to a record $2.1 billion, and Russian investment 371% to $1.9 billion, also an all-time high.

The increased involvement of European Union based utilities Enel and Fortum was seen in the two biggest deals in the Russian market last year, and the country held its sixth renewable energy auction, awarding 1GW of capacity to wind, solar and small hydro. Ukraine has been offering relatively generous 'green tariffs' to qualifying wind and solar projects, but these will be replaced by an auction system in 2020 – giving developers an incentive to move ahead before that.

OTHER DEVELOPED ECONOMIES

Figure 43 shows the trend in five other developed countries in 2018. The only one to enjoy an increase in investment was Australia, with a 36% advance to $9.2 billion, easily the highest annual total it has seen for renewable energy capacity investment and twice the average figure for this decade.

Behind the surge in Australia has been developers rushing to meet the country's Large-scale Renewable Energy Target, and earn the associated certificates –

[21] Note that Ukraine and Russia are both counted as developing countries in the split shown in Figures 12 and 34 of this report.

which can then be sold to utilities. The LRET program, however, ends in 2020, and projects will soon have to depend on other mechanisms (auctions held by the states, or power purchase agreements with corporate or utility buyers) to secure their revenues.

Among the big projects financed in 2018 were the 530MW Goldwind Stockyard wind farm, for an estimated $536 million, the Tilt Renewables Dundonnell wind park, at 336MW and $405 million, and the Edify Energy Darlington Point PV plant, at $317 million for 333MW.

Japan continued in 2018 to be one of the biggest country investors in green power. Its total of $17.6 billion was 17% down on the previous year, and the lowest figure since 2012. Some of this decrease reflected the fact that solar capital costs have, belatedly, been falling in Japan after a few years in which the generosity of the government's feed-in tariff meant that developers and equipment providers were not under the same pressure to keep costs down as their equivalents in other countries. The risks of finding project operating hours curtailed by local utilities have also made some developers hesitate.

Nevertheless, 2018 still saw significant investment in Japanese solar, at $14.8 billion, down a fifth on 2017. Most of the utility-scale projects were relatively small by international standards – a function of Japan's shortage of large plots of land. But the larger ones include Canadian Solar's Oita Hijimachi PV plant, at 53MW and $150 million, and Sonnedix Japan's Sano project, at an estimated $160 million for 42MW.

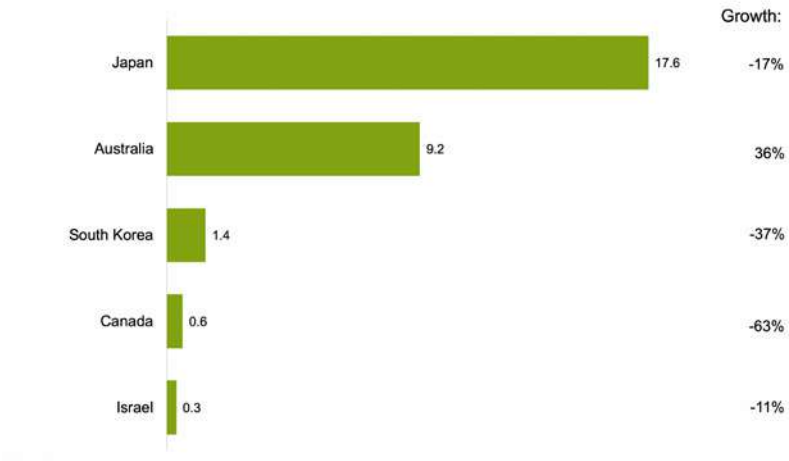
Japan is also one of the major centers for biomass investment, along with the U.K. and parts of Scandinavia. In 2018, biomass and waste-to-energy attracted $1.8 billion, up 13% on the year earlier and Japan's highest figure to date. Projects financed included the conversion of the 200MW unit 2 of the Aioi power station in Hyogo from oil to wood pellets, at an estimated cost of $558 million.

The other three developed economies shown in Figure 43 were all relatively small players in renewable energy capacity investment in 2018 by international standards. South Korea's total of $1.4 billion was 37% down on 2017, but only a little below its average for the last five years. It was split fairly evenly between solar ($618 million), biomass and waste ($442 million) and wind ($360 million), with the largest project financed being the Hyundai Seosan Daesan biomass plant, at $315 million for 100MW.

Canada's investment of $579 million in 2018, down 63% on the previous year, was its lowest during the whole period since 2004, and compared with a peak figure of $7.4 billion in 2011. The main project development activity is in wind, with the province of Alberta holding renewable energy auctions late in 2018 for a total of 763MW of capacity. Ontario saw much of the investment in wind and solar earlier in the decade, but policy changes have dulled project activity there more recently.

Israel's capacity investment of $349 million was also a multi-year low and only about half the average for the last five years. The solar market there was subdued in 2018 but is expected to pick up in 2019-2020 with a planned tender for 300-600MW of PV capacity toward a target of 10% renewable electricity by the end of next year.

FIGURE 43. RENEWABLE ENERGY CAPACITY INVESTMENT IN OTHER MAJOR DEVELOPED ECONOMIES, 2018, AND GROWTH ON 2017, $BN



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

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.

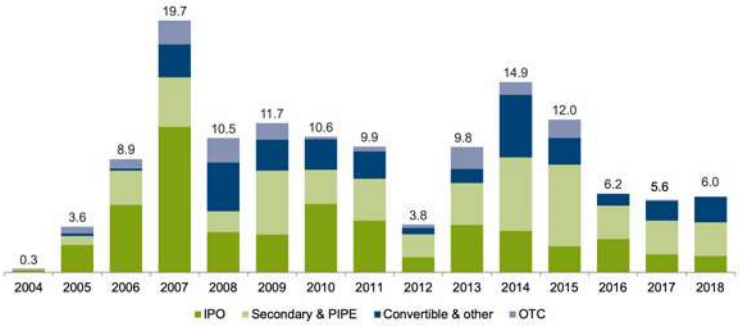
Among the sectors, solar secured the greatest investment, as usual, rising 8% to $3 billion, while wind slumped by a third to $1.5 billion, as shown

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.

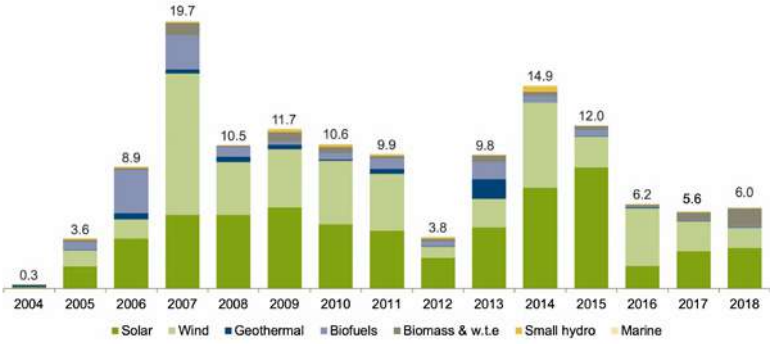
The value of IPOs slipped 10% to $1.3 billion in 2018, and there were not many of them: only four in the top 16 deals. In the largest, Neoen, the French solar, wind and biomass developer, raised $808 million on the Euronext Paris exchange. The company has 2.8GW of capacity already operating or financed 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



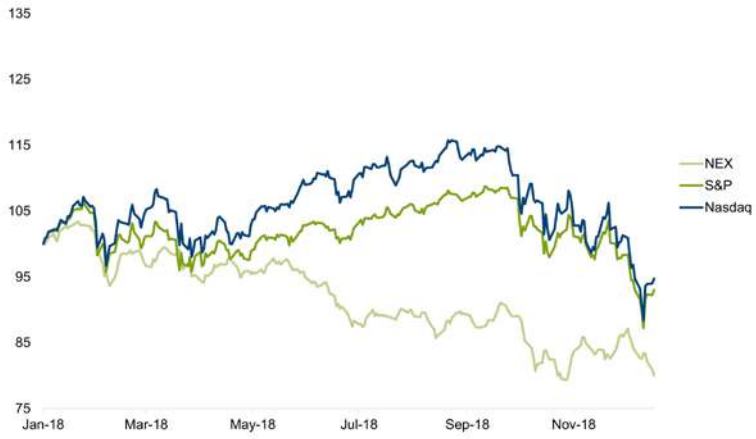
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

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
Innergex 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

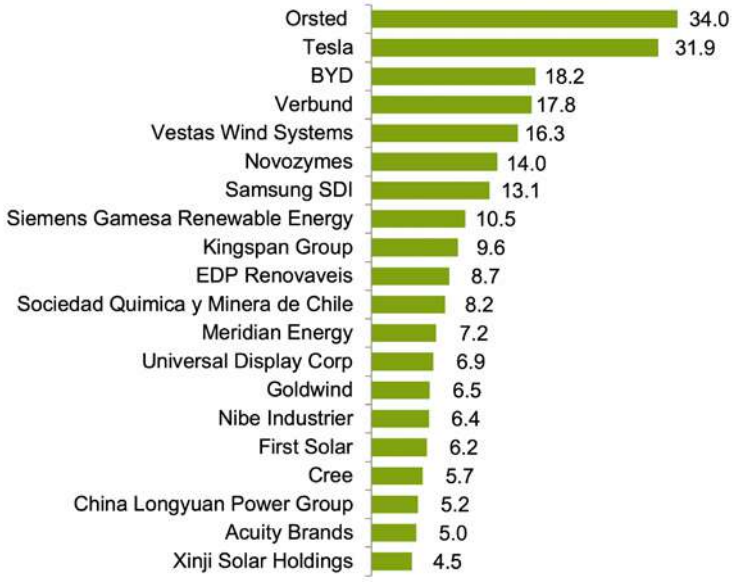
The table shows the largest deals with disclosed values.
* Merger of Siemens wind business with Gamesa produced SGRE.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

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

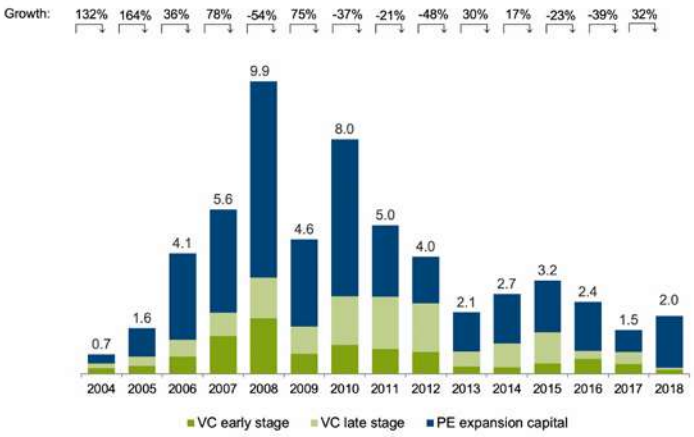
Investment in renewable energy companies through venture capital and private equity rebounded 32% in 2018 to $2 billion. However, this increase followed a decade of near-constant declines from the $9.9 billion peak reached in 2008.

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.

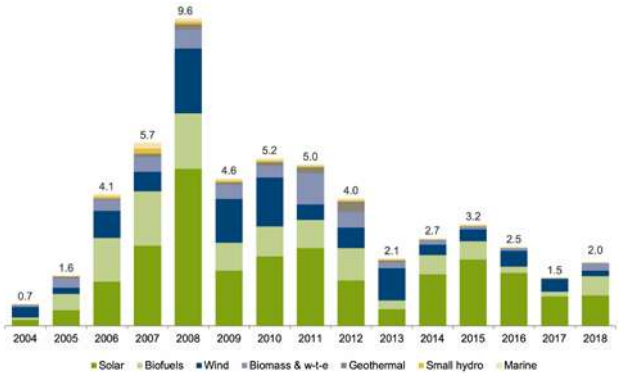
Half the VC/PE investment in 2018 went to solar, up 4%, and just a tenth went to wind, down 57%, as shown in Figure 50. The big gainers were biofuels, where investment more than quadrupled to $598 million, and biomass & waste, where inflows jumped eleven-fold to $241 million. The geographical breakdown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



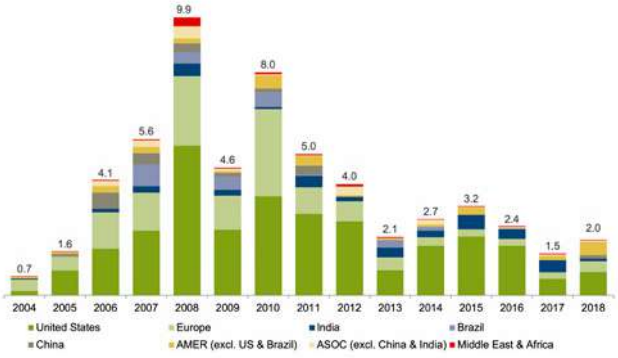
Buy-outs are not included as new investment. Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

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.

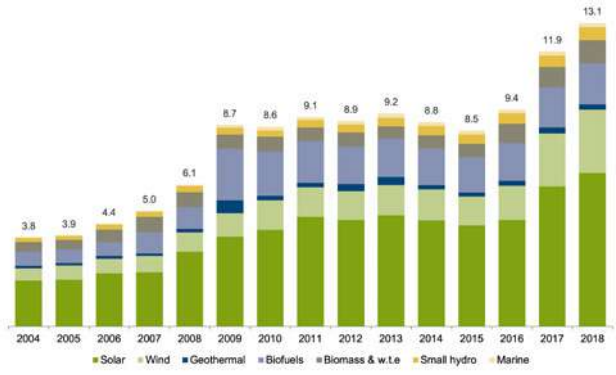
Innovation is also spreading to the auction process itself. In 2018, India pioneered 'hybrid' auctions for projects that combine solar and wind capacity. The advantage of this is that it smoothes intermittency and makes more efficient use of land and grid connections. The first hybrid auction awarded 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 report [25] – 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.

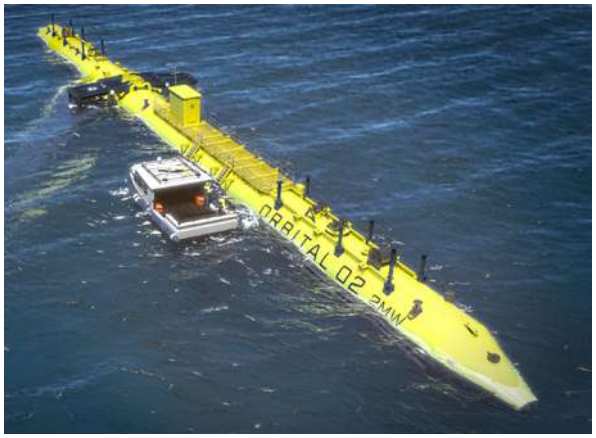
[23] BloombergNEF: *2018 PV Manufacturing Overview* https://www.bnef.com/core/insights/19265
[24] BloombergNEF: *PV Cost Reductions Continue, But Slow Down* https://www.bnef.com/core/insights/20609
[25] *Global Trends in Renewable Energy Investment 2017*, pages 78-79

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.

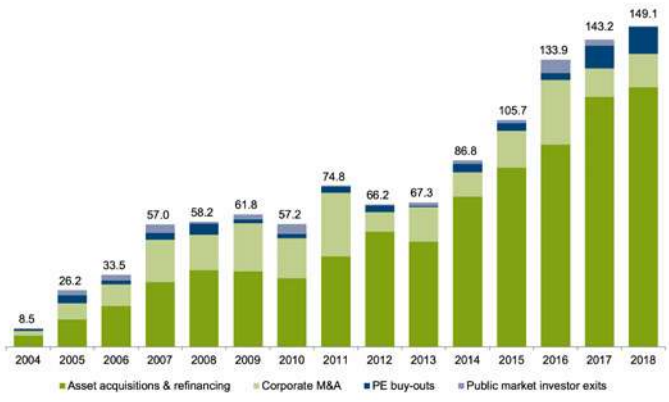
[26] BloombergNEF: *1Q 2019 Global Wind Market Outlook* https://www.bnef.com/core/insights/20441
[27] BloombergNEF: *Floating Wind Drifts Towards Viability* https://www.bnef.com/core/insights/20531

ACQUISITION ACTIVITY

- A record $149.1 billion of renewable energy acquisitions took place in 2018, an increase of almost $6 billion on 2017 and the sixth successive year of growth.
- This was driven by higher totals in asset acquisitions, corporate mergers and acquisitions and private equity buy-outs, but not public market exits, which crashed to their lowest level ever.
- Activity has become more concentrated in wind and solar. The value of deals in these two technologies more than doubled to $144 billion between 2013 and 2019, while it declined across the rest of the renewables sector.
- Some $15.7 billion changed hands in corporate M&A deals in 2018, which was 18% more than in the previous year but still $2.7 billion below the average of the last 10 years.
- 2018 was a record-breaking year for PE buy-outs, as they produced their highest deal tally to date ($12.5 billion) and the largest renewable energy PE deal ever (Global Infrastructure Partners' purchase of Equis Energy for $5 billion).
- An unrivalled $46.8 billion of asset transactions took place in the U.S., slightly down on 2017, while Europe followed with $43.3 billion, a new record for the region.

A record $149.1 billion of acquisitions took place in 2018. This was almost $6 billion higher than in the previous 12 months and the sixth successive year of growth. The increase was driven by larger totals in three out of four asset classes: acquisitions of generating assets grew $4.4 billion to $120.8 billion, while corporate M&A expanded by $2.4 billion to $15.7 billion and PE buy-outs were almost $2 billion higher than in 2017 at $12.5 billion. In contrast, public market exits plummeted to just $89 million from $2.9 billion the previous year (see Figure 54).

FIGURE 54. ACQUISITION TRANSACTIONS IN RENEWABLE ENERGY BY TYPE, 2004-2018, $BN



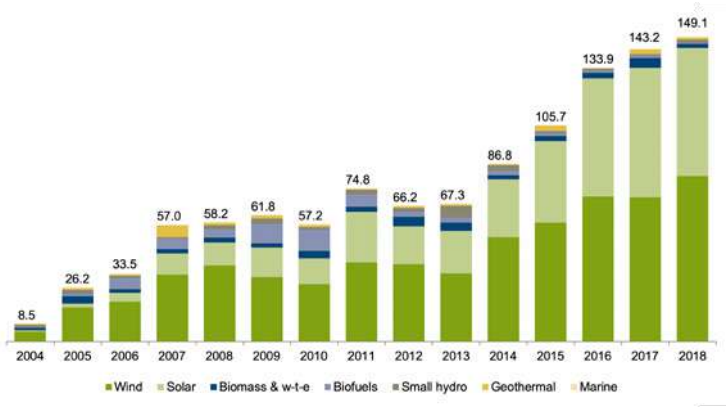
Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

As in previous years, activity was heavily focused on the acquisition of generating assets, whether in the form of wind and solar portfolio purchases (which accounted for four out of every five acquisition dollars) or as corporate M&A and PE buy-out deals. It is notable that renewable energy asset owners and developers were the targets in each of the top 10 largest M&A deals and in nine of the top 10 PE buy-out transactions, the single exception being the purchase of Chinese solar equipment maker JA Solar Holdings by a management group-led consortium in July 2018.

Increased acquisitions activity is being driven by greater demand for renewable power generating assets. This is a result of several factors, including the rising importance of environmental, social and governance investment criteria as well as regulations such as the revised Renewable Energy Directive (2018/2001). The latter entered into force in December 2018 and established a new binding renewable energy target for the EU of at least 32% by 2030. In addition, confidence in overall global economic growth, access to capital and project financing, coupled with low interest rates, have helped to create favorable conditions for M&A.

Activity has become increasingly concentrated in wind and solar in recent years. The value of deals in these two sectors more than doubled between 2013 and 2019 (going from $54.2 billion to $143.8 billion) while the average value of acquisition activity in all other renewable power sectors declined during the same period (see Figure 55). In 2018, a record $81 billion worth of wind deals were recorded and $62.7 billion of solar transactions. In comparison, the overall total of biofuels, biomass and waste, small hydro, marine and geothermal acquisitions amounted to $5.3 billion, equal to just 3.6% of the $149.1 billion total.

FIGURE 55. ACQUISITION TRANSACTIONS IN RENEWABLE ENERGY BY SECTOR, 2004-2018



Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

CORPORATE TRANSACTIONS

Some $15.7 billion changed hands in corporate M&A deals in 2018, which was 18% more than in the previous year, but still $2.7 billion below the average of the last 10 years. There was considerable uniformity among the 10 largest transactions: in each case the acquisition target was a very substantial owner of renewable power generating assets, and in only one case were the assets not either solar or wind. The largest deal involving a renewable power equipment manufacturer (and the only one in the top 15) was the $245 million purchase of solar cell and module manufacturer Solartech Energy by Neo Solar Power.

There was diversity in terms of geography, however. The top three deals – each of which broke through the $1 billion mark – saw buyers targeting entities in the three very different markets of Spain, India and Brazil. The U.S., U.K., Canada and China also featured in the top 10. (See Figure 56 for a list of the largest corporate M&A transactions in 2018).

The biggest corporate transaction was valued at $2.9 billion and involved the purchase of Spain's Saeta Yield by TerraForm Power (both firms are varieties of 'yieldco' – quoted companies set up to own operating-stage renewable power projects and to return almost all the cash flow to investors). U.S.-based TerraForm is owned by Brookfield Asset Management, Canada's largest alternative asset manager, while Saeta has 778MW of recently-constructed onshore wind and 250MW of solar thermal capacity in Western Europe.

In the year's second-largest deal, Indian generator ReNew Power acquired Ostro Energy with its more-than-1.1GW of assets, nearly 850MW of which are operational. The deal made Goldman Sachs-backed ReNew Power into India's largest green energy company, with combined assets of more than 5.6GW. In another major acquisition, the State Grid Corporation of China bought the shares it did not already own in one of Brazil's largest renewable energy players, CPFL Energias Renovaveis. The Chinese state-backed utility paid just over $1 billion for 48.4% of the company.

PRIVATE EQUITY BUY-OUTS

2018 was a record-breaking year for PE buy-outs in renewable energy. Not only was the $12.5 billion deal tally the highest ever recorded (almost three times the annual average of the preceding decade), it also saw closure of the single largest acquisition of renewable energy assets in history – the $5 billion purchase of Equis Energy led by New York fund manager Global Infrastructure Partners (GIP) together with Canada's Public Sector Pension Investment Board and China's CIC Capital.

Headquartered in Singapore, Equis Energy was the largest renewable energy independent power producer in the Asia-Pacific region, with over 180 wind and solar assets comprising more than 11GW in operation, construction and development, including in Australia, Japan, India, Indonesia, the Philippines and Thailand. The deal gives GIP a major platform to access the Asia-Pacific's solar and wind markets that are expected to grow over the long term.

FIGURE 56. LARGEST CORPORATE M&A DEALS IN RENEWABLE ENERGY IN 2018, $M

Acquirer	Target	Country of target	Sector	Business model	$m
TerraForm Power	Saeta Yield	Spain	Solar	Yieldco	2857
Renew Power Ventures	Ostro Energy Pvt	India	Wind	Project developer	1658
State Grid Brasil	CPFL Energias Renovaveis	Brazil	Wind	Project developer	1042
Algonquin Power	Atlantica Yield	Spain	Solar	Yieldco	608
Orsted	Lincoln Clean Energy	United States	Wind	Project developer	580
Innergex Renewable Energy	Alterra Power Corp	Canada	Geothermal	Project developer	567
Orsted	Deepwater Wind	United States	Wind	Project developer	510
Anhui Jiangnan Chemical	Zhejiang Dun'An New Energy Development	China	Wind	Project developer	324
Ontario Power Generation	Eagle Creek Renewable Energy	United States	Small hydro	Project developer	298
Greencoat UK Wind*	Clyde Windfarm Scotland	United Kingdom	Wind	Project owner	269
Boralex	Kallista Energy Investment	France	Wind	Project developer	259
United Renewable Energy	Solartech Energy Corp	Taiwan	Solar	Manufacturer	245
Repsol	Valdesolar Hive	Spain	Solar	Project developer	244
Enel	Parques Eolicos Gestinver	Spain	Wind	Project developer	218

The table shows the largest deals with disclosed values. Other deals might have got onto this list, if their values had been disclosed. Some deals, for instance Atlantica Yield, were for partial control only. *Greencoat was leader of a consortium.

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

GIP followed this up with its acquisition of U.S. generator NRG Energy's development operations and thereby a controlling interest in its publicly-traded wind and solar company NRG Yield (renamed Clearway Power), for $1.3 billion. The deal gave GIP a project portfolio that was the largest by installed capacity of any 'yieldco' in the U.S. and a platform that is enabling it to play an active role in North America. Remarkably, GIP was also linked to two of the year's largest asset deals, Clearway Power's purchase of SunPower's U.S. solar portfolio and its own acquisition of a 50% stake in the U.K.'s 1.2GW Hornsea 1 offshore wind project (see Asset Transactions section below for more details).

There were two further $1 billion-plus PE buyouts and like the NRG Yield and Equis deals, both concerned companies with large renewables portfolios. In one, Italian infrastructure investor F2i agreed to buy Italian solar energy company Rete Rinnovabile (RTR) for $1.5 billion from London-based private equity firm Terra Firma Capital Partners. RTR has 334MW of solar power generating capacity across 134 sites. In the other deal, Capital Dynamics bought quoted yieldco 8point3 Energy Partners, a joint venture set up by First Solar and SunPower, along with its 710MW of operating PV assets.

The only manufacturer to make the top 10 PE deals was the $977 million management buy-out of Nasdaq-listed Chinese company JA Solar Holdings, the third-biggest solar panel maker. The move reflects frustration that its share price has not matched company performance and follows a similar move by Trina Solar the previous year. JA Solar is currently pursuing a backdoor listing in mainland China.

PUBLIC MARKET EXITS

Public market investor exits collapsed in 2018 to less than $0.1 billion from $2.8 billion in 2017 and $6.4 billion the year before. Although traditionally the smallest class of acquisition activity, public market exit volumes have not sunk to such a low level since the renewable power sector was in its infancy more than 15 years ago (but it came close in 2011 with a total of $0.2 billion). The 2018 total was well below the $2.2 billion average of the last 10 years.

A PM investor exit occurs when an existing investor sells some, or all, of its stake through a public share sale, which may or may not also raise new money by selling additional equity. The slump in 2018 took place against a background of relatively robust investment in public equity across the wider clean energy sector, but one in which there was less activity by established renewable energy companies. In 2016 and 2017, public market exit volumes were boosted by the sale of stakes in Danish wind giant Orsted (formerly Dong Energy).

ASSET TRANSACTIONS

Trade in renewable energy generating assets continued to grow, rising to almost $121 billion in 2018 from $116.4 billion in 2017, which equated to more than 80% of all funds expended on acquisitions in the sector. This asset class has long been characterised by big deals and 2018 was no exception: the top 10 transactions had an aggregate value of $29.6 billion, giving an average deal size of almost $3 billion. Half of these were categorized as acquisitions while the remainder were refinancings. In terms of technology, wind held sway over solar, accounting for seven out of the top 10 (four of which related to offshore wind).

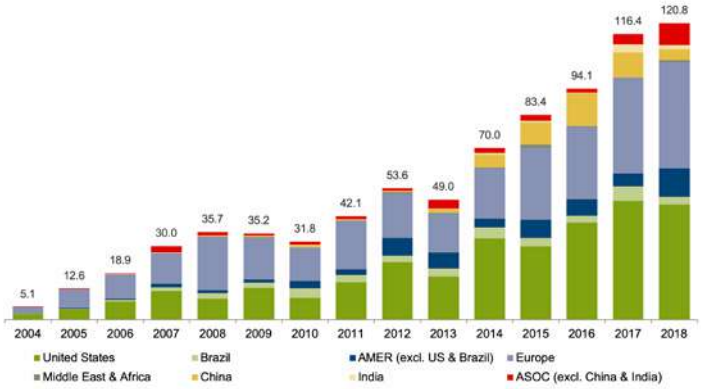
In terms of distribution, much remained unchanged from the previous year. The U.S. continued to lead in 2018 with a total of $46.8 billion, slightly down on 2017, while Europe maintained its traditional second-place spot with $43.3 billion, which was an increase of 10% and a record for the region (see Figure 57). Some very large deals helped to

bump up the latter's total, including the $5.8 billion acquisition of a 50% stake in the 1.2GW Hornsea 1 offshore wind project in U.K. waters by GIP.

In other markets around the world there was greater deviation from the recent past. In China, for instance, the value more than halved to $4.3 billion from $10.1 billion in 2017, reflecting national government efforts to curb overcapacity by abruptly halting approvals for some projects and reducing subsidies. In contrast, the value of acquisitions in the Americas (excluding Brazil and the U.S.) jumped 126% to $11.7 billion, and in the Asia Pacific region (outside of China and India) it also more than doubled to $9.1 billion.

Clearway Energy's purchase of SunPower Corporation's portfolio of solar development projects for $6.3 billion (mentioned in the PE Buy-out section above) involved 6.1GW and accounted for more than one-third of all U.S. solar capacity changing hands in 2018. SunPower, the second-largest U.S. solar maker, plans to focus instead on manufacturing and installing panels on residential and commercial rooftops.

FIGURE 57. ASSET ACQUISITIONS AND REFINANCINGS BY REGION, 2004-2018, $BN



Total values include estimates for undisclosed deals.
Source: UN Environment, Frankfurt School-UNEP Centre, BloombergNEF

Refinancing of U.K. and German offshore wind farms was a notable feature of activity in 2018. Five such deals – together worth $7.3 billion – were included in the top 10 largest asset transactions. In the case of the 402MW Dudgeon offshore wind farm off the U.K. coast, the refinanced debt consisted of approximately $1.6 billion in fully-amortizing senior-term loans, comprising $706 million in commercial debt and an $889 million private placement of senior secured notes maturing in June 2032. Both tranches were oversubscribed, reflecting strong credit features and investor interest.

GLOSSARY [28]

ASSET FINANCE	All money invested in renewable energy generation projects, whether from internal company balance sheets, from debt finance, or from equity finance. It excludes refinancings. The project may or may not be commissioned in the same year.
CAPACITY INVESTMENT	All investment in new renewable energy capacity, whether asset finance of utility-scale projects, or financing of small-scale solar.
CAPITAL EXPENDITURE	Funds used by a company to acquire or upgrade physical assets such as property, industrial buildings or equipment. Some investment will translate into capacity in the following year.
CORPORATE POWER PURCHASE AGREEMENT	A transaction by which a company agrees to buy its electricity from a renewable energy project. Usually involves a set price, or a set amount of electricity per year, for a set period (eg 10 years).
FEED-IN TARIFF	A premium rate paid for electricity fed back into the electricity grid from a designated renewable electricity generation source.
FINAL INVESTMENT DECISION	Moment at which the project developer, or group of investors and lenders, decide that the investment will definitely go ahead. The asset finance figures in this report are based on money committed at the moment of final investment decision.
INITIAL PUBLIC OFFERING (IPO)	A company's first offering of stock or shares for purchase via an exchange. Also referred to as "flotation".
LEVELIZED COST OF ELECTRICITY (LCOE)	The all-in cost of generating each MWh of electricity from a power plant, including not just fuel used but also the cost of project development, construction, financing, operation and maintenance.
MARKET CAPITALIZATION	Value placed on a quoted company by the stock market. It is equal to the number of shares in circulation, multiplied by the prevailing share price.
MERGERS & ACQUISITIONS (M&A)	The value of existing equity and debt purchased by new corporate buyers in companies developing renewable technology or operating renewable energy projects.
NON-RECOURSE PROJECT FINANCE	Debt and equity provided directly to projects rather than to the companies developing them.
ON-BALANCE-SHEET FINANCING	Where a renewable energy project is financed entirely by a utility or developer, using money from their internal resources.
PUBLIC MARKETS	All money invested in the equity of publicly quoted companies developing renewable energy technology and generation.
SMALL DISTRIBUTED CAPACITY (SDC)	Investment in solar systems of less than 1MW, including rooftop and small-scale ground-mounted arrays.
VENTURE CAPITAL AND PRIVATE EQUITY (VC/PE)	All money invested by venture capital and private equity funds in the equity of companies developing renewable energy technology.

[28] Further definitions and explanations can be found in Private Financing of Renewable Energy – a Guide for Policymakers. S. Justice/K. Hamilton. Chatham House, UNEP Sustainable Energy Finance Initiative, and Bloomberg New Energy Finance, December 2009.

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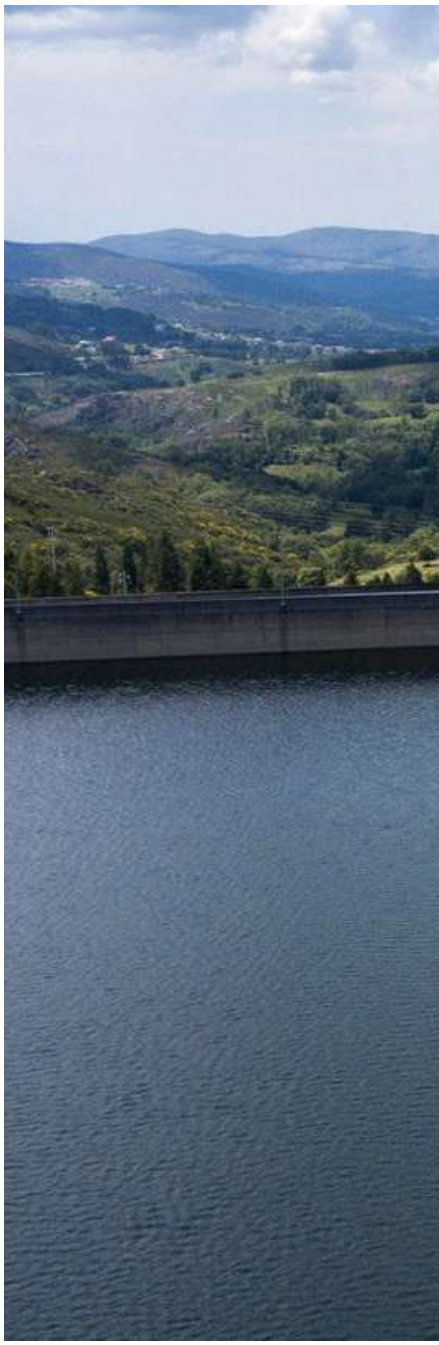

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