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FS-UNEP Collaborating Centre
for Climate & Sustainable Energy Finance

GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2018

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FOREWORD FROM ERIK SOLHEIM, PATRICIA ESPINOSA AND NILS STIEGLITZ

ERIK SOLHEIM

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NILS STIEGLITZ

We are in the middle of a global renewable energy revolution. Investments in renewables have continued to increase each year, led largely by developing countries and since 2004, the world has invested $2.9 trillion in green energy sources. The annual Global Trends in Renewable Energy Investment report illustrates these changes in the global energy map and the road ahead in securing the future of our planet.

The central message of the report is clear. The renewable energy market continues to make remarkable progress. Last year was the eighth in a row that global investment in renewables exceeded $ 200 billion. Much of this can be attributed to falling costs for solar electricity, and to some extent wind power, which continues to drive deployment. More electricity generated by renewable sources in 2017 signals strong commitment to addressing climate change and reducing carbon emissions.

The world installed a record number of new solar power projects in 2017, more than net additions of coal, gas and nuclear plants put together. China has been the leading destination for renewable energy investment, accounting for 45% of the global total last year. The country initiated 13 off-shore wind projects which, in addition to reducing emissions, will generate jobs in all stages of construction and operation. This demonstrates the potential for renewable energy to fight climate change and boost economic growth. Fossil fuel-rich countries are also showing strong progress, with the United Arab Emirates for example recording an astounding 29-fold increase in renewable energy investment in 2017.

While there is much to be positive about, it is also evident that we need to continue to push the acceleration of the global renewable energy revolution. Last year was the second hottest on record and carbon dioxide levels continue to rise. In electricity generation, new renewables still have a long way to go. While generating costs have decreased, the phase-out of subsidies and other government support needs to be complemented by strong private players that can make sure this global momentum continues by providing the necessary finance.

We hope this report will encourage investors, businesses and governments to accelerate action in favour of our planet and power us towards a sustainable future for all.

ERIK SOLHEIM

Head of UN Environment

PATRICIA ESPINOSA

Executive Secretary

United Nations Framework Convention on Climate Change (UNFCCC)

NILS STIEGLITZ

President

Frankfurt School of Finance & Management

“The extraordinary surge in solar investment, around the world, shows how much can be achieved when we commit to growth without harming the environment,”

said Head of UN Environment Erik Solheim.

“By investing in renewables, countries can power new communities, improving the lives and livelihoods of the people who live in them, and at the same time cleaning up the air they breathe.”

“The world added more solar capacity than coal, gas, and nuclear plants combined,”

said Nils Stieglitz, President of Frankfurt School of Finance & Management.

"This shows where we are heading, although the fact that renewables altogether are still far from providing the majority of electricity means that we still have a long way to go."

“In countries that saw lower investment, it generally reflected a mixture of changes in policy support, the timing of large project financings, such as in offshore wind, and lower capital costs per megawatt,”

said Angus McCrone, chief editor of Bloomberg New Energy Finance.

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METHODOLOGY AND DEFINITIONS

All figures in this report, unless otherwise credited, are based on the output of the database of Bloomberg New Energy Finance – an online portal to the world's most comprehensive database of investors, projects and transactions in clean energy.

The Bloomberg New Energy Finance 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 following renewable energy projects are included: all 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; and all solar projects, with those less than 1MW estimated separately and referred to as small-scale projects, or small distributed capacity, in this report.

The 2018 Global Trends report concentrates on renewable power and fuels – wind, solar, biomass and waste, biofuels, geothermal and marine projects, and small hydro-electric dams of less than 50MW.

It does not cover larger hydro-electric dams of more than 50MW, except for brief mentions in the Executive Summary and Chapter 4. Energy smart technologies such as smart grid, electric vehicles and energy storage are also outside the main scope of the report, but they are discussed briefly in Chapter 2.

Where deal values are not disclosed, Bloomberg New Energy Finance 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 are based on annual installation data, provided by industry associations and governments. Bloomberg New Energy Finance continuously monitors investment in renewable energy. 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 2018 report contains revisions to a number of investment figures published in the 2017 edition of Global Trends in Renewable Energy Investment. Revisions reflect improvements made by Bloomberg New Energy Finance to its data during the course of the last 12 months, and also new transactions in 2016 and before that have since come to light.

DEFINITIONS

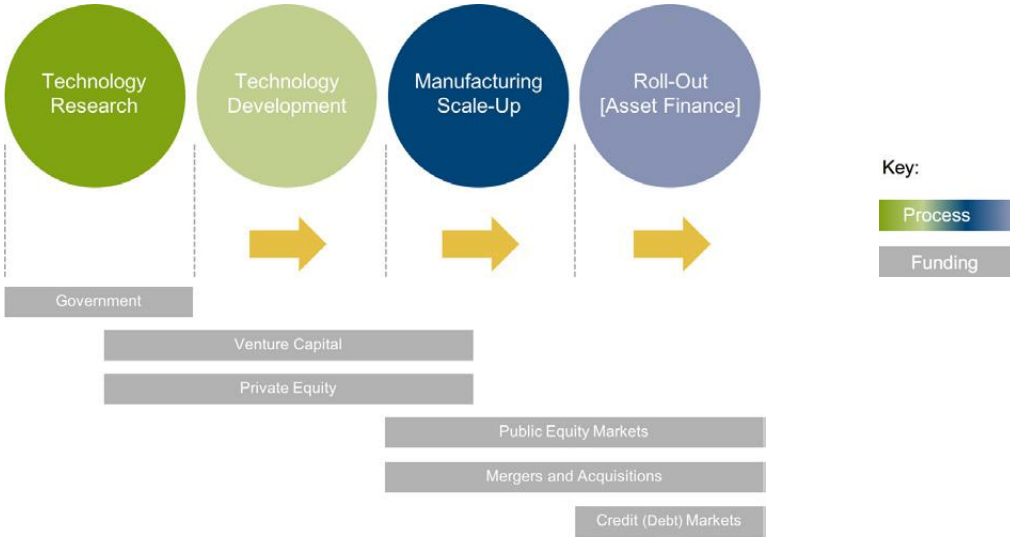
Bloomberg New Energy Finance tracks deals across the financing continuum, from R&D funding and venture capital for technology and early-stage companies, through to asset finance of utility-scale generation projects. Investment categories are defined as follows:

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.

Asset finance: all money invested in renewable energy generation projects (excluding large hydro), whether from internal company balance sheets, from loans, or from equity capital. This excludes refinancings.

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.



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 will be released in June 2018. 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

- A record 157 gigawatts of renewable power[1] were commissioned in 2017, up from 143GW in 2016 and far out-stripping the 70GW of net fossil fuel generating capacity added last year. Solar alone accounted for 98GW, or 38% of the net new power capacity coming on stream during 2017.

- The proportion of world electricity generated by wind, solar, biomass and waste-to-energy, geothermal, marine and small hydro rose from 11% in 2016 to 12.1% in 2017. This corresponds to approximately 1.8 gigatonnes of carbon dioxide emissions avoided.

- Global investment in renewable energy edged up 2% in 2017 to $279.8 billion, taking cumulative investment since 2010 to $2.2 trillion, and since 2004 to $2.9 trillion. The latest rise in capital outlays took place in a context of further falls in the costs of wind and solar that made it possible to buy megawatts of equipment more cheaply than ever before.

- The leading location by far for renewable energy investment in 2017 was China, which accounted for $126.6 billion, its highest figure ever and no less than 45% of the global total. There was an extraordinary solar boom in that country in 2017, with some 53GW installed (more than the whole world market as recently as 2014), and solar investment of $86.5 billion, up 58%.

- Renewable energy investment in the U.S. was far below China, at $40.5 billion, down 6%. It was relatively resilient in the face of policy uncertainties, although changing business strategies affected small-scale solar.

- Europe suffered a bigger decline, of 36% to $40.9 billion. The biggest reason was a fall of 65% in U.K. Investment to $7.6 billion, reflecting an end to subsidies for onshore wind and utility-scale solar, and a big gap between auctions for offshore wind projects. Germany also saw a drop in investment, of 35% to $10.4 billion, on lower costs per MW for offshore wind, and uncertainty over a shift to auctions for onshore wind. The latter change was also one reason, along with grid connection issues, for a fall in Japanese outlays of 28% to $13.4 billion.

- There were sharp increases in renewable energy investment in Australia, of 147% to $8.5 billion, in Mexico, of 810% to $6 billion, and in Sweden, of 127% to $3.7 billion. Just outside the world top 10, investment in Egypt leapt nearly sixfold to $2.6 billion, and that in the United Arab Emirates 29-fold to $2.2 billion.

- Developing economies (including China, Brazil and India) committed $177 billion to renewables last year, up 20%, compared to $103 billion for developed countries, down 19%. This was the largest tilt in favor of developing countries yet seen. It was only in 2015 that the developing world first invested more in green energy than developed economies.

- In 2017, costs continued to fall for solar, in particular. The benchmark levelized cost of electricity for a utility-scale photovoltaic project[2] dropped to $86 per megawatt-hour, down 15% on a year earlier and 72% since 2009. Some of this was due to a fall in capital costs, some to improvements in efficiency.

- Renewable energy auctions around the world once again produced record-low figures for the resulting tariffs. In Mexico in November, solar contracts were agreed at an average of $20.80 per MWh, and onshore wind at an average of $18.60. A U.K. auction in September saw offshore wind projects for commissioning in 2022-23 win through with bids 50% below the 2015 auction.

- Clean energy share prices rose in 2017, by about 28% on the WilderHill New Energy Global Innovation Index, or NEX. However, this has so far not produced a jump in equity issues by specialist companies. Instead, public markets investment in renewable energy dipped 6% to $5.7 billion, a five-year low. Venture capital and private equity (VC/PE) investment was also weak, fading 33% to $1.8 billion, the lowest figure since 2005.

- One way of interpreting the modest public markets and VC/PE activity, and also a record high of $87.2 billion for asset acquisitions and refinancings in 2017, up 14%, is that renewable energy has become a mature sector increasingly dominated by big industrial players, utilities and institutional investors.

- One uncertainty ahead for renewable energy is how investors will take to the coming period in which project revenues have no government price support, and instead depend on private sector power purchase agreements or even just merchant power prices. This issue is highlighted in the Executive Summary and in Chapter 3 (Delivering Investment).

- Another potential issue for the sector in the years ahead could be rising interest rates. The record-low rates of recent years have helped to reduce overall costs per MW, and also attracted new capital from institutional investors into the financing of projects.

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

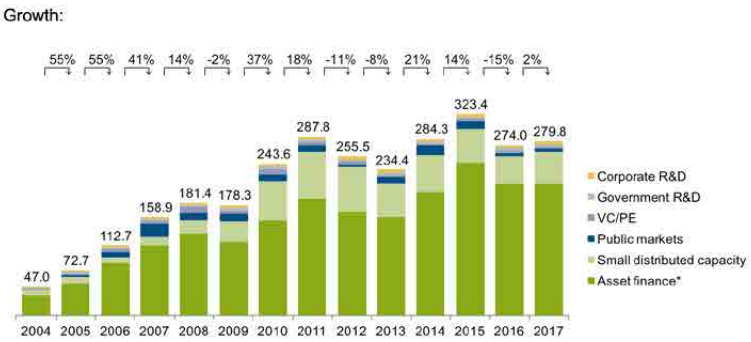
[2] Without a tracking system to follow the sun. Systems with tracking have seen similar-sized cost reductions.

EXECUTIVE SUMMARY

Solar power rose to record prominence in 2017, as the world installed 98 gigawatts of new solar power projects, more than the net additions of coal, gas and nuclear plants put together. The solar build-out represented 38% of all the net new generating capacity added (renewable, fossil fuel and nuclear) last year. China accounted for just over half of that new global solar capacity in 2017, and it accounted for 45% of the $279.8 billion committed worldwide to all renewables (excluding large hydro-electric projects).

This global renewable energy investment total was up 2% on the 2016 figure but still 13% below the record set in 2015. Meanwhile, costs continued to fall: an auction for new capacity in Mexico established new record lows for onshore wind and solar photovoltaics, and for the first time zero-subsidy bids were recorded in European offshore wind auctions.

FIGURE 1. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY ASSET CLASS, 2004-2017, $BN



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

Source: UN Environment, Bloomberg New Energy Finance

If the extraordinary boom in Chinese solar, with an estimated 53GW added, must take top billing in renewable energy investment in 2017, there were also eye-catching jumps in the amount of money deployed in several relatively new markets. These included Mexico, the United Arab Emirates and Egypt. On the downside, there were setbacks to investment in the mature markets of the U.K., Germany and Japan. And some of renewable energy's future challenges, such as how to cope with higher borrowing costs and without subsidy support, have come into plainer view in the last year (see final section of this Executive Summary).

FLOW OF MONEY

Figure 1 shows that in 2017, for the eighth year running, global investment in renewable energy exceeded $240 billion. Last year's total of $279.8 billion was 2% higher than the equivalent for 2016, but still significantly below the all-time high of $323.4 billion reached in 2015.[3] This brought cumulative investment since 2004 to $2.9 trillion.[4] The strength of these renewable energy investment totals over the years has happened despite steady falls in capital costs, particularly in solar. Those reductions have meant that developers have been able to install year on year more megawatts for the same number of dollars.

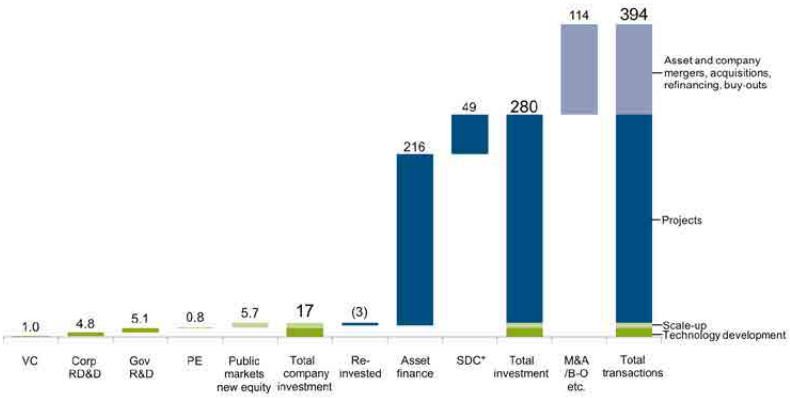
In 2017, as usual, asset finance of utility-scale wind farms, solar parks and other renewable energy plants was by far the largest component

[3] Note that some prior-year figures have been revised since the publication of last year's Global Trends report. The changes reflect new information on projects and deals.

[4] All the aggregate renewable energy investment figures in this report exclude large hydro-electric projects of more than 50MW.

of investment, followed by the financing of small distributed capacity – rooftop and other small-scale solar projects of less than 1MW. However, equity raising by specialist green energy companies on public markets and from venture capital and private equity providers was more subdued in 2017 than in some earlier years, reflecting the fact that sectors such as wind and solar are increasingly dominated by big manufacturers, developers and investor groups, rather than young companies.

FIGURE 2. GLOBAL TRANSACTIONS IN RENEWABLE ENERGY, 2017, $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, Bloomberg New Energy Finance

Dollar figures for the different categories of renewable energy investment in 2017 are shown in Figure 2. At the left side of the graph are the earlier parts of the 'financing continuum' described on page 10 of this report. Venture capital investment in green energy companies was $1 billion last year, up fractionally on 2016 but less than a third of a peak figure reached nine years earlier. However, corporate research and development came to $4.8 billion, up 12% on a year earlier and the highest recorded to date. Government R&D spending is estimated to have been steady at $5.1 billion in 2017, comparable to the totals recorded since 2009.

FIGURE 3. GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2017 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	2016-17 Growth %	2004-17 CAGR %
1 Total Investment																
1.1 New investment	47.0	72.7	112.7	158.9	181.4	178.3	243.6	287.8	255.5	234.4	284.3	323.4	274.0	279.8	2%	15%
1.2 Total transactions	56.1	100.6	148.2	218.0	242.7	243.3	303.6	361.8	322.4	302.5	372.3	421.8	389.5	393.8	1%	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	2.7	2.7	2.6	1.1	1.1	1.5	1.0	1.0	4%	8%
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	0%	8%
2.1.3 Corporate R&D	2.1	2.4	2.9	3.2	3.6	3.8	3.9	4.5	4.2	4.0	3.9	4.2	4.2	4.8	12%	6%
2.2 Scale-up																
2.2.1 Private equity expansion capital	0.3	1.0	3.1	3.5	6.9	3.2	5.5	2.4	1.7	1.4	1.7	1.8	1.7	0.8	-55%	7%
2.2.2 Public markets	0.3	3.6	9.2	20.8	10.8	12.7	10.8	9.9	4.0	10.2	15.1	12.0	6.1	5.7	-6%	26%
2.3 Projects																
2.3.1 Asset finance	33.7	53.0	85.6	115.1	135.6	120.4	155.2	190.1	169.4	159.3	201.3	252.4	215.6	216.1	0.2%	15%
Of which re-invested equity	0.1	0.1	0.8	2.6	3.6	1.9	1.5	1.8	2.6	1.0	3.3	6.1	2.9	3.1	6%	30%
2.3.3 Small distributed capacity	8.5	10.3	9.4	14.0	22.1	33.0	62.2	75.2	71.6	54.4	60.0	53.2	43.1	49.4	14.5%	15%
Total Financial investment	34.5	56.0	98.3	139.0	153.6	136.1	172.6	203.3	174.9	170.9	215.9	261.6	221.5	220.6	-0.4%	15%
Gov't R&D, corporate RD&D, small projects	12.5	14.7	14.4	19.9	28.5	42.2	71.0	84.5	80.5	63.5	68.3	61.8	52.5	59.3	13%	13%
Total New investment	47.0	72.7	112.7	158.9	181.4	178.3	243.6	287.8	255.5	234.4	284.3	323.4	274.0	279.8	2%	15%
3 M&A Transactions																
3.1 Private equity buy-outs	0.8	3.9	1.2	3.4	4.9	2.0	1.8	3.0	3.1	0.5	4.2	3.2	2.2	11.2	414%	22%
3.2 Public markets investor exits	0.4	2.5	2.8	4.1	1.0	2.5	5.1	0.2	0.4	1.7	1.6	1.5	6.5	1.2	-81%	10%
3.3 Corporate M&A	2.4	8.2	11.0	19.8	17.5	23.9	19.6	30.2	9.6	16.9	11.1	17.9	30.0	14.3	-52%	15%
3.4 Project acquisition & refinancing	5.5	13.3	20.5	31.8	37.9	36.7	33.7	40.6	53.8	49.0	71.2	75.7	76.8	87.2	14%	24%
4 New investment by Sector																
4.1 Wind	19.5	28.4	39.8	60.9	74.8	79.5	101.5	87.2	83.6	86.4	110.7	124.7	121.6	107.2	-12%	14%
4.2 Solar	11.2	15.9	21.8	38.7	61.5	64.0	103.3	158.1	140.5	119.9	145.3	179.3	136.5	160.8	18%	23%
4.3 Biofuels	4.0	9.9	28.6	27.4	18.2	10.2	10.6	10.6	7.2	5.2	5.2	3.5	2.1	2.0	-3%	-5%
4.4 Biomass & w-t-e	8.4	9.8	12.8	22.9	17.5	15.1	16.9	20.2	15.8	14.0	12.7	9.4	7.3	4.7	-36%	-4%
4.5 Small hydro	2.7	7.5	7.5	6.5	7.6	6.2	8.2	7.6	6.5	5.8	7.0	3.6	3.9	3.4	-14%	2%
4.6 Geothermal	1.2	1.2	1.4	1.7	1.7	2.8	2.9	3.9	1.6	2.8	2.9	2.5	2.5	1.6	-34%	2%
4.7 Marine	0.0	0.1	0.8	0.8	0.2	0.3	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.2	-14%	13%
Total	47.0	72.7	112.7	158.9	181.4	178.3	243.6	287.8	255.5	234.4	284.3	323.4	274.0	279.8	2%	15%
5 New investment by Geography																
5.1 United States	5.7	11.9	29.3	39.2	35.9	23.9	35.4	49.2	40.8	33.7	39.1	46.7	43.1	40.5	-6%	16%
5.2 Brazil	0.9	2.7	5.1	9.8	11.5	7.8	7.4	10.2	8.1	4.3	7.7	6.7	5.6	6.0	8%	16%
5.3 AMER (excl. US & Brazil)	1.8	3.3	3.7	4.9	5.9	5.5	12.4	9.6	10.4	12.5	14.4	11.4	6.0	13.4	124%	17%
5.4 Europe	24.9	33.1	46.8	67.4	81.3	82.5	113.9	128.4	88.9	59.4	67.9	62.9	64.1	40.9	-36%	4%
5.5 Middle East & Africa	0.6	0.8	1.2	1.9	2.3	1.7	4.2	3.2	10.2	9.2	8.3	13.3	9.0	10.1	11%	24%
5.6 China	3.0	8.7	11.0	16.6	25.3	38.1	41.5	48.2	58.3	63.4	85.3	121.2	96.9	126.6	31%	34%
5.7 India	2.7	3.2	5.4	6.4	5.7	4.2	9.0	13.8	8.0	6.8	8.4	9.9	13.7	10.9	-20%	11%
5.8 ASOC (excl. China & India)	7.4	9.0	10.1	12.8	13.7	14.5	19.8	25.2	30.9	45.1	53.1	51.2	35.7	31.4	-12%	12%
Total	47.0	72.7	112.7	158.9	181.4	178.3	243.6	287.8	255.5	234.4	284.3	323.4	274.0	279.8	2%	15%

New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals.
Source: UN Environment, Bloomberg New Energy Finance

Private equity expansion capital amounted to just $780 million, down 55% from 2016 and the lowest total since 2004.

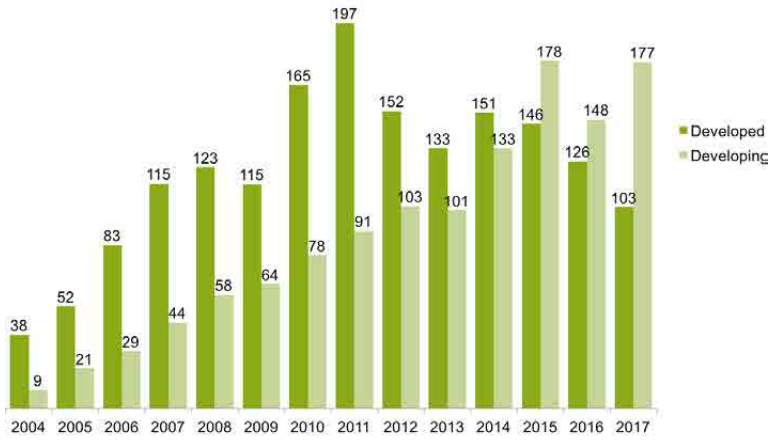
Public markets investment was $5.7 billion, down 6% on the previous year and the weakest figure since 2012. This drop came about despite the fact that 2017 was a generally good year for share prices in the sector, with the WilderHill New Energy Global Innovation Index, or NEX, rising 28%, as discussed in Chapter 6. Moving further along Figure 2, there is an adjustment of $3.1 billion for re-invested equity. This is money raised from public markets, venture capital or private equity investors that subsequently found its way into the build-out of renewable energy capacity.

That build-out is shown in the next two columns on the chart – asset finance of utility-scale projects, at $216.1 billion, up marginally from $215.6 billion in 2016; and small distributed solar capacity, at $49.4 billion, up 15%. That takes us to the $279.8 billion figure for new investment in renewable energy in 2017.

There is one additional number on Figure 2, and that is the $114 billion of acquisition transactions in the sector last year. Down 1% on the 2016 number, but still comfortably the second-highest ever, this is the aggregate of several different ways in which money is recycled in the sector: the acquisition of wind, solar and other assets, refinancings, corporate mergers and acquisitions, private equity buy-outs and public market investor exits. This acquisition activity is not counted in the new investment total, but is part of the total transaction volume.

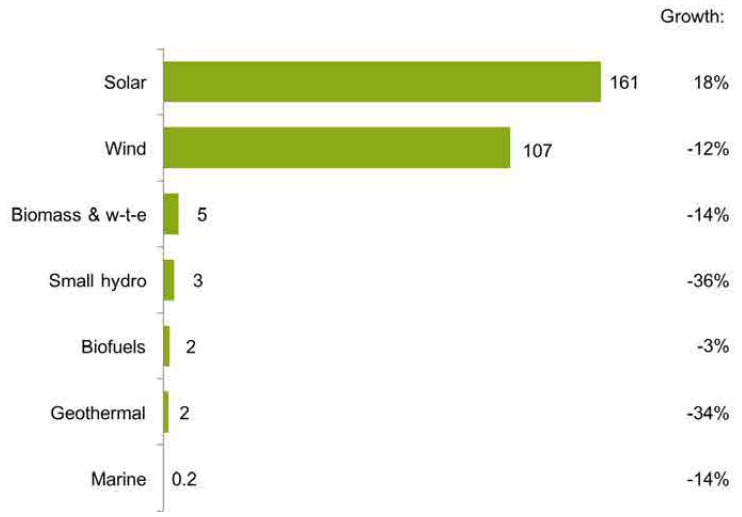
Figure 3 gives a breakdown of all those types of investment over the 14 years since 2004. It also splits investment by sector, showing how solar has shot up from third place in 2006 behind wind and biofuels, to an unchallenged first place in 2017, representing 57% of all the investment in renewables last year. The table also highlights how the geographical split of investment has evolved, from European preponderance in the early years to a dominant China more recently and particularly in 2017. Chapter 1 of this report explores in detail what happened to investment in different countries last year.

FIGURE 4. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY: DEVELOPED V DEVELOPING COUNTRIES, 2004-2017, $BN



New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals. Developed volumes are based on OECD countries excluding Mexico, Chile, and Turkey.
Source: UN Environment, Bloomberg New Energy Finance

FIGURE 5. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2017, AND GROWTH ON 2016, $BN



New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals.
Source: UN Environment, Bloomberg New Energy Finance

The charts that follow give different snap-shots of the investment trend. Figure 4 divides the world into developed and developing economies and shows that, after many years in which developed countries represented the lion's share of investment in renewables, the balance shifted in 2015. Both then and in 2016, developing economies made up the majority of investment in renewable power and fuels – and in 2017, the gap grew sharply, so that the developing world accounted for 63% of the global total and developed countries just 37%.

Figure 5 indicates how solar and wind dwarf the other renewable energy sectors in terms of overall investment, while Figure 6 shows the breakdown in terms of capacity spending only. Investment in new solar installations came to $153.7 billion, up 18% year-on-year. This was split between asset finance of utility-scale projects, up 20% at $104.3 billion, and funding of small-scale systems, 15% higher at $49.4 billion. New wind capacity attracted $104.3 billion, down 10% on 2016. The other sectors covered in this report were much smaller in terms of new capacity investment, with biomass and waste-to-energy for instance at just $3 billion, down 52%.

However, large hydro-electric projects of more than 50MW, which are outside of the scope of this report but briefly discussed in a box at the end of Chapter 4, secured an estimated $45 billion of final investment decisions in 2016. This was up 108% year-on-year thanks to the financing of the huge Baihetan dam in China. Nevertheless, global large hydro investment in 2017 was still a bit less than half the value of the capacity investment announced for wind last year, and between a third and quarter that for solar.

Public markets investment by sector is the focus of Figure 7, with a relatively even split between solar and wind, and biomass and waste-to-energy also attracting significant investment in 2017. However, Figure 8 shows that solar alone remained streets ahead in terms of venture capital and private equity funding specifically. Public markets investment is explored in detail in Chapter 6, and VC/PE funding in Chapter 7.

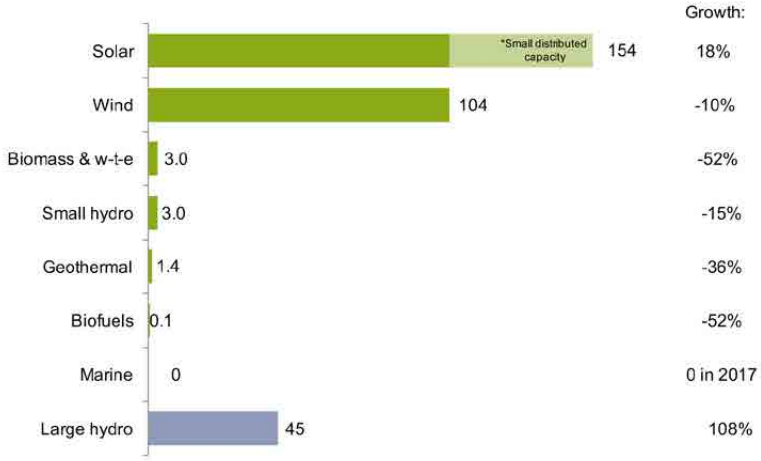
FALLING COSTS

Steep reductions in capital and generating costs for renewables have been instrumental in creating a bigger market than ever before for these technologies. Some projects that would not have been economic at the cost levels prevalent in earlier years have become viable. The new capacity added of renewables excluding large hydro has jumped from 69GW in 2010 to 143GW in 2016, and a record 157GW in 2017.

Note that investment decisions made in one year may not translate into capacity commissioned in the same year, but in a later one. Offshore wind projects, for instance, often reach commissioning 2-3 years after final investment decision. For solar projects, that gap is usually much shorter, at 3-6 months.

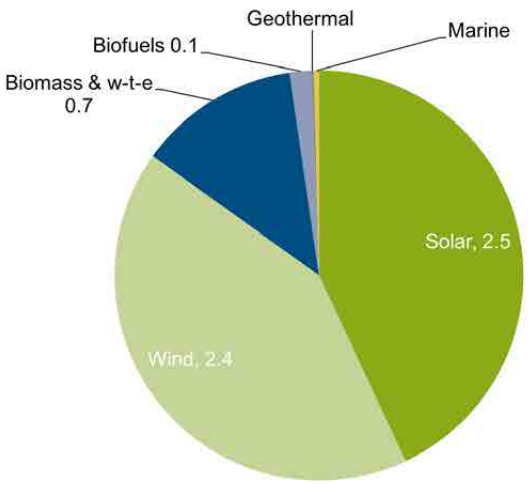
Figure 9 shows how the levelized cost of electricity for the main wind, solar and biomass technologies has evolved over the years. These are benchmark figures based on investment decisions in the year in question, and they come from a model that distils numerous inputs, including project development cost, equipment cost, construction cost, financing cost and operations and maintenance expenses.

FIGURE 6. RENEWABLE ENERGY ASSET FINANCE AND SMALL DISTRIBUTED CAPACITY INVESTMENT BY SECTOR, 2017, AND GROWTH ON 2016, $BN



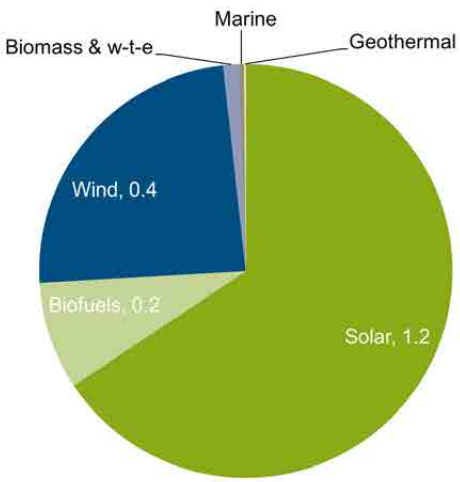
Total values include estimates for undisclosed deals.
Source: UN Environment, Bloomberg New Energy Finance

FIGURE 7. PUBLIC MARKETS INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2017, $BNA



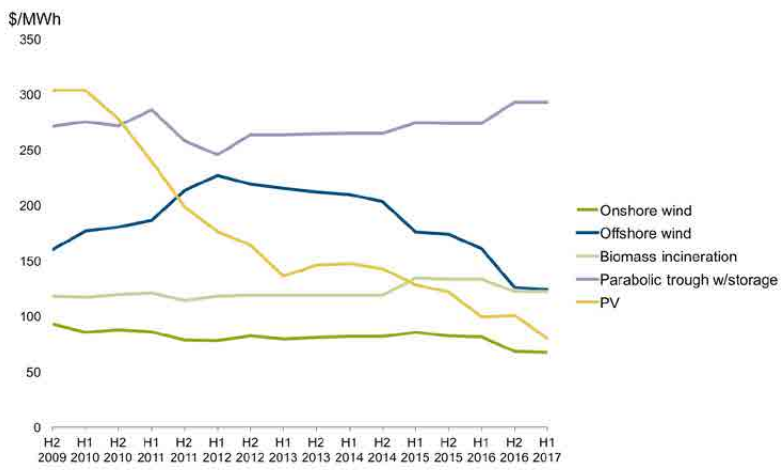
Source: UN Environment, Bloomberg New Energy Finance

FIGURE 8. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2017, $BN



VC/PE new investment excludes PE buy-outs. Total values include estimates for undisclosed deals.
Source: UN Environment, Bloomberg New Energy Finance

FIGURE 9. LEVELISED COST OF ELECTRICITY, BY RENEWABLE ENERGY TECHNOLOGY, 2009 TO 2017, $ PER MWH



Solar thermal is parabolic trough with storage, PV is crystalline silicon with no tracking
Source: UN Environment, Bloomberg New Energy Finance

It also takes account of changing capacity factors for the different technologies – so, for instance, the average yield from a wind turbine per MW has increased significantly year-by-year as the technology has improved. The percentage efficiency of PV modules has also risen incrementally.

Between 2009 and 2017, the benchmark levelized cost of electricity, or LCOE, for photovoltaics without tracking systems fell from $304 per megawatt-hour to just $86, a reduction of 72%. Onshore wind's LCOE dropped from $93 to $67 per MWh, a reduction of 27%. For offshore wind, there was an increasing cost trend for some years as project developers moved into deeper waters, further from shore, but since the peak in 2012, there has been an LCOE decline of 44% to $124 per MWh. Two other technologies are shown – solar thermal parabolic trough, and biomass incineration. Neither has seen a significant change in its LCOE since 2009.

The LCOE reductions for PV, onshore wind and offshore wind have boosted the competitiveness of these sources against established technologies such as coal and gas. In the U.S., for instance, in 2017 the average LCOE without subsidy for PV without tracking was $54 per MWh, with onshore wind at $51 per MWh, versus gas-fired generation at $49 per MWh, coal at $66 and nuclear at $174.[5] The LCOEs of different technologies vary a great deal between countries, and within countries, but in an increasing number of other markets, either onshore wind or PV was the cheapest of all.

[5] All LCOE estimates are from Bloomberg New Energy Finance.

A NEW ERA

Renewable energy investors have managed to finance the build-out of just over 1,000GW of capacity since 2004, most of it in wind and solar. Two vital pillars for that effort have been subsidy support, which has underpinned revenues for the projects concerned during most of their operating lives, and – since the 2008-09 financial crisis – unprecedentedly low costs of borrowing in many markets. For technologies such as wind and solar, where almost all the cost is upfront capital expenditure, cheap capital makes a big difference to competitiveness.

Both those pillars are starting to slip. As discussed in Chapter 3 (Delivering Investment), subsidies such as feed-in tariffs and green certificates are rapidly giving way to fiercely contested auctions and those are a prelude to a situation, before long, where many projects will have to sink or swim without any government-backed price support. That means either building with the backing of a private sector (utility or corporate) long-term power purchase agreement, or PPA, if the developer can get one – or going ahead without a long PPA and hoping to make a return from volatile power prices.

That greater uncertainty about revenues will inevitably affect developers' ability to attract debt and equity for their projects. Admittedly, they start off from a position (in 2017 and early 2018) when there is an abundance of capital available to go into renewable energy. However, world interest rates have started to increase – 10-year rates in the U.S., for instance, have climbed from 2.2% in July 2016 to more than 3.5% in early 2018. If the trend continues, more expensive debt would be a second challenge for renewables. A new era may be beckoning in which solar and wind costs are lower, but financing is more difficult to get, and more expensive.

INVESTMENT BY TYPE OF ECONOMY

- Developing economies accounted for a record 63% of global investment in renewable energy in 2017, up from 54% in 2016. It was only in 2015 that developing countries first took the lead over developed economies in terms of dollar investments.[6]
- The 'big three' of China, India and Brazil accounted for just over half of global investment in renewables excluding large hydro last year, with China alone representing 45%, up from 35% in 2016.
- Europe's share of world investment fell to just 15% in 2017, the lowest recorded since the data series began in 2004. As recently as 2011, Europe accounted for as much as 45% of the global total.
- Among the leading markets seeing the biggest falls in investment last year were the U.K., down 65% at $7.6 billion, Germany down 35% at $10.4 billion, and Japan down 28% at $13.4 billion. The U.S. slipped 6% to $40.5 billion.
- Mexico and Sweden climbed into the top 10 in terms of investment in 2017, recording $6 billion and $3.7 billion of investment respectively, up 810% and 127%. Australia was another strong feature, commitments there reaching $8.5 billion, up 147%.
- Outside the top 10, Egypt, United Arab Emirates and Argentina were three developing economies that saw investment surge in 2017, recording figures of $2.6 billion, $2.2 billion and $1.8 billion respectively.

This chapter looks at the detail of renewable energy investment in 2017, breaking it down first between developed and developing economies, then by main center. It goes on to look at trends in specific developed economies, then at the 'big three' of China, India and Brazil, and finally at individual developing economies in the Middle East and Africa, Latin America and non-OECD Asia. Chapters 4 to 9 look in even more detail at types of investment around the world.

DEVELOPED VERSUS DEVELOPING ECONOMIES

Figure 4 in the Executive Summary showed that developing economies including the "big three" extended their lead over developed economies in 2017 in terms of investment in renewable energy. Excluding large hydro-electric projects of more than 50MW, emerging economies attracted $177.1 billion of new investment last year, less than a billion dollars short of the record figure of 2015, and up 20% from 2016. Meanwhile, developed economies saw investment slide 18% to $102.8 billion, their lowest aggregate since 2006.[7]

Of course, these figures disguise the important reductions in costs per MW that have occurred in recent years – so, for instance, if the record investment figure for developed economies, of $197.1 billion in 2011, were to have been repeated last year, it would have bought a lot more gigawatts of renewables capacity than it did at the time. This cost reduction point makes the total last year for developing economies, and China in particular, all the more impressive.

[6] In this report, "developing countries" are defined as economies outside the OECD plus Mexico, Turkey and Chile. China, India and Brazil are all counted as developing countries.

[7] The two figures in this paragraph add up to $279.8 billion, the global investment total shown in the Executive Summary, once rounding issues are sorted out.

Figure 10 shows investment split into three categories of economy – developed, the 'big three' developing countries of China, India and Brazil, and other developing economies. It reveals that dollar commitments in these 'other' developing economies reached $33.5 billion last year, up 6%, but still below the record of $39.9 billion in 2015.

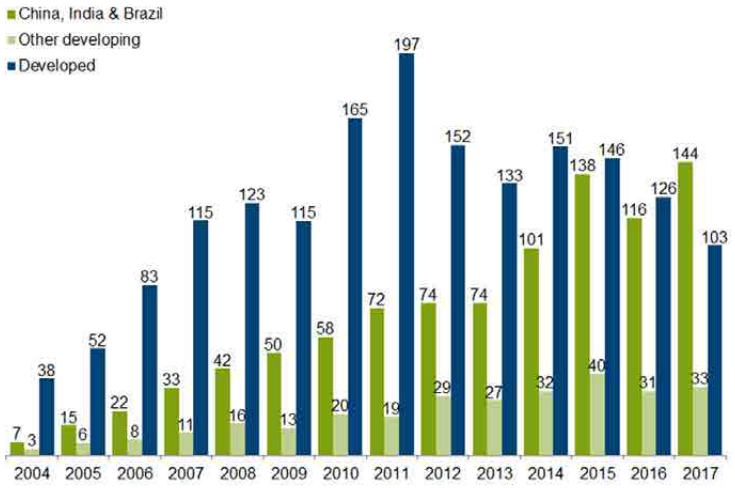
China, India and Brazil together saw dollars allocated to renewables hit $143.6 billion, their highest total ever and up 24% on 2016. China, as discussed below, was even more dominant in that 'big three' last year than previously.

Developed economy investment slipped 19% to $102.8 billion in 2017, the lowest figure since 2006 and only 37% of the global total. Much of this decline reflected the trend in Europe, where there were fewer big offshore wind financings in 2017 than in the previous two years, and both lower capital costs per MW and policy changes also had an impact.

The gap between developing and developed economy investment last year was, in fact, a reflection of demand in the solar market. Figure 11 shows that solar investment split $115.4 billion to $45.4 billion between the two main categories of economy, the developing country part being up 41% and the developed economy part being down 17%.

Wind was more evenly balanced, at $54.8 billion in developing economies, and $52.4 billion in developed countries. Those figures were down 4% and down 19% respectively in 2017 compared to 2016. Biomass and waste-to-energy investment was evenly split at $2.3 billion in both developing and developed economies, while small hydro outlays were, as usual, concentrated mainly in the developing world.

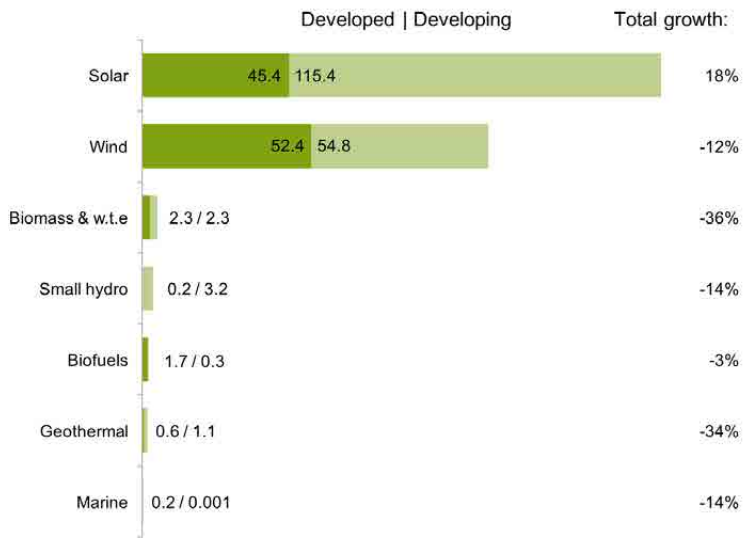
FIGURE 10. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY: SPLIT BY TYPE OF ECONOMY, 2004-2017



New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals. Developed volumes are based on OECD countries excluding Mexico, Chile, and Turkey

Source: UN Environment, Bloomberg New Energy Finance

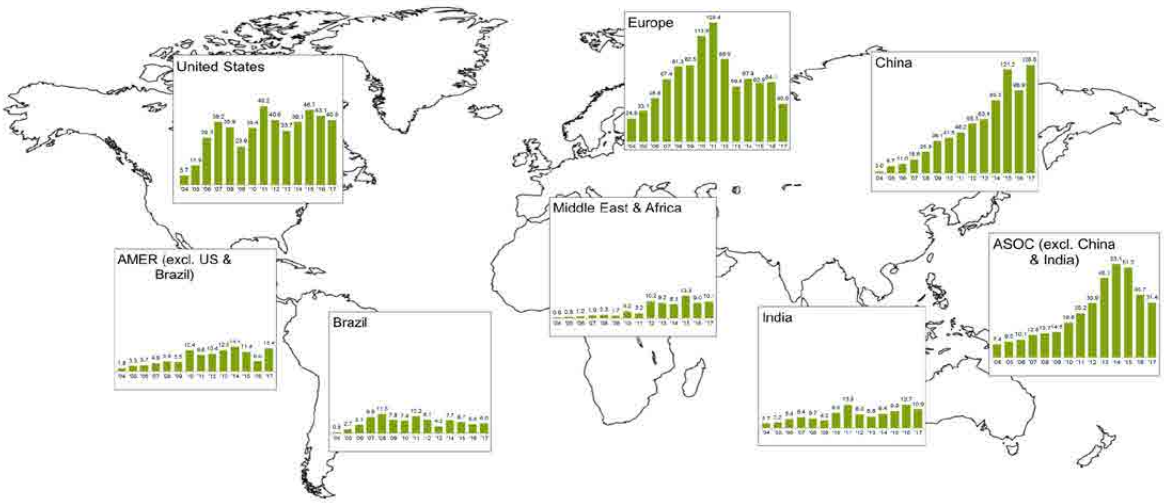
FIGURE 11. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY: DEVELOPED V DEVELOPING COUNTRIES, 2017, AND TOTAL GROWTH ON 2016, $BN



Total values include estimates for undisclosed deals. New investment volume adjusts for re-invested equity. Includes estimates for small distributed capacity, corporate and government R&D. Developed volumes are based on OECD countries excluding Mexico, Chile, and Turkey

Source: UN Environment, Bloomberg New Energy Finance

FIGURE 12. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY REGION, 2004-2016, $BN



New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals
Source: UN Environment, Bloomberg New Energy Finance

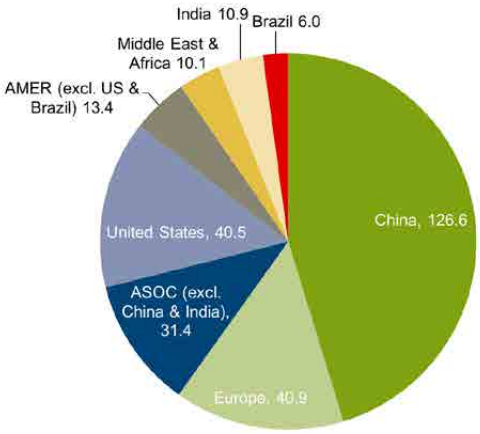
MAIN CENTERS

The different regional markets for renewable energy have showed contrasting trends over the years, as far as dollar investment is concerned, as highlighted in Figure 12.

The China chart shows the powerful build-up of its activity in renewables, hitting records in 2015 and then again in 2017. The Europe graph reveals peaks in dollar investment around the turn of the decade, reflecting frantic spending on solar at relatively high costs per MW as feed-in tariffs in Spain, Germany and Italy lured developers and households. The U.S. chart is notable for sustaining a total in the range $33-49 billion per year since 2010, with a number of influences at work – including green stimulus programs, the rise and decline of the 'yieldco' and uncertainties over the future of the tax credits for wind and solar.

Brazil has seen relatively steady investment in recent years, after the end of the 2007-08 biofuel boom. The chart for Americas excluding the U.S. and Brazil, and the one for Middle East & Africa, both display increased dollar investment since 2010, but with ups and downs caused by the changing performance of particular countries such as Canada, Mexico, South Africa and Egypt. The graph for Asia-Pacific excluding China and India displays a hump in investment in 2013-15 due to the Japanese solar boom. The India chart shows investment oscillating in the $6-14 billion range since 2010 – still not reaching the sort of levels that would be required for that country to meet Prime Minister Narendra Modi's ambitious goals for 2022.

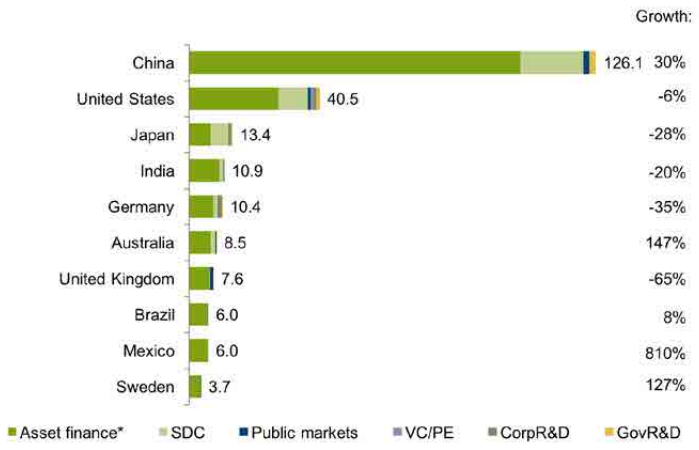
FIGURE 13. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY REGION, 2017, $BN



New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals
Source: UN Environment, Bloomberg New Energy Finance

Figure 13 underlines the dominance of China in last year's renewable energy investment, accounting for $126.6 billion out of the global total of $279.8 billion – equivalent to a record 45%. Its preponderance is equally striking in Figure 14, which shows the top 10 investing countries last year. The sections below will describe developments in particular countries, but it is worth noting that two countries from 2016's top 10 do not appear in the equivalent for 2017 (France and Belgium), and two other countries entered the list (Mexico and Sweden).

FIGURE 14. NEW INVESTMENT IN RENEWABLE ENERGY BY TOP 10 COUNTRY AND ASSET CLASS, 2017, AND GROWTH ON 2016, $BN



Top 10 countries. *Asset finance volume adjusts for re-invested equity. Includes corporate and government R&D
Source: UN Environment, Bloomberg New Energy Finance

DEVELOPED ECONOMIES

The U.S. has seen over the years a rich mix of different types of renewable energy investment. It is usually the largest location for venture capital and private equity funding of specialist green energy firms, and it has also seen high levels of public markets investment and of corporate and government research and development. It has also been one of the world's biggest markets for small-scale solar development, and for utility-scale renewable energy projects.

This heterogeneity was again the case in 2017, as Figure 15 shows. Asset finance was the largest single component of U.S. investment, at $29.3 billion out of the $40.5 billion total, but small distributed capacity (rooftop and other solar systems of less than 1MW) also attracted large sums – $8.9 billion last year. The other elements – corporate and government R&D, VC/PE and public markets investment – were each around the $1 billion mark.

Of these, public markets investment was perhaps the most noteworthy at just $1 billion, since it has hit much higher levels in earlier years (for instance, $8.9 billion in 2015, at the peak of the boom in 'yieldcos', or publicly quoted companies owning operating-stage renewable energy projects). There is further discussion of the yieldco boom and decline in Chapter 6 on Public Markets.

As far as asset finance and small-scale projects were concerned in the U.S. in 2017, the dominant influence was the continuing availability of the Production Tax Credit for wind, and Investment Tax Credit for solar. These programs, providing tax incentives for investment in these technologies, were extended for five years by Congress in late 2015, and so still have a few years to run. Their existence enabled some developers to move ahead with substantial projects.

FIGURE 15. RENEWABLE ENERGY INVESTMENT IN THE U.S. BY SECTOR AND TYPE, 2017, $BN

	Asset finance	Re-invested Equity	SDC	Public markets	VC/PE	CorpR&D	GovR&D	Total
Solar	9.5	-0.3	8.9	0.4	0.6	0.6	0.1	19.8
Wind	19.6	-1.3		0.6	0.1	0.2	0.1	19.2
Biofuels				0.1	0.1	0.1	0.5	0.7
Geothermal	0.1				0.0	0.0	0.1	0.1
Biomass & w.t.e	0.1					0.2	0.1	0.4
Small hydro	0.0					0.0	0.0	0.1
Marine				0.0	0.0	0.0	0.0	0.1
Total	29.3	-1.6	8.9	1.0	0.8	1.1	1.0	40.5

Source: UN Environment, Bloomberg New Energy Finance

FIGURE 16. RENEWABLE ENERGY INVESTMENT IN EUROPE BY SECTOR AND TYPE, 2017, $BN

	Asset finance	Re-invested Equity	SDC	Public markets	VC/PE	CorpR&D	GovR&D	Total
Solar	2.8	-0.3	6.6	0.5	0.3	0.5	0.4	10.8
Wind	26.7	-0.4		1.0	0.0	0.5	0.2	28.0
Biofuels				0.0		0.2	0.4	0.6
Geothermal	0.1					0.0	0.1	0.2
Biomass & w.t.e	0.7			0.0	0.0	0.2	0.1	1.0
Small hydro	0.1					0.0	0.0	0.2
Marine				0.0	0.0		0.1	0.1
Total	30.4	-0.7	6.6	1.6	0.3	1.5	1.2	40.9

Source: UN Environment, Bloomberg New Energy Finance

For instance, American Electric Power said it would be investing $2.9 billion in the 2GW Wind Catcher onshore wind complex in the Oklahoma Panhandle. PacifiCorp, a unit of Warren Buffett's Berkshire Hathaway conglomerate, unveiled plans in April 2017 for 1.1GW of new wind farms in Wyoming by 2020, and the repowering of another 900MW of existing wind projects. Some 24 onshore wind and PV projects worth between $250 million and $800 million reached final investment decision in the U.S. during 2017. However, there was no stampede to install capacity in 2017 or 2018 – because companies were aware that they had a few years of support ahead, and that equipment prices would be likely to fall further in that time.

Small-scale solar investment in the U.S. slipped from $10.1 billion in 2016 to $8.9 billion in 2017. In part, this was due to declining system prices, but there was also restructuring in the market, with the largest supplier of residential panels, SolarCity, slowing down its activity significantly ahead of, and after, its takeover by Tesla.

Figure 16 shows the breakdown in investment for Europe in 2017, where the total finished up at $40.9 billion, down a third on the previous year. Corporate and government R&D, venture capital and private equity investment together amounted to $3 billion, steady with 2016, so the reasons for the fall were concentrated in the other investment categories: public markets, small distributed capacity and asset finance.

Public markets equity raising dropped 55% to $1.6 billion. There were issues by the quoted project fund Greencoat UK Wind and its Irish sister company Greencoat Renewables, worth $447 million and $314 million respectively, but there was nothing to rival Innogy's $2.3 billion initial public offering in 2016. Small-scale project investment, meanwhile, slipped from $8.5 billion in 2016 to $6.6 billion in 2017, partly due to lower system costs and partly to a fall of more than half in U.K. spending, as subsidy support for small solar was cut sharply.

The big impetus, however, for lower European investment came from asset finance, which slid 38% to $30.4 billion last year. This was almost exactly accounted for by big falls in commitments in Germany and, in particular, the U.K. The latter saw just one big offshore wind project financed in 2017 (Hornsea 2, at $4.8 billion), and just one sizeable onshore wind farm reaching the same stage (the Banks portfolio, at $480 million). This reflected the closing of subsidy programs for onshore wind, biomass and solar, and a big gap between auctions for offshore wind. In 2016, the U.K. had four multibillion-dollar offshore wind financings, plus a string of biomass and onshore wind deals in the hundreds of millions of dollars.

German investment fell less steeply than that in the U.K., with four offshore wind projects financed, led by Hohe See, at 497MW and $1.9 billion, and a long list of medium-sized onshore wind projects worth between $10 million and $100 million. Germany is shifting to auctions for all technologies, and away from feed-in tariffs, and this created some uncertainty during 2017. The last auction in 2017 for onshore wind featured specific rules[8] that resulted in almost all capacity being awarded to projects set up by local citizens.

Figure 17 shows the extent of the reverses in overall investment for Europe's two biggest markets, but also reveals that there were pockets of strength elsewhere in 2017, with Sweden seeing a 127% jump in investment to $3.7 billion on the back of several big onshore wind financings that were backed by corporate power purchasing agreements (see Chapter 4). Greece enjoyed a 287% boost to $760 million, helped by Enel's decision to proceed with its 154MW

FIGURE 17. RENEWABLE ENERGY INVESTMENT IN EUROPE BY COUNTRY, 2017, $BN AND CHANGE ON 2016

	2017	% growth on 2016
Germany	10.4	-35%
United Kingdom	7.6	-65%
Sweden	3.7	127%
France	2.6	-14%
Turkey	2.2	-8%
Netherlands	1.8	52%
Italy	1.7	1%
Norway	1.4	-25%
Ireland	0.8	1%
Greece	0.8	287%

Top 10 countries. Total values include estimates for undisclosed deals
Source: UN Environment, Bloomberg New Energy Finance

[8] Local groups, or Buergerenergiegenossenschaften, proposing these projects could participate in the auction without formal planning permission, something that large developers could not do.

Kafireas wind farm. Hungary was another, and unfamiliar, bright spot, seeing investment jump from very little in 2016 to $649 million, on the back of a spurt in solar development.

France's investment in renewable energy dipped 14% to $2.6 billion in 2017. There was the $318 million financing of the 180MW Valeco Mirova solar and wind portfolio, and a string of smallish projects funded in onshore wind, but a lack of other big or even medium-sized deals. The new government of President Emmanuel Macron has published plans to "liberate renewables", with shorter permitting periods for projects. These, together with financing for the first conventional and floating offshore wind projects, may push investment upwards in the years ahead.

Netherlands was the location for one of the biggest ever onshore wind repowering deals. Vattenfall took final investment decision on the first stage (180MW and $236 million) of repowering the Wieringermeer project, removing old turbines and replacing them with new ones nearly three times as powerful.

Moving away from Europe, Figure 18 shows the investment trend for five other developed economies that have seen big renewable energy investments over the years. Commitments increased in 2017 in both Canada and South Korea, by 72% to $2.7 billion and 16% to $2.1 billion respectively. Canada's total was dominated by onshore wind, the largest deal being the Nigig Henvey Inlet project in Ontario, at 300MW and $953 million. South Korea's total owed the most to small-scale solar systems, but there was also $630 million of onshore wind asset finance, led by the Unison Yeonggwang project at 80MW.

Australia was a star turn in renewable energy investment in 2017, its total jumping 147% to $8.5 billion, a record. Solar advanced 189% to $4.9 billion, and wind 109% to $3.6 billion. The largest transactions included the Goldwind Stockyard Hill wind project, at 530MW and an estimated $822 million, and the EGP DIF Bungala PV portfolio, at 270MW and $495 million. High electricity prices and a rush to secure capacity under the Large-Scale Renewable Energy Target, or LRET, were the main factors pushing investors to close deals. The LRET provides certificates for up to 33TWh of renewable generation by 2020.

Renewable energy investment in Japan fell 28% to $13.4 billion in 2017, with a 32% fall in solar commitments to $11.3 billion the central element in that. There were at least a dozen PV projects financed in Japan in 2017 at $100 million or more, the largest being the 258MW Pacifico Energy Mimasaka Sakuto complex in Okayama. Among the factors leading to lower solar investment last year were uncertainties over grid connection, and a move away from feed-in tariffs towards auctions for projects of more than 2MW. The first auction, in October, resulted in disappointing take-up – there were bids for just 141MW out of the 500MW available.

Japan's wind and biomass sectors, although much smaller, also attracted investment in 2017, the former seeing a 31% drop in financings to $896 million, and the latter a 120% gain to $1 billion. The largest biomass plant getting to final investment decision last year was the 112MW Sumitomo Heavy Hofu project, at an estimated $314 million. A strategy shift towards biomass on the part of some solar developers, and a looming feed-in tariff cut, both served to stimulate activity in that sector.

FIGURE 18. RENEWABLE ENERGY INVESTMENT IN OTHER MAJOR DEVELOPED ECONOMIES, 2017, $BN, AND CHANGE ON 2016, $BN

	2017	% growth on 2016
Japan	13.4	-28%
Australia	8.5	147%
Canada	2.7	72%
South Korea	2.1	16%
Israel	0.4	-61%

Top 10 countries. Total values include estimates for undisclosed deals
Source: UN Environment, Bloomberg New Energy Finance

CHINA, INDIA, BRAZIL

The sector detail of China's $126.6 billion aggregate by sector is shown in Figure 19. What is clear is the dominance of solar, at $86.5 billion (up 58% year-on-year and the highest ever), far ahead of wind at $36.1 billion (down 6%), small hydro down 7% at $2.4 billion and biomass and waste-to-energy also down 7% at $1.5 billion.

The spectacular build-out of 53GW of solar took place despite worries over a growing subsidy burden and worsening power curtailment. China's regulators, under pressure from the industry, were slow to curb build of utility-scale projects outside allocated government quotas. Developers of these projects are crossing their fingers that they will be allocated subsidy in future years.

FIGURE 19. RENEWABLE ENERGY INVESTMENT IN CHINA, INDIA AND BRAZIL BY SECTOR, 2016, $BN

	China	India	Brazil
Solar	86.5	6.7	2.1
Wind	36.1	4.0	3.6
Biofuels	0.1	0.0	0.2
Geothermal	0.0		
Biomass & w.t.e	1.5	0.1	0.0
Small hydro	2.4	0.1	0.1
Marine			
Total	126.6	10.9	6.0

Source: UN Environment, Bloomberg New Energy Finance

In addition, the cost of solar continues to fall in China, and more projects are being deployed on rooftops, in industrial parks or at other distributed locations. These systems are not limited by the government quota. Large energy consumers in China are now installing solar panels to meet their own demand, with a minimal premium subsidy. A breakdown of China's solar surge in 2017 reveals that $19.6 billion of the investment took the form of systems of less than 1MW, against $64.9 billion for utility-scale arrays of more than 1MW.[9] Many of the latter, however, were distribution-grid-connected rather than transmission-grid-connected, in other words local projects, often ground-mounted or on industrial rooftops.

However, there were also many Chinese solar projects financed in 2017 that were in the first rank globally in terms of size: for instance, the 540MW Jiangxi Municipal Poverty Alleviation plant, at an estimated $653 million, and the Huanghe Hydropower Hainan Gonghe installation, at about $605 million. And there were three solar thermal plants reaching final investment decision, including the 100MW China Three Gorges Jiuquan Jinta Molten Salt Tower, at $420 million.

In wind, offshore was particularly prominent in 2017, with the go-ahead for 13 projects worth between $600 million and $1.2 billion, led by the 400MW CGNWP Yangjiang Nanpengdao array. It was a record year by far for offshore wind asset finance in China, at $10.8 billion, up 180%.

Meanwhile, onshore wind's $24.6 billion of asset finance in 2017 represented that sub-sector's lowest dollar figure since 2008, and down 28% from 2016. Worries about curtailment and declining feed-in tariff rates contributed to the slowdown, but China remained the biggest onshore wind market in terms of installations, with 20GW added last year, down from 22GW in 2016 and a record 29GW in 2015. Many of the new onshore wind financings were medium-sized in scale, but there were also some stretching over much larger sites, such as the 400MW CR Power Neihuang Runfeng project, at an estimated $451 million.

India came fourth in the world rankings by country for renewable energy investment last year, at $10.9 billion, down 20%. As Figure 19 highlights, solar took the biggest share, at $6.7 billion, with wind at $4 billion. These lead sectors were up 3%, and down 41%, in dollar terms respectively. Solar activity was held back by an unexpected rise in PV module prices in local currency terms, due to a sudden reduction in the oversupply of imported Chinese units, exacerbated by the imposition of a 7.5% import duty on modules, and a local goods and service tax on panels. There was also a slowing in the pace of solar auctions around India.

In the medium term, PV installations look set to increase sharply, as India seeks to hit its ambitious target of 100GW of solar by 2022. However, that acceleration did not materialize in 2017. There were, nevertheless, several projects financed that rivalled in size anything financed in China last year – including the APPGCL Andhra Pradesh PV park, at 500MW and an estimated $400 million.

The third of the 'big three', Brazil, attracted $6 billion of renewable energy investment in 2017, up 8% on the previous year but still far below the peak total of $11.5 billion in 2008, when the biofuel boom in that country was still in full swing. Last year, as Figure 19 shows, activity was mainly concentrated in wind, at $3.6 billion, and solar at $2.1 billion. The former was down 18% on 2016 levels, but the latter was up a spectacular 204% as projects that won power purchase agreements in prior-year auctions secured financing.

The Brazilian market has been affected by political and economic uncertainty in recent years, and specifically by the cancellation of a renewable energy auction at the end of 2016. Projects that went ahead in 2017, such as the 216MW Rio Energy Serra da Babilonia wind farm and the 184MW Pirapora 1 PV portfolio, at $479 million and $350 million respectively, were winners in prior-year auctions and had deadlines to start delivering power. In biofuels, the imposition of duties on U.S. imports and a faltering of domestic demand combined to keep investors in cautious mood.

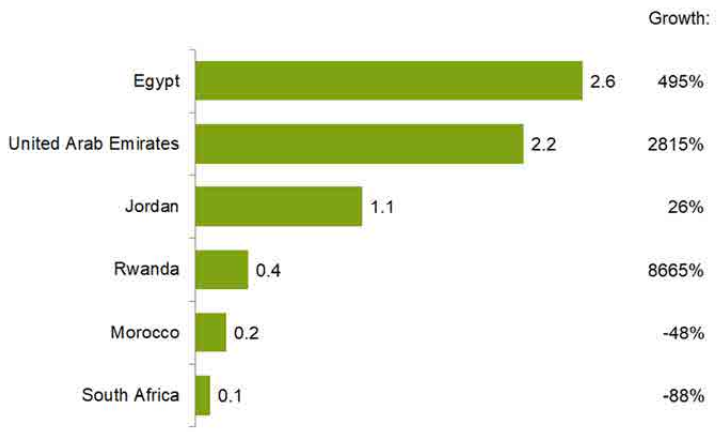
[9] These two dollar figures do not quite add up to the $86.5 billion investment total for China mentioned in the first paragraph of this section. That is because the $86.5 billion also includes public markets, VC/PE and corporate and government R&D spending.

OTHER DEVELOPING ECONOMIES

Figure 20 shows investment in six leading markets in the Middle East and Africa in 2017. The stand-out performances were by Egypt and the United Arab Emirates (U.A.E.), recording $2.6 billion and $2.2 billion respectively, in both cases many times their 2016 totals. In Egypt, some 1.3GW of solar projects from the second phase of the country's feed-in tariff program reached financial close by the deadline in October, with many of these around the 50MW mark. But the biggest single project to clinch investment in 2017 was in wind – the 263MW Gulf of Suez project, at $400 million.

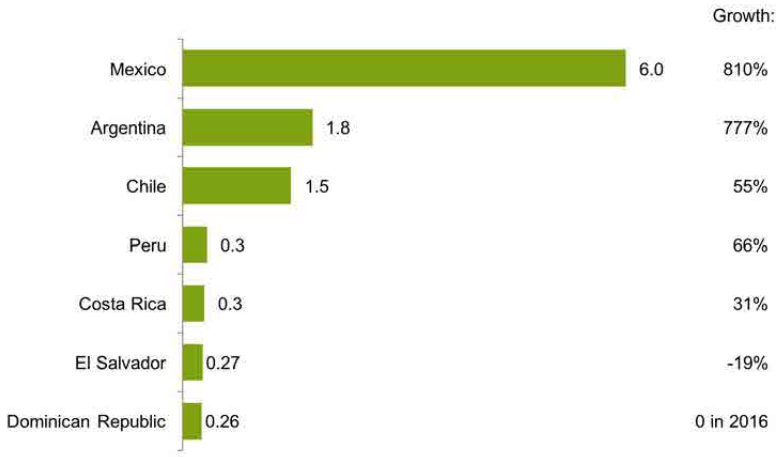
U.A.E.'s investment last year was more heavily concentrated. Two PV projects, the largest to go ahead anywhere in the world last year, reached financial close: the Sheikh Mohammed Bin Rashid Al Maktoum III installation, at 1.2GW and $899 million, and the Marubeni JinkoSolar and Adwea Sweihan plant, at 800MW and an estimated $968 million. Both projects have been financed by equity and debt from international development and commercial banks, and were won by international developers with keenly priced bids in 2016.

FIGURE 20. RENEWABLE ENERGY INVESTMENT IN MIDDLE EAST AND AFRICA BY COUNTRY, 2017, AND CHANGE ON 2016



Source: UN Environment, Bloomberg New Energy Finance

FIGURE 21. RENEWABLE ENERGY INVESTMENT IN LATIN AMERICA BY COUNTRY (EXCLUDING BRAZIL), 2017, $BN, AND CHANGE ON 2016



Source: UN Environment, Bloomberg New Energy Finance

Jordan saw renewables investment rise 26% to $1.1 billion, that country's highest ever, thanks to financing of utility-scale PV projects from its second round of auctions, aimed at meeting the country's growth in power demand. There is also growth in smaller-scale solar systems built by commercial customers wanting both to consume power and sell a surplus to the grid.

The biggest disappointment in African renewable energy investment in 2017 was the continued slump in South Africa. Local utility Eskom continued to refuse to sign power purchase agreements with renewable energy developers, without first securing cuts in electricity prices paid. The result was that commitments in that country fell to just $102 million, compared to $844 million in 2016, $3.5 billion in 2015 and the record figure of $5.6 billion in 2012.

Investment in renewables in Latin America (outside Brazil) was also heavily skewed to a few countries, as Figure 21 makes clear. Uruguay, which has seen strong activity in wind in recent years but then ran into market saturation, fell off the leaderboard, with investment there down 49% to $175 million. Chile, a consistent magnet for solar projects at low costs thanks to high insolation levels, continued to be a busy market, with investment up 55% in 2017 to $1.5 billion.

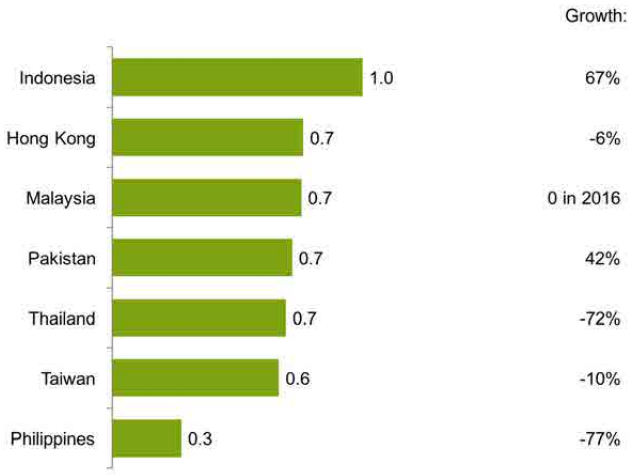
More of a surprise was Argentina, until recently a market that non-hydro renewable energy had passed by because of economic and political uncertainties. However, in 2017 investment there jumped nearly ninefold to $1.8 billion, with wind attracting $1.2 billion and solar $456 million. In 2016, the country set targets for renewable energy consumption and contracted 2.4GW of capacity via tenders. This led to significant project financings last year, including the 300MW Jemse Cauchari PV portfolio at $400 million, and the 195MW Arauco 2 wind farm at an estimated $302 million.

Mexico chalked up a record $6 billion of renewable energy investment in 2017, up 810% on the previous year. This was thanks to wind commitments of $3.3 billion, and solar outlays of $2.6 billion, both up roughly ninefold. The top projects financed included the 424MW Zuma Reynosa 3 wind farm, costing $772 million, and the year's third largest PV undertaking to reach that stage anywhere in the world, behind only the two in U.A.E. mentioned above. This was the 754MW Enel Villanueva PV portfolio, at $650 million. Renewable energy has been flourishing in Mexico thanks to plentiful resources for wind and solar, growing electricity demand, an auction program resulting in low-priced bids, and a government certificate scheme linked to a target for 13.9% of generation to come from green power by 2022.

Developing economies in Asia-Oceania excluding China and India had a mediocre year in terms of investment, as Figure 22 displays. Indonesia took top spot, at just $1 billion, thanks to the Supreme Energy Muara Laboh geothermal project, at 80MW and $610 million – continuing that country's leading position in that technology but also showing its lack of momentum in wind and solar.

Hong Kong owed its position in Figure 22 to public market activity, rather than to the build-out of renewable energy capacity – in particular, the $434 million initial public offering by China

FIGURE 22. RENEWABLE ENERGY INVESTMENT IN NON-OECD ASIA (EXCLUDING CHINA AND INDIA), 2017, AND CHANGE ON 2016



Source: UN Environment, Bloomberg New Energy Finance

Everbright Greentech, a company active in biomass generation technology. Elsewhere, there was a smattering of project financing in wind and solar, including the ItraMAS Scatec Malaysia PV portfolio, at 197MW and $292 million, and the Energy Logics Pasuquin East wind farm in the Philippines, at 132MW and an estimated $205 million.

Pakistan continued to attract investment in non-hydro renewables, particularly large-scale and small-scale solar, but its total of $695 million, while up 42% on 2016, was far below the average of $1.7 billion achieved in 2014 and 2015. The tempo could change in 2018, since its government announced in December 2017 that it would hold auctions for 600MW of solar and 400MW of wind.

The modest renewable energy investment figures for the populous South East Asian economies with fast-growing electricity demand resulted mainly from policy uncertainty. Indonesia announced competitive tenders for solar but the tender evaluation process has been unclear, and participation limited to a few developers. In the Philippines, developers of more than 1GW of wind projects have been unable to progress because of the lack of a suitable regulatory framework.

Thailand was host to $671 million of renewable energy investment in 2017, but this was down from $2.4 billion the previous year, mainly due to a cut in the size of the country's second Agro-Solar program and the introduction by the government of a new type of power purchase agreement less friendly to intermittent generation.

Vietnam announced a solar feed-in tariff but developers were in cautious mood over the bankability of power purchase agreements. Meanwhile, international investors and manufacturers have announced ambitious plans for wind projects in Vietnam, but so far the tariffs on offer have been insufficient for many projects to be built.

PUTTING RENEWABLE ENERGY INTO PERSPECTIVE

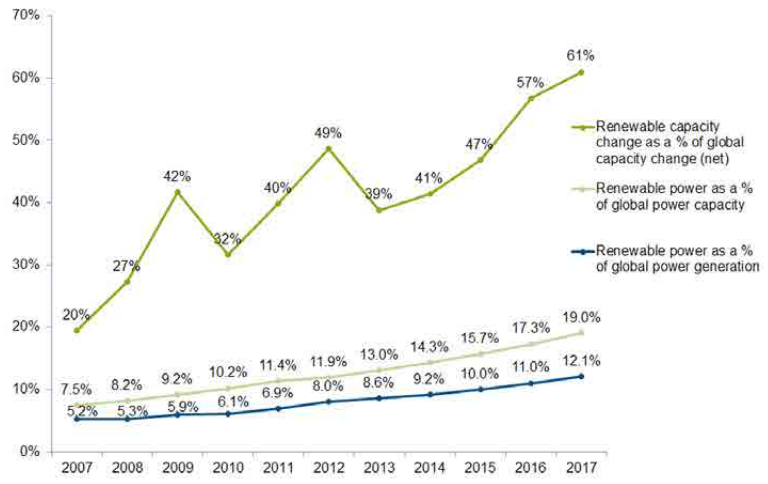
- Renewable energy excluding large hydro made up a record 61% of all the net power generation capacity added worldwide in 2017, with solar alone accounting for 38%.
- In electricity generation, new renewables still have a long way to go. Last year, they represented 12.1% of electricity produced worldwide, up from 11% in 2016. However, their contribution had the effect of preventing the emission of 1.8 gigatonnes of carbon dioxide.
- The $265 billion invested in new green power capacity in 2017, excluding large hydro, far exceeded the $103 billion invested in new fossil fuel generators, the $42 billion allocated to additional nuclear reactors, or the $45 billion to large hydro dams.
- Global sales of electric vehicles jumped 57% to 1.1 million in 2017, with China making up more than half a million of those. Falling battery costs are boosting the economics of electric vehicles. Lithium-ion battery pack prices dropped 23% to $209 per kWh last year.
- Carbon dioxide levels in the atmosphere reached 406.5 parts per million in 2017, up 2.3ppm on the previous year. Last year was the second hottest on record, behind only 2016's record of 0.99 degrees Celsius above the 1951-80 average.

GLOBAL GENERATION MIX

The rising importance of renewable energy in the global electricity generation mix is confirmed in three ways in Figure 23. The upper line shows the percentage of net new generating capacity added in each year that is made up of renewable technologies (excluding large hydro). This has increased spectacularly over the years, from just under 20% in 2007, to 39% in 2013, to 57% 2016 and 61% in 2017.

These percentages are worked out by taking the estimated gross additions in gigawatt terms for each technology (coal, gas, oil, nuclear, large hydro, small hydro, geothermal, biomass and waste, onshore and offshore wind, PV and solar thermal), and then subtracting the gigawatts of each

FIGURE 23. RENEWABLE POWER GENERATION AND CAPACITY AS A SHARE OF GLOBAL POWER, 2007-2017, %



Renewables figure excludes large hydro. Capacity and generation based on Bloomberg New Energy Finance totals.
Source: UN Environment, Bloomberg New Energy Finance

that is taken out of service. That gives a total net addition figure. The net addition of renewables excluding large hydro can be compared against that.

The middle line on Figure 23 shows the percentage of cumulative world generating capacity that is accounted for by renewables excluding large hydro. This has increased in almost a straight line, from 7.5% in 2007 to 13% in 2013 and 19% in 2017, as the gigawatts of new wind and solar plants added have grown and the net additions of fossil fuel power stations have decreased.

However, that line is capacity, not actual electricity generation. Clearly, wind and solar will always account for a higher proportion of capacity than generation, because they cannot produce power when the wind does not blow and the sun does not shine. The lower line on the chart shows that, in 2017, their share of total electricity produced grew to 12.1%, a record, up from 5.2% in 2007, 8.6% in 2013 and 11% in 2016.

There are two ways of looking at that 12.1% figure. One (the "glass seven-eighths empty" view) is to say that new renewables are still only generating a small share of world electricity, even after $2.9 trillion of investment since 2004. The other (the "glass one-eighth full" view) is to say that those projects that already exist saved the world from emitting 1.8 gigatonnes of CO2 last year.[10]

For renewables excluding large hydro, this report is putting the addition last year at 157GW, made up of 98GW of solar (almost all PV but with a few hundred MW of solar thermal), wind 52GW (mostly onshore but with about 5GW of offshore), biomass and waste-to-energy just over 3GW, small hydro just under 3GW and geothermal about 700MW.

[10] This is worked out by taking the International Energy Agency's estimate for global emissions from power generation in 2016 (13,353Mt), adjusting it to 2017 according to the IEA's trend to 2025. Then we assume that the 12.1% of generation coming from new renewables in 2017 was instead done by the same mix of technologies (fossil fuel, nuclear and large hydro) as the remaining 87.9%. That would have meant 1,838Mt of extra emissions. A similar exercise using BNEF's New Energy Outlook 2017 produces a figure of 1,809Mt saved last year.

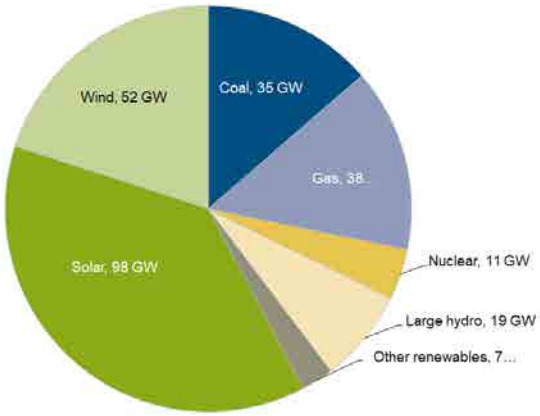
There was virtually no capacity withdrawn, so the net additions were almost exactly the same as the gross additions.

For fossil-fuel technologies, Bloomberg New Energy Finance estimates that in 2017 a net 35GW of coal-fired generation were added to the global fleet, after subtracting retirements totaling 32GW (mainly in the U.S. and Europe) from gross additions of 67GW (mainly in developing economies). The net addition of gas-fired plants was 38GW (made up of gross additions of 54GW and retirements of 16GW). The net addition of oil-fired capacity was minus 3GW (more capacity was switched to gas or closed, than opened). It is estimated that a net 19GW of large hydro dams were added, plus a net 11GW of nuclear.

So the net addition of renewables excluding large hydro adds up to 61% of all the net capacity installed in 2017, according to these estimates (note that the addition figures for all the different technologies may be revised during this year, as more information becomes available). The zero-carbon capacity, including also large hydro and nuclear, was equivalent to 73% of the net capacity added, and fossil-fuel power stations just 27%.

Figure 24 shows the estimated net addition of generating capacity in 2017 according to technology. A strong message is the extent to which solar dominated last year, not just in the context of renewables but in terms of all generating sources. Solar's 98GW of installations outnumbered by far wind's 52GW and the net 70GW of all fossil fuel technologies. Solar was equivalent to 38% of all the net new power capacity added worldwide in 2017.

FIGURE 24. NET POWER GENERATING CAPACITY ADDED IN 2017 BY MAIN TECHNOLOGY, GW



The chart does not show the negative addition of 3GW from oil-fired capacity
Source: UN Environment, Bloomberg New Energy Finance

COMPARING INVESTMENT

In 2017, some $265 billion was invested in new capacity of renewables excluding large hydro.[11] Bloomberg New Energy Finance estimates that just $103 billion was invested in new fossil fuel power stations around the world last year, consisting of $70 billion spent on new coal-fired power stations, $31 billion on new gas-fired plants and $2 billion on new on-grid oil-fired units. Many of the new coal plants were in China and India, many of the new gas turbines were in the U.S. or the Middle East. BNEF also estimates that $42 billion was invested in new nuclear reactors and $45 billion in large hydro-electric projects. The large hydro investment is discussed in a box at the end of Chapter 4 (Asset Finance).

There is a different profile to expenditures on wind and solar compared to those on coal, gas, oil and biomass generation. The former group of technologies incur the overwhelming majority of their lifetime costs upfront, at the construction stage, since the feedstock involved is free (sunshine and wind), and operations and maintenance expenses are relatively low. The latter group incur a larger share of costs during the operating phase, as fuel has to be purchased and transported.

Hydro-electric and geothermal are closer to wind and solar in terms of the profile of spending, as would be wave and tidal technologies – if those reach commercialization. Nuclear is somewhere in between the two groups, with a relatively high upfront capex, but also some ongoing expense on feedstock (uranium or other).

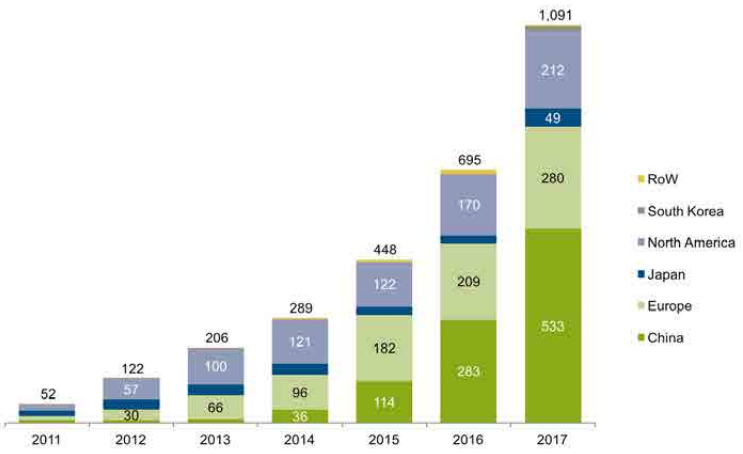
OTHER LOW-CARBON TECHNOLOGIES

Until recently, the incursion by renewables into the power generating mix was one of only two approaches that were having a clear-cut impact on emissions across a wide range of countries. The second was the effort to improve energy efficiency via products such as LED lighting, fuel economy in cars and buildings insulation. For instance, world investment in smart meters jumped 35% in 2017 to a record $18.5 billion.

[11] This is the £279.8 billion figure for total investment shown in the Executive Summary of this report, minus investment in biofuels and minus non-capacity investment (venture capital and private equity, public markets, corporate and government research and development).

Among other developments, coal-to-gas switching was having a big effect in some places such as the U.S., but not in the majority of countries. Carbon capture and storage had failed to take off, barring a few demonstration projects, mostly small. Nuclear reactors were under construction, but the share of that technology in the world electricity mix looked more likely to decline than rise – unless long hoped-for cost breakthroughs were made soon, either on large plants or small modular units.

FIGURE 25. GLOBAL SALES OF ELECTRIC VEHICLES 2012-2017, THOUSANDS



These totals include both battery electric vehicles, or BEVs, and plug-in hybrid electric vehicles, or PHEVs. They do not include conventional hybrids. RoW stands for rest of the world
Source: UN Environment, Bloomberg New Energy Finance

However, there is now a third major leg to global low-carbon efforts, and that is the electrification of road transport. Figure 25 shows that global sales of electric cars have soared from 122,000 globally in 2012 to 1.1 million in 2017, a compound annual growth rate of 66%. Almost half the world market (533,000) was estimated to be accounted for by China, with Europe on 280,000 and North America on 212,000.

Skeptics of electric vehicles, or EVs, would point out that 1.1 million cars still represent only 1.8% of world light-duty vehicle sales in main markets, and that in many countries – including China – electric car companies rely on tax breaks or other subsidies to encourage motorists to switch. However, like the proverbial acorn that becomes an oak, the EV market had to start somewhere. It is starting to reach higher levels of penetration in some markets, notably Norway at around 40% in the latter months of 2017.

There is also activity on the electrification of other areas of transport, notably buses. In 2017, some 386,000 electric buses were estimated to be on the road globally, a figure growing at some 30% a year, encouraged by concern about urban pollution. As with EVs, China is the biggest market for electric buses, accounting in 2017 for some 99% of the world total.

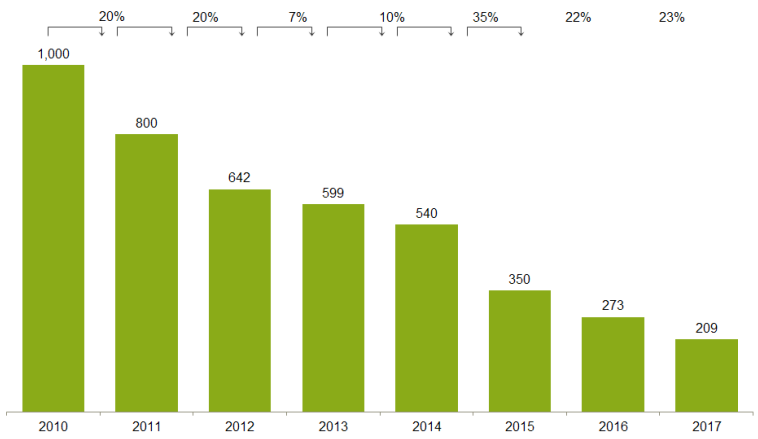
So far, the electrification of transport has had a miniscule effect on global emissions. The passenger EVs on the road in 2017 are estimated to have displaced only 101,000 barrels per day of transport fuel, compared to world consumption of more than 90 million barrels of crude oil per day. Overall, global transport demand for oil in 2016 resulted in 7.5 gigatonnes of CO2 emissions, just over half that from power generation, according to the International Energy Agency.[12]

So EVs have a long way to go before they have a material impact on transport emissions, and certainly compared to the 1.8Gt effect that "new renewables" are already having via the electricity system. However, cost reduction dynamics similar to those in solar and wind appear to be at work in batteries, the key component of EVs. If they continue, then relative economics could cause the EV share of the global car market to grow rapidly without subsidies during the next decade.

Figure 26 highlights how the cost of lithium-ion batteries has plummeted since 2010, as a result of improving technology and economies of scale as manufacturers move to higher-volume production. Modeling by Bloomberg New Energy Finance suggests that the average price per kWh, which fell to $209 per kWh in 2017, could decline to as little as $109 per kWh by 2025. This forecast depends to some extent on growth in the EV market continuing to generate scale efficiencies in production, and on the cost of key metals such as lithium and cobalt.

[12] IEA World Energy Outlook 2017

FIGURE 26. LITHIUM-ION BATTERY PACK PRICE, GLOBAL AVERAGE, $ PER KWH



Source: UN Environment, Bloomberg New Energy Finance

The latter have increased in price on world markets in recent months.

If these issues do not start to impinge on battery costs, and barring a collapse in world crude oil prices that might change the relative economics, Bloomberg New Energy Finance's forecast is that the lifetime costs of ownership of an electric vehicle could start to undercut that of an internal combustion engine car in most markets around the mid-2020s. By the mid-to-late 2020s, EVs could also "cross over" in terms of upfront purchase prices compared to conventional cars. If this comes to pass, then EVs could account for more than 50% of world light-duty vehicle sales by 2040, saving some 8 million barrels of transport fuel per day.[13]

Falling battery costs are, meanwhile, having a second important impact, and that is on the cost-effectiveness of battery storage in the electricity system. Batteries are emerging as one of the main options for providing "flexible capacity" in an electricity mix with large shares for variable generation sources such as wind and solar.

In 2017, a record 1.2GW of behind-the-meter and utility-scale battery storage projects were installed, up from just 139MW five years earlier.[14] Some 3.3GW of utility-scale projects were announced during 2017, suggesting further, substantial growth ahead.

EMISSION AND CLIMATE TRENDS

Despite the progress of new technologies such as wind, solar, EVs and battery storage, the challenge for the world on emissions and climate remains as daunting as ever. In 2017, the amount of carbon dioxide in the atmosphere hit 406.5 parts per million, up 2.3ppm since 2016, and 37ppm since the year 2000. Since records began at the National Oceanic & Atmospheric Administration monitoring station at Mauna Loa, Hawaii in 1959, the level of carbon dioxide has increased by 90.5 points, from 316 to 406.5ppm.

Emissions at current levels appear to be sufficient to keep pushing up the CO2 proportion by about 2 or 2.5ppm per year, even though the rate of growth of world emissions has slowed markedly. The International Energy Agency estimates that total CO2 emissions increased from 23 gigatonnes in the year 2000, to 32.1Gt in 2015, a compound growth rate of 2.2%. However, they stayed more or less static in 2017, and the IEA's forecast is for them to increase again, but only at a rate of 0.4% per year between 2016 and 2040.

Statistics on global temperature indicate that 2016 was the hottest year since 1880, and 2017 the second hottest. NASA's combined land surface, air and sea-surface water temperature index shows 2017 being 0.9 degrees Celsius hotter than the 1951-80 average globally, exceeded only by 2016 at 0.99 degrees hotter. A five-year moving average of this temperature "anomaly" has moved up from 0.46 degrees in 2000 to 0.83 degrees in 2017.

[13] Bloomberg New Energy Finance: Long-Term Electric Vehicle Outlook, 6 July 2017

[14] Bloomberg New Energy Finance: 1H 2018 Energy Storage Market Outlook

DELIVERING INVESTMENT

- Policy and other support mechanisms such as power purchase agreements still play an important role in underpinning returns and limiting risks for project developers, indirectly bolstering the availability of finance.
- The volume of auctioned renewable energy capacity, completed and announced in 2017, reached a record 50.6GW globally, up from 33.6GW in 2016. This is likely to back somewhere between $30 billion and $50 billion worth of investment.
- Mexican auctions broke all records, with average wind contracts agreed at $18.60 per MWh, and solar at $20.80 per MWh. India, where agreed bids are not inflation-indexed, also saw record-low results from auctions last year.
- Corporate power purchase agreements for renewable energy totaled 5.4GW in 2017. This represented a 27% increase over 2016, and was the highest annual figure yet.
- Low costs of capital reflected plentiful availability of finance, at least in mature markets. For instance, in Europe, banks provided long-term loans at much lower all-in rates than five years earlier, and institutional investors in 2017 put record amounts into renewable energy projects.
- Green bond issuance jumped 67% in 2017 to a record $163.1 billion. Two of the strongest features were non-financial corporations issuing green bonds, and asset-backed securities being issued on securitized small-scale solar systems.

TARIFF SECURITY

Investors in renewable power projects have historically relied on government policies to provide them with confidence about the prices they will receive for the electricity generated – and hence for project revenues. The costs of wind and solar have fallen in recent years, as discussed in the Executive Summary of this report, but most projects still rely on some sort of contract to set, or partially set, the electricity price received. Only a very few wind farms and solar parks around the world went ahead in 2017 purely on the basis of merchant power prices.

That security about the electricity price received can come from government programs, laying down a feed-in tariff that fixes the price, or a green certificate that supplements the merchant price. More recently, many countries have moved to auctions as a way of allocating new renewable energy capacity at a tariff that has been subject to an auction bidding process. In most cases, that bidding process has resulted in low tariffs compared to what was provided under previous incentive programs.

The other way of getting security about the electricity price received is via a power purchase agreement, or PPA – either with a utility or with a corporate buyer. This fixes the tariff for the project over a particular time period, which could be as short as one or two years or as long as 15-20 years. Normally, developers will aim for a long PPA in order to give confidence to equity investors and banks that their projects will earn sufficient cash-flows, for a financing package to be put together.

The coming section looks at policy support programs, and the next one at PPAs.

POLICY SUPPORT

Feed-in tariffs have been the most popular method around the world over the last decade to stimulate investment in renewable energy projects. Set by the government concerned, they lay down an electricity tariff that developers of qualifying new projects can expect to receive for the resulting electricity over a lengthy period, usually 15 to 20 years.

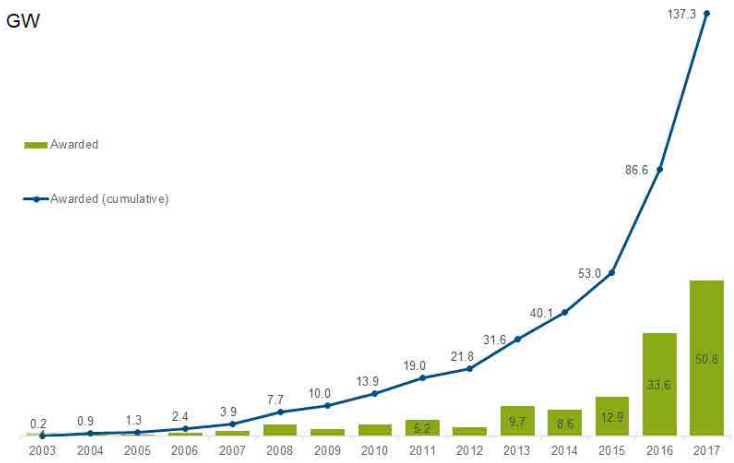
They were the main policy mechanism that led to heavy deployment of solar in countries such as Spain and Italy around the turn of the decade, and of both wind and solar in Germany throughout the last decade and a half. They underpinned strong activity in small-scale PV in Japan, particularly in the 2012-15 period, when some $84 billion was invested, and most strikingly in wind and solar in China over recent years. There was some form of feed-in tariff in operation in 35% of the emerging economies studied in the 2017 edition of the Climatescope report.[15]

Green certificates have also been used in some countries as a way of boosting the value of output from new renewable energy projects, but also leaving open some exposure to merchant electricity prices. They were the main policy instrument for driving onshore and offshore wind additions in the U.K. up to the middle of this decade, plus also onshore wind in Romania and Italy earlier in the decade, and the same technology in Sweden and Norway right up to now.

Feed-in tariffs and green certificates were both successful in driving deployment. But they ran into the criticism that the resulting electricity costs for consumers was higher than they needed to be, because there was insufficient incentive for project developers – and the supply chain behind them, including manufacturers, construction contractors, landowners and financiers – to squeeze costs. That prompted an increasing shift by governments over recent years away from those policy support mechanisms, to auctions.

[15] Climatescope 2017: The Clean Energy Country Competitiveness Index (Bloomberg New Energy Finance and UKAID)

FIGURE 27. GLOBAL AUCTIONED RENEWABLES CAPACITY, 2003-2017, GW



Excludes 60.8TWh of renewable electricity auctioned in Chile between 2006 and 2017, because it was not allocated on a GW basis

Source: Bloomberg New Energy Finance

The principle behind auctions is that they provide transparency on costs, with only the most aggressive cost-cutters among the developers submitting bids likely to be rewarded with tariffs. Figure 27 shows that the amount of capacity globally being awarded as a result of auctions has been increasing sharply since 2012. In 2017, a total of 50.6GW of renewables were given tariffs in auctions, up 51% on 2016 levels and 18-fold since 2012. Increasingly, auctions are being announced well in advance, giving developers a clearer sight of the opportunities ahead.

This acceleration in auction activity in 2017 was most pronounced in Europe, where the capacity awarded jumped to 25.2GW, from 5GW the previous year, as countries such as the U.K., Germany and Netherlands put offshore wind through this process, and as Spain held an auction for solar.

The headlines included a German onshore wind auction in September for 1GW of capacity that saw winning bids fall 11% to a record low of EUR 38 per MWh (equivalent at the time to $44.6); a Dutch offshore wind auction in December for a 700MW project that attracted several bids without any subsidy at all; and a U.K. auction in September that saw Contracts for Difference agreed for more than 3GW of offshore wind to be built by 2022-23 at GBP 57.50 per MWh in 2012 prices, some 50% cheaper than the country's first CfD auction in early 2015.

The lowest tariffs from 2017's crop of auctions, however, came from Mexico. In November, its third power auction, for 1.3GW of PV projects and 857MW of wind farms, attracted average solar bids of $20.80 per MWh, and average wind bids of $18.60 per MWh. Both figures are regarded as world record-lows.

Japan, India and Argentina also held auctions for renewables that produced results that were noteworthy in one way or another. In Japan, an eagerly awaited auction in November attracted a disappointing level of interest from bidders, due to worries over grid connection and the penalties for non-delivery. Bids were accepted for only 141MW out of the 500MW limit and the average price, of 19.64 yen per kWh – although 18% below the previous feed-in tariff – was high by international auction standards.

By contrast, in May, India auctioned 500MW of PV projects in Bhadla solar park in Rajasthan at the rupee equivalent of $37.90 per MWh, some 26% lower than the previous auction a few months earlier. Unlike other auctions around the world, winning tariffs in India are not inflation-indexed, so their real value rapidly erodes.

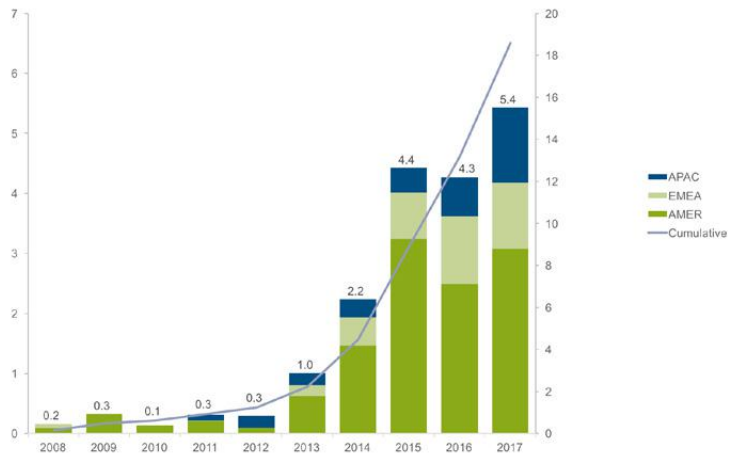
And in Argentina in November, the government contracted 1.4GW of new capacity, with wind, solar and biomass sharing most of that figure. Wind's average price was $41 per MWh, and solar $43 per MWh, figures well above those in Mexico last year. However, this was the first auction held in Argentina, a country relatively new to non-hydro renewable energy investment, and the big international players who loomed large in many other auctions around the world in 2017 were unable to take part – so the winning bids came only from smaller, local players.

POWER PURCHASE AGREEMENTS

The other way for project developers to get reassurance on future power prices is to sign a PPA with either a utility or a significant corporate buyer of electricity. Utility PPAs have long been a feature of the U.S. market, where the main method of incentivizing renewable energy build-out has been via the Production Tax Credit for wind and the Investment Tax Credit for solar.

These provide investors in the 'tax equity' of renewable energy projects with a credit that they can use to offset tax liability elsewhere in their businesses. Estimates are that some $12 billion of tax equity was required for wind and solar in the U.S. in 2017, roughly on a par with the previous two years.[16] In addition to tax equity, developers often agree a PPA with a local utility, to nail down a fixed selling price for their electricity.

FIGURE 28: GLOBAL VOLUME OF CORPORATE POWER PURCHASE AGREEMENTS SIGNED, BY REGION, 2008-2017, GW



Onsite PPAs not included. APAC number is an estimate. Pre-market reform Mexico PPAs are not included. APAC is Asia-Pacific, EMEA is Europe, Middle East and Africa, AMER is the Americas.
Source: Bloomberg New Energy Finance

In an increasing number of cases, however, these PPAs are not with a utility but with a corporate electricity customer. In 2017, corporate buyers in the U.S. signed power purchase agreements for the output from 3.1GW of renewable energy projects. As Figure 28 shows, the worldwide total came to 5.4GW, a 27% increase over 2016, and the highest ever.

Corporations have signed contracts to purchase nearly 19GW of clean power since 2008, an amount comparable to the generation capacity of Portugal, with 76% of this activity coming since 2015.

The largest deal anywhere in 2017 was in Europe, in the shape of aluminum producer Norsk Hydro's commitment to purchase most of the electricity from the 650MW Markbygden Ett wind farm in Sweden, from 2021 to 2039.

In Asia, most of the 3.2GW of offsite PPA contracts signed since 2008 have been in India. Cheap renewable energy resulting from competitive auctions, coupled with concern about security of supply and volatile electricity prices, have prompted numerous Indian and multinational corporates to sign PPAs.

SOURCES OF EQUITY AND DEBT

As Chapter 4 on asset finance shows, most renewable energy projects are financed in one of two ways – either on-balance-sheet by a utility, independent power producer or other investor; or using non-recourse project finance, typically made up of a large debt slice from banks, and a smaller equity slice from developers and other investors.

The cost of this capital for renewable energy projects has been exceptionally low in recent years. Because wind and solar projects incur the dominant part of their lifetime costs upfront, at the construction stage, not during the operating phase, this low cost of capital has helped to push down levelized costs of electricity for these technologies, contributing to the trend seen in Figure 9 in the Executive Summary of this report.[17]

Here are some examples of this reduced cost of capital. First, on-balance-sheet finance: this tends to be done by utilities, which in turn rely on bond markets to provide their central funds. Italy-based Enel was one of the largest single investors in renewable energy projects in 2016 and 2017. In January 2017, its Enel Finance International entity issued EUR 1.25 billion of 10-year bonds at a coupon of 1.375%. In October 2012, it issued EUR 1 billion of 10-year bonds at a coupon of 4.875%.

[16] Tax Equity Update 2017, Bloomberg New Energy Finance. https://www.bnef.com/core/insights/15996

[17] Other technologies, such as coal-fired, gas-fired and biomass generation, have a much larger part of their total costs incurred during the operating phase – particularly buying and handling fuel. So low costs of capital for upfront construction do not push down their LCOEs as much as they do for wind and solar.

Second, non-recourse debt finance for projects: most often, this takes the form of bank loans. Bloomberg New Energy Finance estimates are that the initial all-in cost of debt for an onshore wind project in France, after agreeing an interest rate swap to fix the cost of borrowing, was around 5% in 2012 but had fallen to between 2% and 2.5% in 2017. Reductions in European Central Bank interest rates, narrower commercial bank margins on loans, and cheaper interest rate swaps all contributed to this shift. These helpful effects will not necessarily last, as the Executive Summary of this report discusses.

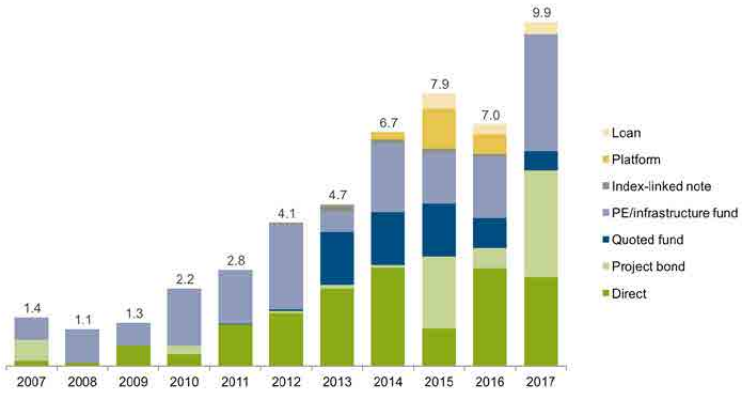
Often, after that original on-balance-sheet or debt-plus-equity funding and after they progress to a somewhat lower-risk phase, projects are refinanced. This is often post-construction, but sometimes immediately pre-construction or during construction. This refinancing stage has become the commonest moment for institutional investor cash to be deployed into the equity of renewables projects.

Figure 29 shows that institutional investor commitments to European renewable energy projects hit a record in 2017, of $9.9 billion, up 42% on 2016. This measure covers a number of different ways in which money from pension funds, insurance companies and other institutions reaches projects. These are direct investment in project equity; the purchase of project bonds; investment via quoted project funds or private equity or infrastructure funds devoted to European renewables; the purchase of index-linked notes in projects; investment via platforms set up by specialist investors; and direct provision of loans to projects.

This measure is not a comprehensive one covering all institutional activity. For instance, it excludes the sale of equity by renewable energy project developers, and it excludes money raised by funds that invest in other infrastructure sectors, not just green energy, and money raised by renewable energy funds that invest a large proportion of their capital outside Europe. However, it does give an idea of the trend.

Two of the biggest transactions of 2017 that are included in Figure 29 were Copenhagen Infrastructure Partners' raising of $2.1 billion for its third private equity fund oriented towards renewables; and the purchase for $2.7 billion of a 50% stake in Orsted's 659MW Walney Extension offshore wind project in the U.K. North Sea, backed by a bond issue.

FIGURE 29: INSTITUTIONAL INVESTOR COMMITMENTS TO EUROPEAN RENEWABLE ENERGY PROJECTS, $BN



Source: UN Environment, Bloomberg New Energy Finance

DEVELOPMENT BANKS AND ECAs

Multilateral development banks have been important providers of finance for renewable energy for more than a decade, often backing projects in countries where commercial banks are concerned about risk, or in technologies where commercial banks are only just starting to get comfortable.

Eight of the largest development banks, led by KfW of Germany, the European Investment Bank and the World Bank Group, lent $55 billion between them to clean power in 2016, a figure comparable to that in other recent yeas. This total includes funding for energy efficiency and transmission, as well as for renewables projects. KfW was by far the largest contributor, with $34.1 billion of commitments, up from $30.7 billion in 2015.[18]

Figures from some development banks for 2017 had not been published by the time this report went to press. However, the European Investment Bank said it provided finance for renewables totaling EUR 4.7 billion in 2017, up from EUR 3.9 billion in 2016.

Export credit agencies, or ECAs, have also become vital elements in financing packages, particularly for large-ticket projects. Their presence has the effect of covering at least in part the exposure of bank lenders to the project, protecting them from problems such as equipment failure or breach of contract by the electricity off-taker. Because it takes away some of the risk from lenders, it has the effect of reducing the interest rate payable on debt. In some cases, this may be the difference between a project being economically viable, and it not being so.

One of the biggest ECA interventions in 2017 was the cover by German ECA Euler Hermes for just under half of the EUR 500 million of debt provided for the 650MW Markbygden Ett onshore wind project in northern Sweden.

Some countries' export-import banks can provide actual debt as well as cover for other lenders. In November, for instance, the Export-Import Bank of China said it would provide the debt finance for the 300MW Cauchari solar park in Argentina. The same month, India's Export-Import Bank said it would hand Nigeria $100 million in concessionary loans to fund power projects, including two gas-fired plants and one solar park.

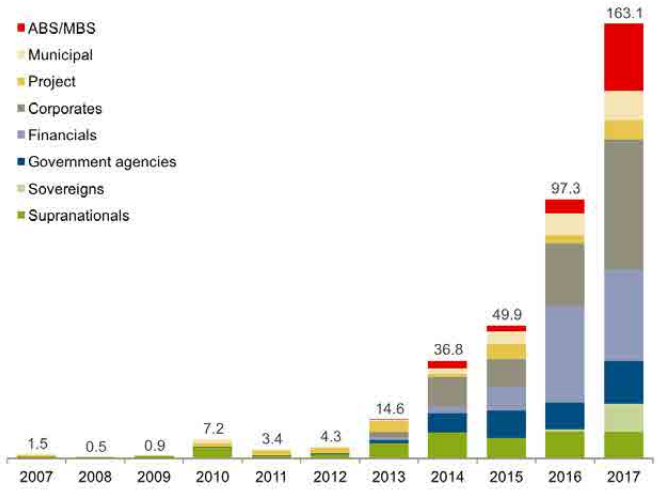
[18] BNEF Research Note: Eight Development Banks Lent Clean Power $55 Billion in 2016, 7 August 2017. https://www.bnef.com/core/insights/16747/view

GREEN BONDS

Green bonds include qualifying debt securities issued by development banks, central and local governments, commercial banks, public sector agencies and corporations, and asset-backed securities and green mortgage-backed securities, and project bonds. Last year, total global green bond issuance jumped 67% to $163.1 billion, as Figure 30 shows.

Three of the features of last year were a leap in the volume of asset-backed securities issued – these were mainly linked to residential solar systems in the U.S.; growth in green bond issuance by sovereign governments, with France, Fiji and Nigeria joining the trend; and, perhaps most significantly, a jump in issuance by non-financial corporations.

FIGURE 30. TOTAL GREEN BOND ISSUANCE BY CATEGORY, 2007 TO 2017, $BN



SSA stands for supranational, sovereign and agency; ABS stands for asset-backed securities; MBS stands for mortgage-backed securities

Source: Bloomberg New Energy Finance

The volume of green bonds issued is not directly linked to the volume of new investment coming into renewable energy shown in Figure 1 in the Executive Summary. This is because the only types of green bond shown in Figure 30 that channel money directly into projects are the project bonds ($7.3 billion in 2017), and even those are mostly issued at the refinancing stage, not at the point where the wind farm, solar park or other renewable energy installation is first financed. However, most of the categories provide indirect support for renewable power investment, for instance ring-fencing money at supranational development banks or corporations that has to be used in the future for projects that meet set green credentials. These can be related to emission reduction, or to energy efficiency, or to water use reduction, but they are often related to renewable generation.

ASSET FINANCE

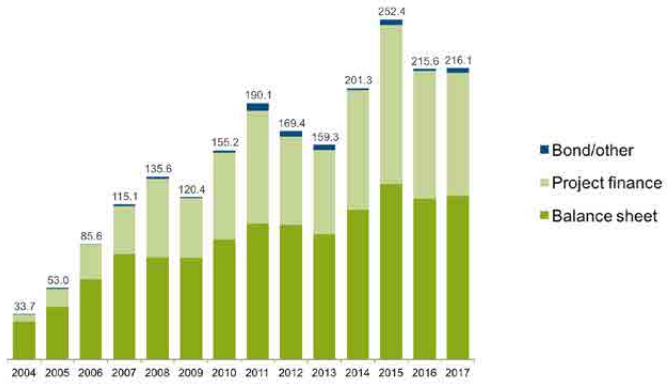
- Asset finance of new renewable energy projects (excluding large hydro) reached $216.1 billion in 2017, an increase of just 0.2% or $500 million on the previous year. Solar in China was the biggest feature by far, at $64.9 billion.
- Globally, wind and solar power projects still dominate investment in utility-scale renewable energy. The two leading sectors accounted for $208.6 billion, or 97% of the total in 2017, with biomass and waste, geothermal, small hydro and marine making up just 3%.
- Renewable energy projects in China attracted $103.3 billion of asset finance, a 14% increase on the previous year, with a jump for solar outweighing a decline for wind. Europe and the U.S. maintained their positions as second and third biggest regions respectively for asset finance.
- The Americas region excluding the U.S. and Brazil attracted $12.8 billion of renewable energy asset finance last year – more than double the amount for 2016. Mexico, in particular, performed well, attracting more than ten times the amount it did in 2016.

Asset finance of utility-scale renewable energy projects of more than 1MW totaled $216.1 billion in 2017, up 0.2% on the $215.6 billion reached in 2016. These figures exclude hydro-electric projects of more than 50MW (discussed in a box at the end of this chapter).

Figure 31 shows the split in last year's asset finance total between on-balance sheet financing on the one hand, and non-recourse project finance on the other. On-balance sheet financing of projects by utilities and energy companies amounted to $121.5 billion, up 2% on the 2016 figure, while non-recourse project finance came to $91.2 billion, down 4%. The latter category consists of packages of equity and debt linked to the project vehicle itself, rather than the corporate developer of the project. In non-recourse deals, debt almost always makes up the majority of the project value, and equity the minority.

The final category on the chart is for bond and other financings, which increased by almost 90% from 2016 to 2017. In fact, bonds hardly figured in 2017 for new-build projects, being used almost always for refinancing. The "bond and other" total this time reflects a string of leasing deals, and one big U.S. rooftop PV deal that did not fit neatly into either on-balance-sheet or project finance categories.

FIGURE 31. ASSET FINANCE OF RENEWABLE ENERGY BY TYPE, 2004-2017, $BN



Total values include estimates for undisclosed deals
Source: UN Environment, Bloomberg New Energy Finance

The balance between on-balance-sheet and non-recourse project finance shifted further in 2017, with project finance accounting for 42% of the total, compared with 44% in 2016 and 47% the previous year. One reason for the recent decline in this percentage could be more energy companies opting to finance initially on balance sheet, with a view to bringing in institutional investors to share the cost at a slightly later stage. Also, the trend towards corporate power purchase agreements may have contributed, since banks may offer less debt to a project if the time period of contracted cash flows under the PPA is shorter than under a government-backed feed-in tariff scheme.

REGIONS

China once again accounted for an outsized, if not quite the lion's, share of asset finance of renewable energy projects in 2017, with $103.3 billion invested. This equated to 48% of the global total. In comparison, the U.S. and Europe each accounted for 14% of the total – a significant decrease for Europe, which in 2016 had contributed 23% to global asset finance. Project investment in China was well up on the previous year, when it accounted for 42% of the global total with a figure of $91 billion. This was largely due to solar – which accounted for 63% of Chinese asset finance in 2017.

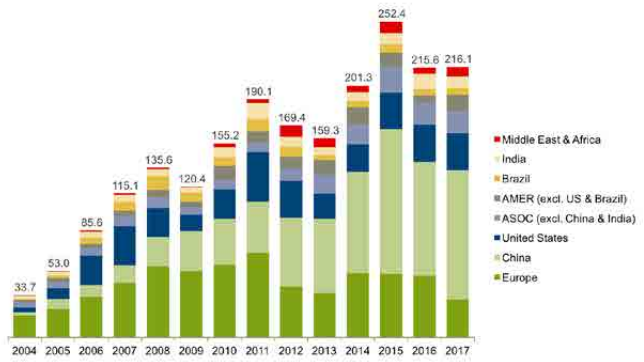
Wind projects attracted $35.4 billion of investment in China last year, including the commitment of an estimated $10.8 billion to finance construction of 13 offshore wind projects with total capacity of 3.7GW. The largest of these projects was the 400MW CGNWP Yangjiang Nanpengdao offshore wind farm that raised some $1.2 billion and is expected to be complete in 2020. In solar, there were big transactions in both PV and thermal. In PV, the largest recorded project by value was the 372MW Jiangxi Municipal Poverty Alleviation PV Plant for an estimated cost of $653 million. In solar thermal, the largest was the China Three Gorges Jiuquan Jinta Molten Salt Tower, at 100MW and an estimated $421 million.

Figure 32 shows the breakdown of assets financed over the years by region. Europe maintained its position as the second most important region in 2017, but only by a small margin over the U.S., contributing $30.4 billion against the latter's $29.3 billion. Europe's total was down 38% from its 2016 total, reflecting a sharp fall in offshore wind financings, of 60%, and a much smaller drop in onshore wind deals. European solar asset finance edged up to $2.8 billion in 2017, from $2.3 billion, while there was a reduction of 83% in capital for biomass and waste projects, with less than $600 million committed in 2017.

The U.S. came in third place among the regions for asset finance last year, contributing $29.3 billion, down slightly from $29.5 billion the previous year. Investment in wind projects rose 27% to $19.6 billion for 2017 – the highest annual figure for wind energy on record, while investment in utility-scale solar power fell 31% to $9.5 billion. The largest wind project by far to reach financial go-ahead was the Oklahoma Wind Catcher, which at 2GW of capacity will cost $2.9 billion to build. The second largest was the Texoma Wind Portfolio on the Texas-Oklahoma border, at 500MW and $775 million.

Taking a look at the other regions in the chart, the Americas (excluding the U.S. and Brazil) enjoyed asset finance of $12.8 billion in 2017 – more than double the previous year's amount. Canada, Mexico and Argentina were all top performers, seeing substantial increases in

FIGURE 32. ASSET FINANCE OF RENEWABLE ENERGY BY REGION, 2004-2017, $BN



Total values include estimates for undisclosed deals
Source: Bloomberg New Energy Finance, UN Environment

utility-scale commitments. Mexico alone attracted more than 10 times the amount it did in 2016, with $5.8 billion committed last year. Much of this will be used to finance wind and solar projects contracted in the power auctions of 2016, some of which produced record-low prices. Mexico's largest project financing of 2017 was the 424MW Zuma Reynosa III Wind Farm for an estimated cost of $772 million. Argentina saw a near-eightfold rise in asset finance to $1.8 billion, as much of the 2.4GW of renewable projects contracted in tenders in 2016 reached financial close. Canada recorded $2.2 billion of project financings in 2017 – some 84% up on the previous year, albeit still less than half the $5 billion-plus figures of 2013 and 2014. Chile saw asset finance of $1.4 billion, up 46% year-on-year but well below the $3.9 billion peak reached in 2015.

Figure 32 shows that Brazilian asset finance for renewable energy increased from $4.9 billion in 2016 to $5.5 billion in 2017, with around two-thirds of this amount committed to wind energy. Investment figures are well down on the heights of 2011-2012, due to an oversupply of power and lack of distribution lines, making utilities and developers wary about contracting new generation. India saw lukewarm demand for new project finance in 2017, with investment falling 24% to $9.4 billion. The largest project to be financed last year in India was the 500MW APPGCL Andhra Pradesh PV Plant for $400 million.

The Middle East and Africa region saw asset finance increase by 48% to $7.4 billion last year. Some particular bright spots were the U.A.E, where finance jumped from almost nothing in 2016 to $2.1 billion in 2017, and Egypt, where it leapt from $400 million to $2.6 billion. Just four projects were asset-financed in the U.A.E. last year but two of these were very large solar PV arrays, of 1.2GW and 800MW respectively, for the Marubeni JinkoSolar and Adwea Sweihan PV Plant and the Sheikh Mohammed Bin Rashid Al Maktoum III PV Plant. These had estimated costs of $899 million and $968 million respectively. In Egypt, 24 deals were financed in 2017, compared to just two in 2016. A market that performed less well in the region was South Africa, where investment fell almost 100% year-on-year, due to the failure of state utility Eskom to sign power purchase agreements for projects contracted in auctions. Back in 2012 and 2013, South Africa recorded $5 billion-plus figures for asset finance.

The Asia-Oceania region excluding China and India managed an increase of just 1% in asset finance last year, to $18.1 billion. In Australia, investment increased more than threefold to $6.6 billion; and in Indonesia by 59% to $1 billion. But Japan saw a drop of 23% to $6.6 billion; and Thailand 77% to $504 million, due to a policy change in 2016 whereby applications for utility-scale wind and solar projects were no longer accepted.

Figure 33 lists the top 10 countries in the world for renewable energy asset finance. China's first place position is cemented at $103.3 billion, a 14% increase on the previous year, while the next four countries have all seen decreasing investment volumes – the U.S. down 1%, India down 24%, Germany with $7.6 billion, down 32%, and the U.K. with $6.7 billion, down 67%. New entrants to the top 10 list are Australia, Mexico, Brazil and Sweden in order of investment value.

WIND

Wind and solar power continued to dominate asset financing of renewable energy last year, as shown in Figure 34. These two technologies raised $104.3 billion each in 2017 – jointly accounting for 97% of the $216.1 billion global total.

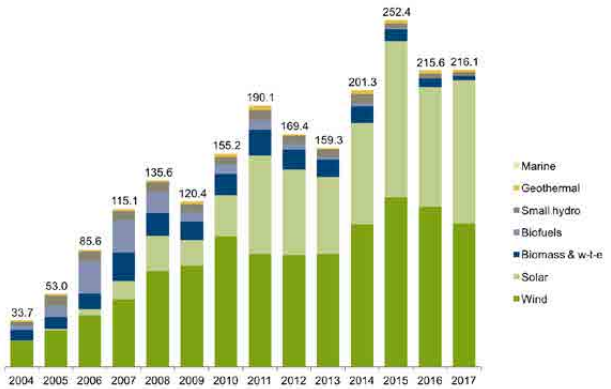
Investment in wind energy had its second successive year-on-year decline in 2017, this time by 10% on 2016's figure. Both offshore and onshore wind investment dropped in comparison to 2016, with onshore wind declining 6% to $83 billion, and offshore wind experiencing a steeper decline of 26% to $21.3 billion (see Figure 35).

FIGURE 33. ASSET FINANCE BY TOP 10 COUNTRY, 2017, AND CHANGE ON 2016

	2017	% growth on 2016
China	103.3	14%
United States	29.3	-1%
India	9.4	-24%
Germany	7.6	-32%
United Kingdom	6.7	-67%
Australia	6.6	212%
Japan	6.6	-23%
Mexico	5.8	970%
Brazil	5.5	11%
Sweden	3.6	207%

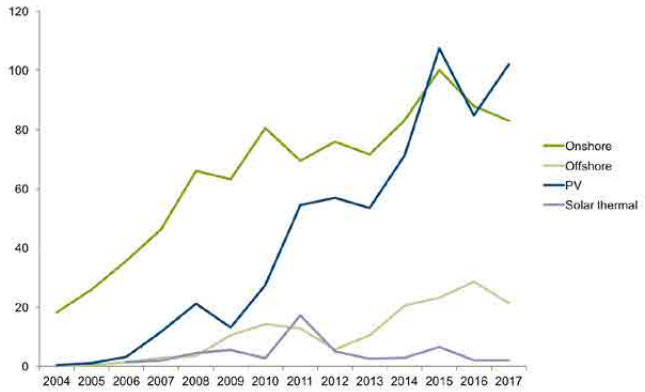
Top 10 countries. Total values include estimates for undisclosed deals
Source: UN Environment, Bloomberg New Energy Finance

FIGURE 34. ASSET FINANCE OF RENEWABLE ENERGY BY SECTOR, 2004-2017, $BN



Total values include estimates for undisclosed deals
Source: Bloomberg New Energy Finance, UN Environment

FIGURE 35. ASSET FINANCE OF WIND AND SOLAR PROJECTS WORLDWIDE, BY SUB-SECTOR, 2004-2017, $BN



Total values include estimates for undisclosed deals
Source: Bloomberg New Energy Finance, UN Environment

Offshore wind costs have declined in the past couple of years as developers compete for contracts in auctions, meaning that less investment is required per megawatt of capacity. The average capital expenditure for offshore wind has fallen from $4.1 million per MW in 2016 to $3.7 million per MW in 2017.

Onshore wind investment in 2017 fell to its lowest level since 2013, as a result mainly of a drop in activity rather than lower costs. Some 47GW of onshore wind projects were commissioned last year, down from 53GW in 2016, with China responsible for a sizeable part of that reduction.

The 2GW Oklahoma Wind Catcher project in Texas was the biggest onshore wind project financed by far last year, at $2.9 billion. The equity for the wind farm has been provided by developer Invenergy and it is expected to be acquired by Southwestern Electric Power and Public Service Company of Oklahoma once it connects to the grid.

Globally, there were 12 onshore wind projects financed last year, estimated to cost more than $500 million to build. Two projects costing in excess of $900 million were the 300MW Nigig Henvey Inlet Wind Farm in Canada and the 650MW Markbygden Ett Wind Farm in Sweden.

The second stage of the Hornsea array in the U.K. was the largest offshore wind project financed in 2017, at 1.4GW. For an estimated capital cost of $4.8 billion, stage two should be less expensive than stage one of Hornsea, which is estimated to be costing $5.7 billion for 1.2GW of capacity and reached financial close in 2016. Hornsea Project Two won support in the U.K. Contract for Difference auction on 11 September 2017 and will be financed by Orsted, the Danish company formerly called Dong Energy. It will be completed in three phases, with the final phase expected to commission in 2025.

As many as 13 of the 18 offshore wind financings in 2017 were located in China, with the remaining projects situated in Germany and the U.K. Apart from Hornsea 2, these included the 497MW Hohe See project off Germany, at $1.9 billion, and the 252MW Deutsche Bucht array, also in German waters.

SOLAR

Solar asset finance increased by 20% in 2017 to $104.3 billion globally, largely due to a ramp-up in Chinese investments, which accounted for 63% of the total. The global increase is all the more significant given that the average utility-scale PV system was about 25% cheaper per megawatt in 2017 than two years earlier.

By sub-sector, funding of utility-scale solar PV projects increased by 20% to $102.2 billion, while funding of solar thermal, or CSP, plants advanced by 5% to $2.2 billion.

There were just seven solar thermal projects financed in 2017; all were located in China and had capacity in the range from 50 to 100MW. Six of the seven projects were for salt tower technology and the remaining project will use parabolic trough technology. The two largest, both at 100MW, were the Jiuquan Jinta Molten Salt Tower plant built by China Three Gorges, and the Inner Mongolia CNI Royal Tech Wulatezhongqi installation. China has set a target to reach 5GW of solar thermal capacity by 2020, and has awarded a feed-in tariff of $170/MWh to 1.3GW of projects that must commission by 2019.

Two of the biggest PV projects by capacity globally were in the U.A.E., as mentioned above. Other supersized PV plants getting the go-ahead last year included the 328MWMount Signal III complex in California, the 754MW Enel Villanueva solar park in Mexico and the 270MW EGP DIF Bungala portfolio in South Australia.

OTHER SECTORS

Geothermal project financing decreased by 36% between 2016 and 2017, with $1.4 billion invested, the lowest level for four years. Some 11 significant projects reached financial close last year, with Indonesia and the Netherlands accounting for three projects each.

Indonesia's Supreme Energy Muara Laboh Geothermal Plant Phase I, with 80MW of capacity and costing $600 million, was the largest geothermal project in 2017, and the 55MW ICE Borinquen I Geothermal Project in Costa Rica for $230 million came in second place. Indonesia holds 40% of the world's geothermal power potential, according to estimates, and the country aims to install 4.4GW of that technology between 2017 and 2026. Favorable regulation for geothermal development includes expedited permitting for drilling rights, although a lack of reliable mapping can hinder exploration activity.

Financing of small hydro projects (greater than 1MW and less than 50MW) slipped last year to $3 billion, from $3.5 billion, continuing a downward trend that has been in place since 2014. Brazil, Argentina and Peru contracted small hydro projects in previous years' auctions, where the power price was guaranteed under long-term power purchase agreements, and were subsequently financed in 2017. China remains the biggest market – its Five-Year plan aims to commission an extra 5GW of small hydro, to bring the total to 80GW by 2020. Other countries seeing projects just short of 50MW financed in 2017 included Russia, Uganda and Ecuador.

Investment in biofuels shrunk to its lowest level on record last year, as only one project was financed – the IGPC Aylmer Bioethanol Plant Phase II in Canada for $113 million. Demand for biofuels has shrunk due to unfavorable economics, and a switch on the part of policy-makers towards encouraging electric cars rather than ethanol or biodiesel. Countries that mandate the use of biofuels, such as the U.S. and Brazil, already have sufficient capacity.

Biomass and waste-to-energy projects attracted less than half the amount of finance in 2017 that they did in 2016. Some 36 projects raised $3 billion of capital last year, the lowest figure on record for the sector since 2004. One reason for the fall was that the U.K., one of the biggest markets in recent years for biomass conversions and dedicated plants, brought to an end its Renewable Obligation support program, and the Contract-for-Difference auctions that replaced it have so far been dominated by offshore wind, with little space for biomass.

China, Japan and India were the leading locations for the financing of biomass and waste installations in 2017. Among the largest projects to get the go-ahead were the 112MW Sumitomo Heavy Air Water Chugoku Electric Hofu Biomass Plant in Japan, at $313 million, and the 75MW Buzen New Energy Biomass Plant also in Japan, at $216 million.

LARGE HYDRO

Large hydro-electric projects of more than 50MW are not covered in the main part of this report, partly because this is a long-established technology in the generation mix of many countries. In addition it is difficult to track the trends in large hydro investment because of the long – sometimes decade-or-more – construction periods. Often big dams commence construction, suffer delays or even stoppages, and may be part-financed at different times.

They are, however, important in terms of electricity generation worldwide, accounting for some 13% of the total in 2017. And they are also significant in investment terms, albeit now much smaller than either solar or wind, as shown in Figure 8 of the Executive Summary of this report.

Using the same methodology as for the other renewable energy technologies in this report, in other words capturing the whole value of a project at the moment of final investment decision, asset finance of large hydro is estimated to have been $45 billion in 2017, up from $22 billion in 2016 but close to the total for 2015.

The biggest project, by far, to clinch financing in 2017 was the 16GW Baihetan dam on the Jinsha River, in southwest China. The second largest hydro-electric project ever, Baihetan will be built by developer China Three Gorges, at a cost in yuan equivalent to $28 billion, and is due to be fully operational in 2022. Other projects reaching key financing milestones included the 870MW Suki Kinari dam in Pakistan, the 260MW Don Sahong in Laos and the 254MW Genale Dawa 3 in Ethiopia.

The 3GW Mambilla project in Nigeria also made strides forward last year, with a construction contract signed between the government and a Chinese consortium led by Sinohydro and China Gezhouba. Costing an estimated $5.8 billion, it is due to be finished within six years.

Despite this activity, statements from specialist hydro-electric equipment suppliers have generally been downbeat in the last year. Andritz, for instance, said at the time of its third-quarter 2017 results that it was facing an "unchanged, challenging market environment, with only a few medium-sized projects awarded". One of the stronger parts of the hydro market worldwide in 2017 was pumped storage, with China ordering turbines for a 6GW project in Hebei Province.

SMALL DISTRIBUTED CAPACITY

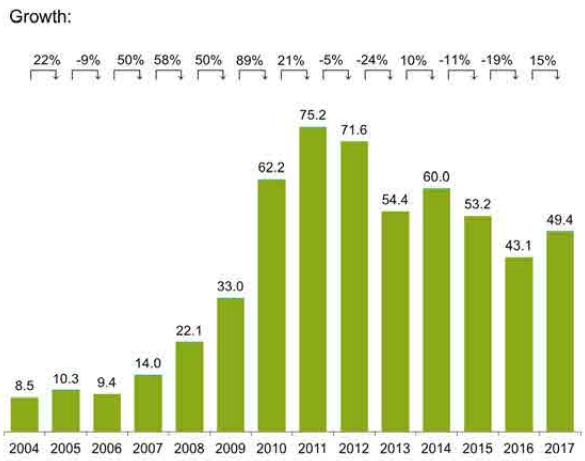
- Worldwide investment in solar projects of less than 1MW increased by 15% to $49.4 billion. This included a mix of residential and commercial rooftop systems, off-grid units in remote areas, and ground-mounted projects with tens, hundreds or a small number of thousands of panels.
- The cost of solar continued to fall. The average price of crystalline silicon modules in Europe fell by 14% in 2017 and is expected to drop by a further 15% in 2018.
- China surprised the industry by recording $19.6 billion of investment in small-scale projects, a fivefold increase on the previous year and almost 40% of the global total.
- U.S. small-scale PV paused for breath after a decade of growth, while Pakistan's solar sector sprang to life and South Korea appeared poised for an investment boom.

Investment in small-scale solar projects of less than 1MW capacity increased by $6.3 billion in 2017. An estimated $49.4 billion was spent building about 28GW of such power plants. This dollar value was up 15% on the $43.1 billion invested the year before. Nevertheless, this was a considerably smaller amount than in years prior to that – between 2010 and 2015, the average invested in small-scale renewables was $63 billion a year, with a peak of $75.2 billion in 2011 (as illustrated in Figure 36).

Any comparison of investment over time needs to take account of falling PV costs – $1 invested in 2017 bought considerably more solar PV generating capacity than it did at the start of the decade. In 2010, the average cost per Watt of a residential PV system in Germany was $3.90, but by the end of 2017 it had fallen 57% to $1.68. In Australia, the decline was even more pronounced. A 4kW PV system cost an average of $6.40 per Watt in 2010, yet by the end of 2017 it had plummeted 78% to just $1.40 per Watt (see Figure 37).

PV prices continued to fall in 2017. The average cost of mainstream crystalline silicon modules in Europe fell by 14% over the course of the year, according to pvXchange, a brokerage platform for solar components. Prices varied for different types of modules and in different regions of the world, but the overall direction was downward. Industry analysts expect modules will drop by a further 15% in 2018, when more upstream manufacturing capacity comes on line.

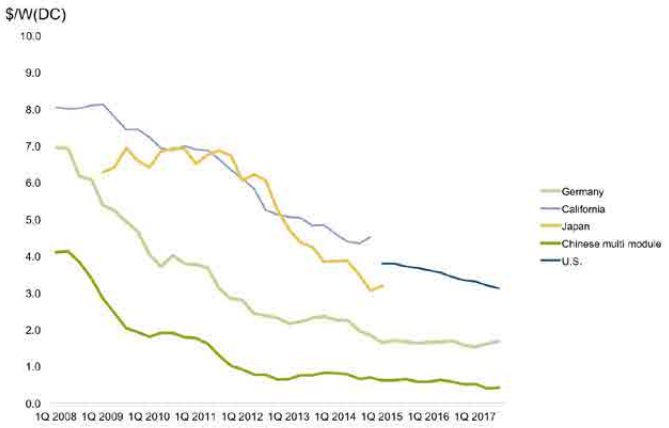
FIGURE 36. SMALL DISTRIBUTED CAPACITY INVESTMENT, 2004-2017, $BN



Represents investments in solar PV projects with capacities below 1MW
Source: Bloomberg New Energy Finance

The impact of steadily declining costs, coupled with the recent rebound in dollar investment, has been positive. Global installed residential and commercial PV capacity grew by 28GW to 173GW in 2017, slightly up on the 22GW added the previous year, according to preliminary data from Bloomberg New Energy Finance. Cumulative capacity is now double what it was in 2013 and more than five times the 31GW in existence at the start of the decade.

FIGURE 37. SMALL PV SYSTEM COST IN JAPAN, GERMANY AND CALIFORNIA, AND TREND IN CHINESE MODULE PRICES, $ PER W

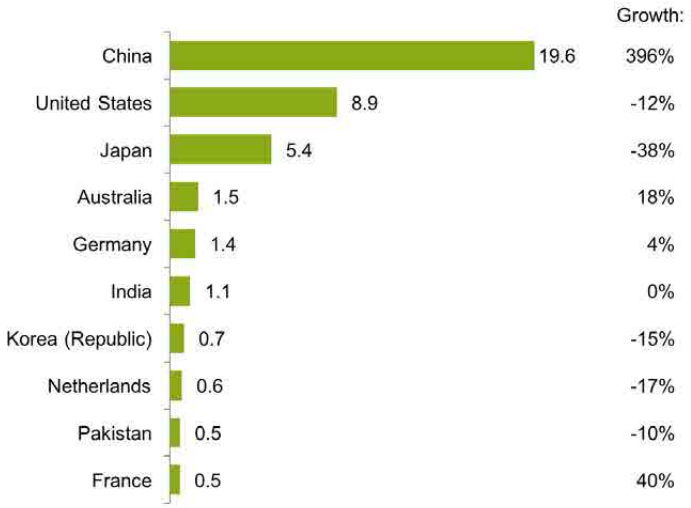


$/W DC rated
Source: UN Environment, Bloomberg New Energy Finance

Japan was estimated to have 36GW of installed residential and commercial PV capacity by the end of 2017, the most of any country worldwide. Germany was next with 30GW, then came the U.S. on 18GW, followed by China and Italy with 17GW and 15GW, respectively. Australia trailed the major nations with 6GW. The rapid build-out in these countries, together with more moderate growth in France, Belgium and India, has been driven chiefly by government policy, mainly in the form of financial subsidies.[19]

[19] Bloomberg New Energy Finance, Socket Parity Is Here, But Solar Adoption Needs More, 16 October 2017

FIGURE 38. SMALL DISTRIBUTED CAPACITY INVESTMENT BY COUNTRY, 2017, AND GROWTH ON 2016, $BN



Top 10 countries. Represents investments in solar PV projects with capacities below 1MW
Source: Bloomberg New Energy Finance

Each of the top six countries listed in Figure 38, with the exception of China, has achieved commercial PV 'socket parity' (where commercial rooftop solar electricity is cheaper than electricity from the grid), and two (Australia and Germany) have attained 'residential' PV socket parity. Such low costs mean markets are better able to withstand subsidy cuts. In Australia, for example, when installers were faced with reduced support, they were able to lower their prices to maintain sales.

CHINA BOOM

A breakdown of investment by country reveals that $19.6 billion – almost 40% of the global total of $49.4 billion – was concentrated in just one country, China (see Figure 38). This represented a very sharp increase on the $3.9 billion raised the previous year and was more than double the $8.9 billion recorded in the U.S. If investment had remained flat in China in 2017, the global total would have fallen by almost 22% to $33.7 billion. Instead it rose by 15%.

The Chinese solar boom caught the industry by surprise. Total PV installations (both small and utility-scale) in that country reached 53GW in 2017, which was 20GW more than forecast. Predictions were upended by investors' unexpected enthusiasm for building projects before subsidies had been allocated. Investor sentiment played a more significant role where subsidy quotas do not apply, such as rooftop systems and PV for Poverty Alleviation projects.

By encouraging development on a massive scale, China's National Energy Administration hopes to drive down the cost of solar PV to the point where it becomes subsidy-free, which will help tackle the burgeoning deficit in the country's National Renewable Subsidy Fund. Investment in 'behind-the-meter' rooftop projects (where power generated is consumed on-site) is expected to remain high in the coming years thanks to the comparatively attractive subsidy rates.

U.S. CONSOLIDATION

In contrast to the Chinese market, the U.S. small-scale sector paused for breath after a decade of strong growth. Investment in 2017 fell to $8.9 billion, down from $10.1 billion the previous year. Over the same period, residential PV installations dropped by 9% to 2.1GW, led by declines in California and the states of Massachusetts and Maryland. States that enacted net-metering reforms in 2016 were among those that saw new PV installations shrink in 2017.

Installers in the U.S. are turning away from the once-dominant solar leasing model to more conventional debt financing. Both incumbent and new U.S. residential solar financiers now offer solar equipment loans, which are simpler if less tax-efficient than leases. The shift has prompted several major players to reorient their businesses from a 'growth-at-all-costs' model that encouraged over-spending on customer acquisition, to one that is higher-margin and lower-volume.

U.S. solar companies are also having to navigate regulatory reforms that make the technology less attractive. The country's flagship incentive mechanism, the Investment Tax Credit, will be phased out by 2022, and a growing number of

states are lowering the rate customers receive for the solar power they produce. The eventual removal of incentives might bring the residential market to a halt, but it could also intensify competition, thereby prompting vendors to cut costs to attract new customers.

JAPAN AND U.K.

Japan's decision to slow runaway growth in its PV sector by slashing subsidies brought investment in small-scale renewables crashing down from a record-breaking $28.1 billion in 2014 and $20.9 billion in 2015 to $8.7 billion in 2016. The downward direction continued in 2017, with investment falling by a further 38% to $5.4 billion. Installations dropped 30% in 2017 to an estimated 3.8GW.

As part of Japan's national drive to enhance energy resilience and independence, a number of projects have emerged that meld small-scale PV with energy storage and smart microgrid technologies. Among the latest developments, PanaHome Corp, Eneres, IBJ Leasing and the government of Hyogo Prefecture will install PV-lithium-ion battery storage systems in 117 homes and integrate them to create a microgrid in Smart City Shioashiya Solar-Shima, Ashiya City.

Like the Japanese authorities, the U.K. government has applied the brakes, with predictable results. Reductions in subsidies paid to PV systems in early 2016 saw investment in that year fall by 60% to $609 million, and by a further 57% in 2017 to $260 million. The government also set a 400MW annual cap for new projects receiving a feed-in tariff, although the current low level of subsidy ensures that investment remains well below the cap.

The subsidy cuts have had an impact on community energy projects, where local residents and businesses invest in a renewable power plant in exchange for a small return on their investment and cheaper electricity. These had been growing in number. In 2015, some 76 new community energy organisations were registered, according to trade body Co-operatives UK. However, by mid-2017, Community Energy England reported that 44 had stalled in the wake of the subsidy cuts and after the axing of a key tax relief.

FRANCE, GERMANY, SOUTH KOREA

Unlike the U.S., Japan and the U.K., investment in French small-scale solar increased in 2017. A total of $520 million was channelled into the sector, up 40% on the previous year's $373 million. This came as more supportive measures were introduced. In May 2017, just as Emmanuel Macron swept to victory in the Presidential election, the government won EU state aid approval for its 20-year sub-100kW PV feed-in tariff program. The scheme has been allocated a budget of EUR 190 million ($237 million) per year and has a target to install 2.1GW of such capacity.

In December 2017, the PV industry welcomed a measure to reduce grid fees by 40% for projects of less than 100kW, and by up to 40% for larger solar installations. This is expected to boost demand for small-scale solar in 2018, despite a reduction in feed-in tariffs for the smallest plants in the first quarter of this year.

Germany continues to have significantly higher levels of support for small PV projects than for utility-scale. Those of less than 10kW, for instance, were eligible in August 2017 to January 2018 for a feed-in tariff of EUR 122 per MWh, and those of between 40 and 500kW eligible for EUR 106 per MWh. This, together with high retail electricity prices, helped to support small-scale solar investment in 2017, with $1.4 billion deployed on small solar, up 4% on 2016. This was far below the peak figures of $10 billion to $25 billion recorded during the subsidy-driven boom in 2008-12.

Investment in South Korea's small-scale sector may have fallen by 15% in 2017 to $741 million, but it should increase substantially over the next decade as the government has announced a $101 billion program to lift the share of renewable power from 7% to 20% by 2030. The Ministry of Trade, Industry and Energy released a draft of its 'Renewable Energy 3020' implementation plan in December 2017, in which it details how 30.8GW of solar (both large and small-scale) will be added.

The government proposes committing $17 billion in loans to small-scale power providers, while it suggests state energy firms will invest $47 billion. The remaining $38 billion is to come from the private sector. The administration also says it plans to revive temporarily its feed-in tariff scheme (abolished in 2012), to bolster small-scale solar projects of less than 100kW until 2022, when President Moon Jae-in's term in office ends.

DEVELOPING COUNTRIES

Small-scale renewable power is also on the rise in Pakistan, thanks in part to the country's frequent power cuts. The sector attracted investment of $540 million in 2017, having recorded less than $100 million in each of the previous two years. Some banks have started offering financing for home solar systems and the industry regulator has issued guidelines for 'net metering', which enables consumers to sell electricity to the grid. Islamabad Electric Supply Company is among those pioneering use of net-metering, with others expected to follow suit soon.

In late 2016, the Asian Development Bank agreed to lend Pakistan $325 million to fund a program that will install clean energy systems and improve access to electricity in Khyber Pakhtunkhwa Province, one of the country's poorest regions, and in Punjab, which has its highest consumption of power in the country. The loan will fund 1,000 micro-hydropower plants in off-grid areas, as well as rooftop solar plants at 23,000 schools and more than 2,500 primary healthcare facilities.

In the developing world, off-grid pay-as-you-go (PAYG) solar is growing fast. Since 2013, the sector has netted investment of more than $800 million, according to Bloomberg New Energy Finance. In October 2017, for example, Bboxx, a London-based off-grid solar developer, agreed to borrow $5 million from Deutsche Asset Management's sustainable investing arm, Essential Capital Consortium, to expand services to 150,000 people in Rwanda. The loan will be provided in local currency and managed by Banque Populaire du Rwanda.

In the same month, Kenya-based M-Kopa Solar secured $80 million in debt from a consortium of development banks, impact investors and local bank Stanbic Holdings, which contributed $9 million. The deal was the largest debt transaction to date in the PAYG solar segment and one of the biggest solar deals in Africa in 2017. By denominating as much as 69% of the debt in Kenyan and Ugandan shillings, M-Kopa was able to shift the currency risk to its lenders and simplify the transaction.

The Lighting Global initiative of the World Bank and the International Finance Corporation estimates the entire off-grid solar sector, from solar lights to plug-and-play home kits and do-it-yourself systems, is worth $1 billion per year in sales revenue terms, and that it will grow eightfold by 2022. The solar home systems that are popular with pay-as-you-go companies currently account for just $150 to $200 million of this total. Further discussion on PAYG company financings can be found in Chapter 7 (Venture Capital and Private Equity).

Several developing countries introduced new, or accelerated existing, rural electrification plans in 2017. For example, Mozambique's Energy Fund launched a $500 million program aimed at bringing electricity to 332 villages with hydro projects totaling 1GW. It will also build 343 solar power projects, a third of which will be smaller than 100kW. India, meanwhile, has said it is accelerating its rural electrification program and aims to reach every household by the end of this year, three months ahead of the previous deadline.

Nigeria passed a policy in 2017 targeting 180MW of power from mini-grids by 2020. Also last year, the Micro-Grid Investment Accelerator was launched. It works with renewable energy service companies to initiate investment in micro-grids in India, Indonesia and East Africa, and is backed by companies including Facebook and Microsoft.

PUBLIC MARKETS

- In 2017, some $5.7 billion of new investment was raised by 62 clean energy companies and funds on 27 stock markets. This was the smallest dollar total since 2012.
- The NEX, which tracks the performance of 105 mainly clean energy and energy efficiency stocks, performed better than the S&P 500 and only slightly less well than the Nasdaq in 2017.
- The solar sector raised $2.5 billion on the public markets in 2017, an improvement of $1 billion on 2016. Three Chinese PV firms were responsible for almost half of this total.
- Asia-Pacific companies dominated fundraising in 2017, taking $2.9 billion, or just over half of the global total.

Renewable energy fundraising on the public markets fell for the third consecutive year in 2017. Bloomberg New Energy Finance recorded $5.7 billion of new investment by 62 specialist renewable energy companies and funds, on 27 exchanges around the world (see Figure 39).

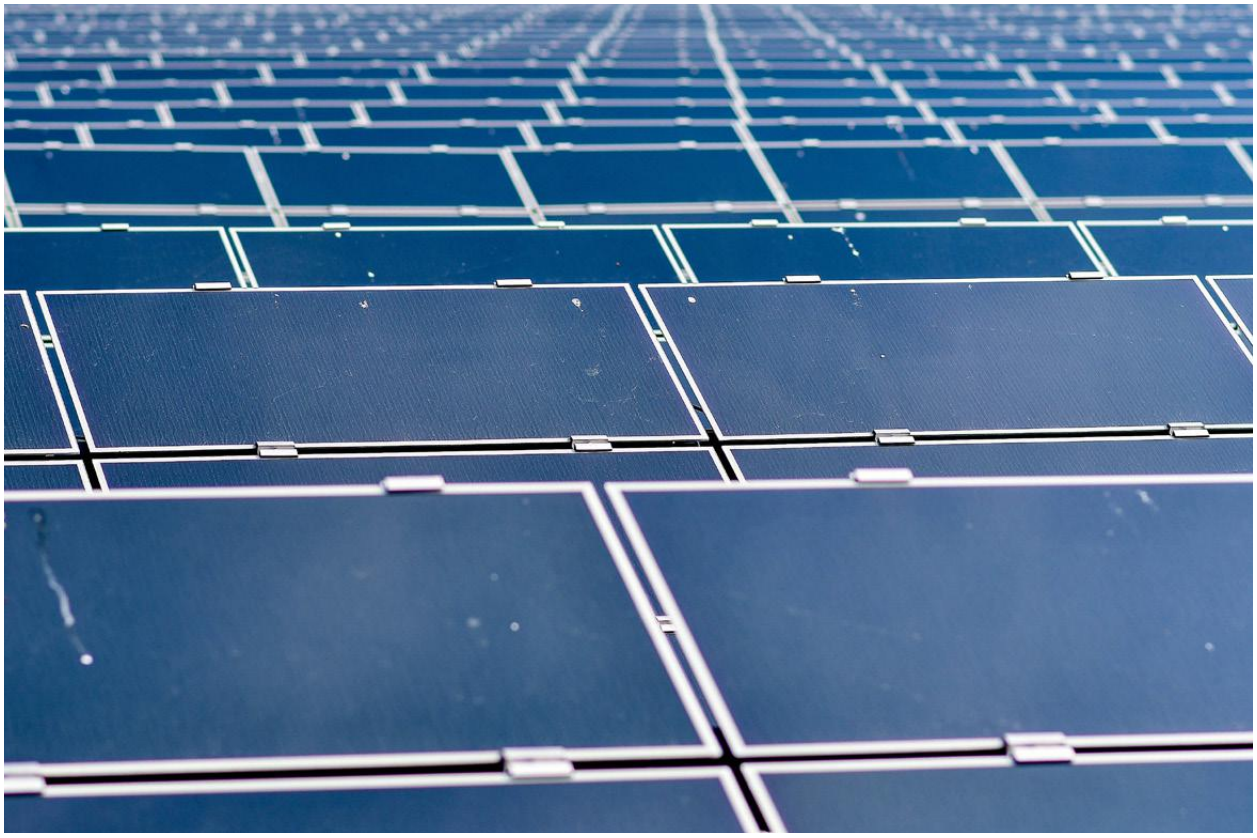
While only 6% lower than the previous year's $6.1 billion, this was the smallest volume since 2012, when just $4 billion was invested, and the second worst since 2005, when renewables was still a niche opportunity. It was also around half that seen in 2014 and 2015. Based on these figures, it would seem that some investors are shunning the sector. However, closer analysis of the recent fundraising history and deals done in 2017 reveals a somewhat healthier picture.

The summer of 2015 was a watershed moment for the sector. In the preceding year and a half, investors poured some $12 billion into quoted renewable asset vehicles, known as 'yieldcos' in the U.S., and into European quoted project funds on the other side of the Atlantic. This accounted for the surge in investment seen between 2013 and 2015. However, when it became clear that some investors had been unrealistic about dividend growth prospects for the North American yieldcos, the bubble burst and it became difficult for the surviving funds to issue fresh equity.

Yieldcos and European quoted project funds are still active on the markets, though not to the same extent. One of the latter, Greencoat UK Wind, was responsible for the second biggest deal of 2017 – a $447 million secondary offering on the London Stock Exchange – and related company, Greencoat

FIGURE 39. PUBLIC MARKET NEW INVESTMENT IN RENEWABLE ENERGY BY STAGE, 2004-2017, $BN

PIPE = private investment in public equity, OTC = over-the-counter
Source: Bloomberg New Energy Finance, UN Environment



Renewables, produced the second largest initial public offering (IPO) of the year when it raised $314 million on the Irish Stock Exchange. NextEra Energy Partners and Pattern Energy Group, both U.S. yieldcos, also raised funds, while The Renewables Infrastructure Group and Foresight Solar Fund completed share issues in London.

Conventional project development companies also tapped the markets in 2017. Of the 10 IPOs last year, seven were by developers or quoted project funds, while just three were by equipment manufacturers and technology firms. The largest IPO of the year was by China Everbright Greentech, which raised HKD 3.4 billion ($434 million) in new capital on the Hong Kong Stock Exchange, partly to fund projects that will use agricultural and forest by-products to generate electricity and heat.

There were smaller debuts from Brazilian wind developer Omega Geracao, which raised BRL 789 million ($252 million) on the Sao Paulo Stock Exchange, and New Energy Solar, an Australian PV projects company that will use its $154 million proceeds to fund developments in the U.S. and its homeland. Fellow Australian firm Windlab scooped $40 million, which it will use to develop the first phase of a 58MW hybrid wind and solar project in Queensland.

A comparison of the various deal types reveals that 2017 was similar to 2016 in some respects, but substantially different in others. For example, the volume of funds raised by secondary and 'private investment in public equity' (PIPE) deals remained flat at $2.5 billion, and there was little improvement in the 'over-the-counter' markets. The total raised via convertible and 'exercise of rights' deals doubled to $1.8 billion in 2017, whereas the amount raised through IPOs fell by almost 50% to $1.4 billion from $2.6 billion.

The IPO figures for 2016 included one very large deal – the $2.2 billion flotation on the Deutsche Börse by Innogy, the renewable energy arm of German utility RWE. Although it should not be discounted, the sheer size of this deal obscures the fact that only $397 million was raised by the eight other IPOs in that year. In contrast, the 10 flotations in 2017 raised $1.4 billion, an average of $140 million each, and they ranged in size from $434 million down to $5.2 million.

If the IPO and convertible fundraising figures for 2017 were respectable, it was partly thanks to the brightening outlook for shares in renewable energy companies. These gained steadily in value over the course of the year. The WilderHill New Energy Global Innovation Index, or NEX, which tracks the performance of 105 clean energy and energy efficiency-related stocks worldwide, has mostly under-performed other indices, but in 2017 it performed better than the U.S. S&P 500 and only slightly less well than the Nasdaq Composite.

SHARE PRICES

Figure 40 shows the performance of the three indices, rebased to 100 at the start of January 2017. By January 19, 2018, the Nasdaq had increased by 36%, the NEX was up 31% and the S&P 500 trailed with a gain of 25%. For a short period, between mid-September to the end of October, the NEX was ahead of the other indices in terms of performance since the start of 2017, and this in a year in which President Trump set out to remove some domestic regulations to reduce greenhouse gas emissions, and said he would withdraw the U.S. from the Paris Agreement.

SolarEdge Technologies, a maker of electronic components for rooftop solar power systems, was the best performing stock on the NEX in the year to January 26, 2018. Shares in the Israel-based company climbed 178% as investors greeted news of higher-than-expected earnings and rising sales outside the U.S.

The next two stocks in terms of performance were both clean energy, but not strictly speaking renewable energy. Tanaka Chemical Corp gained 164%. The Japanese maker of lithium, cobalt and nickel compounds for batteries, surged on growing electric vehicle sales around the world. U.S.-based Universal Display Corp, a maker of organic LEDs, jumped 163% in the year to January 26, 2018. Two solar stocks rounded off the top five in the NEX – Swiss PV production equipment manufacturer Meyer Burger Technology jumped 147%, while Sino-American Silicon Products, a Taiwanese maker of silicon ingots and wafers, was up 144%.

At the other end of the spectrum, German wind turbine manufacturer Nordex fell 46% over the same period. The company has said it will cut as many as 500 jobs this year amid declining demand and mounting price pressure, as countries seek to drive down the cost of wind power through competitive auctions. Its European peers are also feeling the squeeze. Siemens Gamesa Renewable Energy, a newly-formed joint venture between two of the continent's major players, fell 25%, while Denmark's Vestas Wind Systems sank 17%.

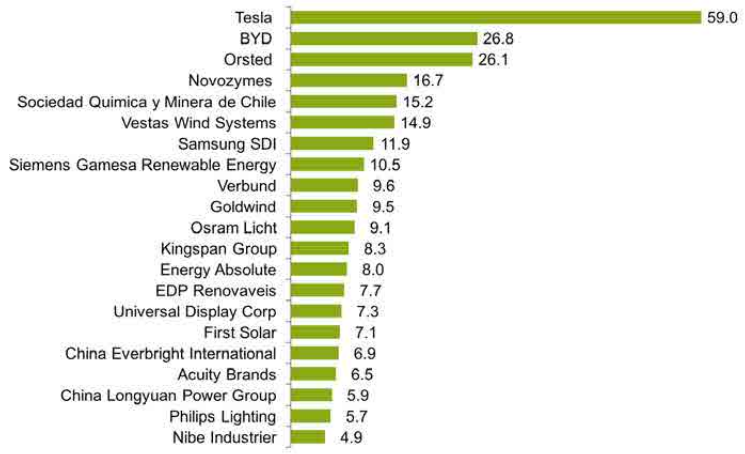
Also in the bottom group were Taiwan's Gigasolar Materials, down 33%, and U.K. biomass-fired power generator Drax Energy, down 28% on uncertainty over its dividend policy as it expands into the natural gas sector. German biofuel producer Verbio Vereinigte Bioenergie ended the period 27% lower.

FIGURE 40. NEX VS SELECTED INDICES, 1 JANUARY 2017 TO 31 DECEMBER 2017

Values as of 19 January 2018, all indexes rebased to 100 on 1 January 2017
Source: Bloomberg

The biggest 20 companies on the NEX are listed in Figure 41. As of February 2, 2018, electric vehicle manufacturers Tesla and BYD led the field (as they did in January 2017) with market capitalizations of $59 billion and $26.8 billion, respectively. They were followed by an assortment of wind developers and turbine manufacturers (Orsted, Vestas and Siemens Gamesa Renewable Energy), battery companies (Sociedad Quimica & Minera de Chile and Samsung SDI) and LED makers (Samsung SDI and Osram Licht).

FIGURE 41. LARGEST COMPANIES IN THE NEX INDEX, BY MARKET CAPITALIZATION, $BN



Top companies (2 Feb 2018)
Source: Bloomberg New Energy Finance

Solar companies were conspicuous by their absence. None made the top 10, and only one featured in the top 20. American thin-film module manufacturer First Solar, ranked 16th with a market cap of $7.42 billion, followed by Chinese PV glass manufacturer Xinyi Solar Holdings in 26th place with a $3.4 billion valuation. The former saw its stock jump ahead of President Trump's decision in January to impose duties of as much as 30% on solar cells made outside the U.S.

SOLAR

Frustrated with what they see as low valuations by Wall Street, a string of major Chinese solar manufacturers either have been taken private or have an offer to be taken private in management-led buyouts. Trina Solar completed a $1.1 billion privatization deal in March 2017, while Nasdaq-listed JA Solar Holdings, the world's third-biggest PV panel manufacturer, entered into an agreement to be taken private in an all-cash deal valuing the company at $362 million. Canadian Solar's chief executive also made an offer to buy all common shares he does not already own. Having extricated itself from the New York Stock Exchange, Trina Solar said it intended to float in China.

Despite the misgivings of certain U.S.-listed Chinese companies, the solar sector as a whole had a better year for fundraising in 2017, as illustrated in Figure 42. Some 28 companies and quoted funds raised a total of $2.5 billion in 40 deals (some companies undertook more than one fundraising), an improvement of $1 billion on the total for 2016. Companies based in the Asia Pacific region accounted for almost $1.6 billion of this, or 64% of the total. Those in Europe, Middle East and Africa raised $522 million, while the Americas trailed on $371 million.

Three Chinese firms alone were responsible for almost half (47%) of all solar company public equity raised globally. Risen Energy, a cell and module maker and PV plant developer, took home more than any other firm with a $465 million secondary share placement on the Shenzhen Stock Exchange. Longi Green Energy Technology, which manufactures and sells silicon rods and wafers, raised $424 million via a convertibles issue on the Shanghai Stock Exchange, while Xinyi Solar Holding, a solar glass and PV project developer, raised $194 million through a rights issue.

FIGURE 42. PUBLIC MARKETS INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2004-2017, $BN

Source: Bloomberg New Energy Finance, UN Environment

WIND

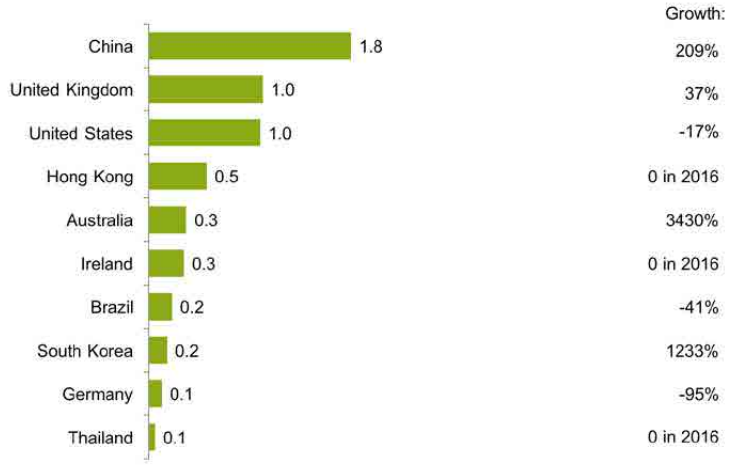
Wind companies, on the other hand, did less well in 2017 than in 2016. Some 13 companies and funds tapped the public markets for new investment in 2017, raising $2.4 billion in 15 deals globally, a decline of 44% compared with the $4.3 billion recorded the year before. All but one of the 13 entities were involved in the development or ownership of wind farms. The exception was Unison, a South Korean wind turbine manufacturer, which raised $5.4 million via two convertible issues and a further $1.4 million in a PIPE deal.

Quoted project funds and yieldcos dominated the list of wind transactions in Europe and the Americas. In the former, Greencoat Renewables scooped $314 million from an IPO on the Irish Stock Exchange, while Greencoat UK Wind and the Renewables Infrastructure Group raised $447 million and $138 million respectively, via secondary offerings on the London Stock Exchange. In the U.S., NextEra Energy Partners raised $300 million via a convertible issue on the New York Stock Exchange, and Pattern Energy Group gained $215 million from a secondary offering on the Nasdaq Global Select Market.

REGIONAL SPLIT

The distribution of fundraising around the globe changes dramatically from year to year, as shown in Figure 43. During the height of yieldco bubble in 2015, the U.S. had an unassailable lead of $8.9 billion, but by 2017 its tally had dwindled to just $1 billion, on a par with the U.K. and behind China's $1.8 billion. Germany led the field in 2016 with $2.3 billion of investment, largely thanks to Innogy's $2.2 billion IPO, but in 2017 produced just one deal, a $115 million convertible issue by Capital Stage Finance, part of the quoted project fund Capital Stage.

FIGURE 43. PUBLIC MARKETS INVESTMENT IN RENEWABLE ENERGY BY COMPANY NATIONALITY, 2017, AND GROWTH ON 2016, $BN



Top 10 countries
Source: Bloomberg New Energy Finance

Companies and funds in the Asia-Pacific region dominated renewable energy public market fundraising in 2017, raising $2.9 billion, or just over half of the global total. This was thanks mainly to activity in China, as well as South Korea and Australia. In other regions, investment fell. In the case of EMEA, it fell sharply to $1.6 billion (some $2 billion less than in 2016), while in the Americas it fell by around $200 million to $1 billion, which was the lowest seen since 2005.

Across the regions, one conspicuous feature of 2017 in public markets was that the larger equity raisings that did happen tended to be for project ownership platforms such as Greencoat UK Wind and NextEra Energy Partners, with only a few cash calls by equipment companies. A decade ago, exactly the opposite would have been the case.

VENTURE CAPITAL AND PRIVATE EQUITY

- Venture capital and private equity (VC/PE) investment in renewable energy fell by exactly a third in 2017 to $1.8 billion, just a sixth of its 2008 peak of more than $10 billion. Investment in these asset classes continues to fall as the sector matures and R&D in wind and solar is increasingly in the hands of large manufacturers.
- Investment in private equity expansion capital fell 55% to $780 million, and early-stage venture capital dropped 18% to $511 million, but late-stage venture capital rose 43% to $502 million.
- While early-stage venture capital fell overall, some individual stages saw substantial gains. Seed/angel funding jumped 16-fold to $85 million, and Series A rose 19% to $283 million, but these increases were outweighed by the decline of Series B, which fell 62% to $143 million.
- In late-stage venture capital, that balance was reversed. Double-digit falls in bridge and Series C investment were comfortably outweighed by gains in the further/Series D stages, which jumped 146% to $424 million.
- VC/PE investment fell across all sectors, with solar dropping 38% to $1.2 billion, and wind down 12% to $433 million. Despite falling the most in absolute terms, solar still attracted more investment than any other sector, as it has for all but three of the last 14 years.
- VC/PE investment in the U.S. fell 57% to $770 million, but remained almost three times higher than in Europe, which fell 26% to $287 million. India was a bright spot, gaining 27% to $457 million. The 'Other AMER' region jumped 13-fold to $174 million from a low base.

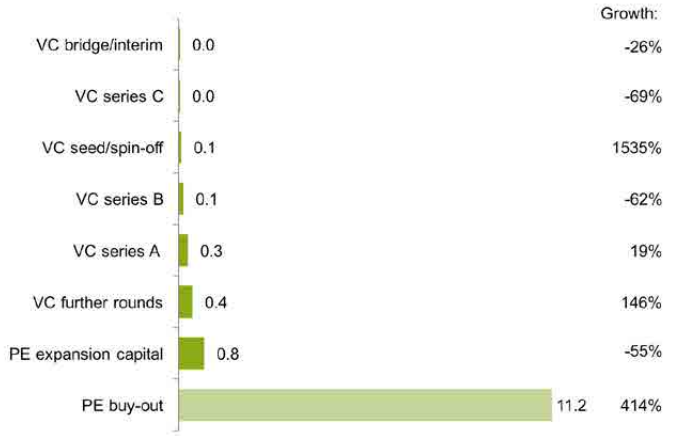
FIGURE 44. VC/PE INVESTMENT IN RENEWABLE ENERGY BY STAGE, 2004-2017, $BN

Buy-outs are not included as new investment. Total values include estimates for undisclosed deals
Source: Bloomberg New Energy Finance, UN Environment

VC/PE investment in renewable energy continued its long-term retreat in 2017 (Figure 44). At $1.8 billion, total VC/PE investment fell to a sixth of its 2008 peak, and PE expansion capital specifically to just a ninth. Both early and late-stage VC were down to a quarter of their all-time highs, although late-stage VC did manage to claw its way up 43% from an even deeper trough the previous year.

The main reason is the increasing maturity of the renewable energy sector. Wind and solar are now such huge global industries that the barriers to entry are higher. With

FIGURE 45. VC/PE INVESTMENT IN RENEWABLE ENERGY BY STAGE, 2017, AND GROWTH ON 2016, $BN

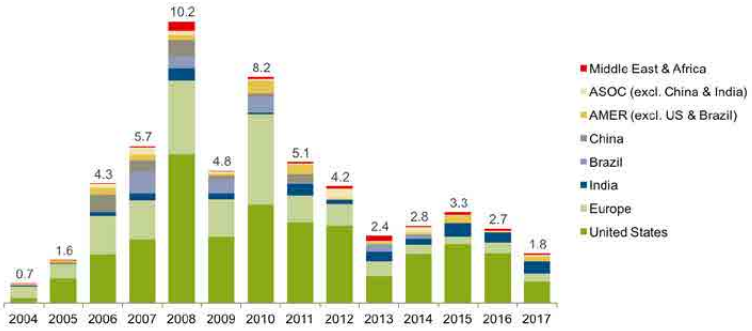


Buy-outs are not included as new investment. Total values include estimates for undisclosed deals
Source: Bloomberg New Energy Finance, UN Environment

FIGURE 46. VC/PE INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2004-2017, $BN

Buy-outs are not included as new investment. Total values include estimates for undisclosed deals
Source: Bloomberg New Energy Finance, UN Environment

FIGURE 47. VC/PE INVESTMENT IN RENEWABLE ENERGY BY REGION, 2004-2017, $BN



Buy-outs are not included as new investment. Total values include estimates for undisclosed deals
Source: Bloomberg New Energy Finance, UN Environment

the dominant technologies now well established, and R&D largely driven by big companies, there are generally fewer opportunities for start-ups to develop a new technology and commercialize it on their own – although of course there are exceptions.

Another reason may be competition for funding. The fall in VC/PE investment during 2017 coincided with a quintupling of PE buy-outs to $11.2 billion (Figure 45), as a swathe of publicly traded companies were bought out by private equity investors. It may be, therefore, that some VC/PE investors' capital was diverted into a strong acquisition market. In the years since 2008, changes in PE expansion capital and PE buy-out investment have moved in opposite directions more often than not, although the correlation is loose. Since PE buy-outs represent a shuffling of existing funds rather than fresh investment into the sector, they are covered in the chapter on Acquisition Activity, rather than in this chapter, and they are not included in the new investment statistics in Figure 44.

Among the sectors, solar investment fell 38% to $1.2 billion yet still claimed two thirds of all VC/PE investment (Figure 46), while wind dropped 12% to $433 million and took almost a quarter share. Biofuels declined 22% to $151 million and secured just 8% of the total. Biomass and waste, geothermal and marine all fell close to zero.

The regional breakdown of VC/PE investment (Figure 47) shows that the U.S. continues to take the largest share, 43%, of total investment in 2017, despite falling 57% to $770 million. But the situation is

not entirely static. One interesting development is that India beat Europe into second place for the second time in three years. India's VC/PE investment rose 27% to $457 million, or 26% of the total, while Europe's fell 26% to $287 million, a 16% share.

INDIA

India's VC/PE investment grew strongly because it secured three of the five largest deals. Two of those were wind companies raising funds to expand in that country, a fiercely competitive market with huge growth potential that is attracting many foreign investors.

The largest deal was secured by Greenko Energy, an independent power producer based in Hyderabad, which raised $155 million in PE expansion capital from GIC, the sovereign wealth fund of Singapore, and the Abu Dhabi Investment Authority. The pair had already invested $230 million in the company in 2016. Greenko has around 3GW of wind, solar, hydro, gas and biomass capacity in operation, and a further 800MW under construction.

Another Indian independent power producer, Hero Future Energies, raised $125 million in PE expansion capital from the International Finance Corporation and the IFC Global Infrastructure Fund. Founded in 2012, by mid-2017 Hero had around 640MW of wind and solar in operation and a pipeline of around 1GW. The company said it hopes to reach 2.7GW installed capacity by 2020, and is thinking of expanding overseas.

The third large Indian deal was secured by Clean Max Enviro Energy Solutions, which claims to be India's biggest rooftop solar developer, having installed 100MW since the company was founded in 2011. It also has 130MW of solar farms in operation and another 100MW in development. In 2017, Clean Max secured $109 million from Warburg Pincus to fund further expansion.

SOLAR

Looking beyond India to VC/PE overall, 27 of the 40 largest deals were in solar. The largest was secured by Sunlight Financial, a residential solar finance company based in New Jersey, which is backed by Tiger Infrastructure Partners, a fund founded by Hudson Clean Energy Partners. Sunlight raised $130 million in Series A funding from Route 66 Ventures. Later in the year, Sunlight arranged a further $450 million in funding from Technology Credit Union to support up to 20,000 residential solar installations.

One theme in 2017 was continuing fundraising by providers of pay-as-you-go (PAYG) home solar products and services to off-grid customers in developing countries. These companies typically sell solar lighting or small home systems for a low down-payment, followed by regular small payments made by mobile phone money services. Since more than 1 billion people worldwide have no access to electricity, the sector has enormous potential. In 2016, the Dutch company Nova Lumos raised $90 million and BBOXX of the U.K. secured $20 million, and in 2017 three further deals followed.

Greenlight Planet, which claims to be the world's largest company offering PAYG solar services direct to consumers, raised $60 million in a funding round led by Apis Partners and supported by existing shareholders Eight Roads Ventures and Bamboo Capital Partners. This U.S. company, founded in 2006, operates in 60 countries, with 27 million users of its solar lanterns and almost 17MW of rooftop solar.[20] Its solar home energy systems power lights, mobile phones, radios and fans, for which its customers make daily payments of as little as 25 U.S. cents. They get to own the systems outright after 6-8 months.

[20] https://www.greenlightplanet.com/about/#ourstory

Mobisol, a German PAYG company that operates mainly in Tanzania, Rwanda and Kenya, raised $11.4 million in VC bridge funding from the Finnish Fund for Industrial Cooperation. Later in the year it secured a loan worth "tens of millions of dollars" from the Africa-EU Renewable Energy Cooperation Program to fund further expansion. The company has already installed 10MW of solar capacity and brought electricity to 500,000 people.

BBOXX came back for its second bite in two years, raising a $5 million VC bridge/interim round from Deutsche Asset Management to fund expansion to 150,000 people in Rwanda. The company has 650,000 customers so far, and hopes to reach 20 million by 2020.[21]

Technology opportunities may be thinner on the ground in VC/PE these days, but several leading-edge solar technologies did secure VC funding in 2017. One was 1366 Technologies, a U.S. company, which has developed a process to produce photovoltaic wafers directly from molten silicon, eliminating the ingot and cutting stages altogether. It says that this should cut capital costs by two thirds and operating costs by half. The company, which is building a 250MW-per-year capacity factory, raised $9 million from a group of private investors in a VC Series D funding round.

NexWafe is a German company spun out from the Frauenhofer Institute and pursuing a similar approach to reduce solar manufacturing costs.

[21] Bloomberg New Energy Finance: Africa Off-Grid Solar Growing Up, Woos Investors, 21 November 2017

The company's 'EpiWafer' technology produces monocrystalline silicon wafers directly from gaseous source material, so eliminating five stages of production, a change the company says dramatically reduces wafer cost. In 2017, it raised $8 million in a Series B funding round led – perhaps in a sign of things to come – by Saudi Aramco Energy Ventures.

Another technology that secured funding is less high tech, but important nonetheless. Israeli company Ecoppia has developed a robotic system to clean utility-scale solar farms without water, using automatic mobile brushes. The dust gathered by desert systems can reduce output by 35%, and the Ecoppia system is claimed to remove 99% of dust every day. The company has installed the equipment on 350MW of solar farms, which it says produced an extra 8GWh as a result. The company's Series C funding round raised $13 million.

OTHER SECTORS

Although the value of biofuels deals fell 22% in 2017 – and stood more than 90% down compared with 2008 – there were still a few sizeable transactions. Cool Planet, a cellulosic biofuel developer, raised $19.3 million in a Series A funding round. The company produces a biochar product called Engineered Biocarbon for use as a soil additive and fuel. Agrisoma Biosciences raised $15.4 million in a Series B funding round led by Groupe Lune Rouge and Cycle Capital Management. This company has developed carinata, a non-food oilseed crop for producing biofuels and animal feed. The Canadian company Airex Energy, which produces pellets for biomass incineration, raised $10 million in an unattributed funding round.

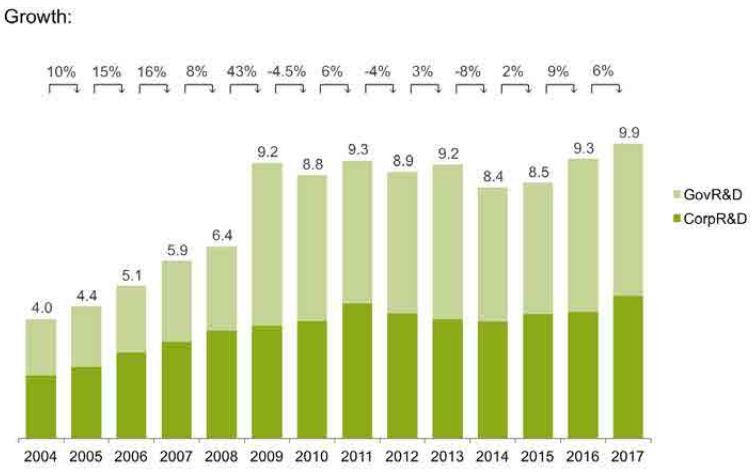
RESEARCH AND DEVELOPMENT

- Investment in research and development in renewable energy set a record high in 2017, rising 6% to $9.9 billion.
- The increase was entirely driven by corporate R&D, which rose 12% to $4.8 billion while government spending remained unchanged at $5.1 billion.
- Overall R&D investment rose across all sectors except marine, which stayed flat. Solar gained 6% to $4.7 billion; wind rose 6% to $1.9 billion, a new high; and biofuels inched up 2% to $1.7 billion. Biomass and waste gained 10% to $918 million.
- Regionally, the biggest investor was Europe, where R&D spending rose 8% to $2.7 billion, followed by the U.S., also up 8% at $2.1 billion and China steady at $2 billion. The U.S. outspent China for the first time since 2011.

Investment in renewable energy R&D grew for the fourth year running, to establish a second successive annual record, rising 6% to $9.9 billion (Figure 48). The increase last year was entirely due to rising corporate investment, up 12% to $4.8 billion, while government spending stayed flat at $5.1 billion. Government investment was still 6% lower than its peak of $5.4 billion in 2009, when it was boosted by 'green stimulus' spending after the financial crisis. This gap has persisted despite the creation of Mission Innovation at the Paris climate talks in 2015, when 22 countries committed to double their clean energy R&D within a decade, implying perhaps $10 billion per year by 2025. There was a 16% rise in government renewable energy R&D in 2016, but so far further increases have not been recorded.

Solar remained by far the biggest recipient of overall renewable energy R&D investment, rising 6% to $4.7 billion (Figure 49), though still a shade below its 2011 peak. Wind was the next largest sector, setting a new high of $1.9 billion, up 6% on 2016. Biofuels managed a small advance amid difficult conditions for the industry, up 2% at $1.7 billion. Unlike solar and wind, where corporate R&D generates well over half the total, in biofuels government spending accounts for four fifths. Note that the totals mentioned in this paragraph for solar and biofuels are consistent with the respective numbers in Figure 49, once rounding is taken into account.

FIGURE 48. R&D INVESTMENT IN RENEWABLE ENERGY, 2004-2017, $BN



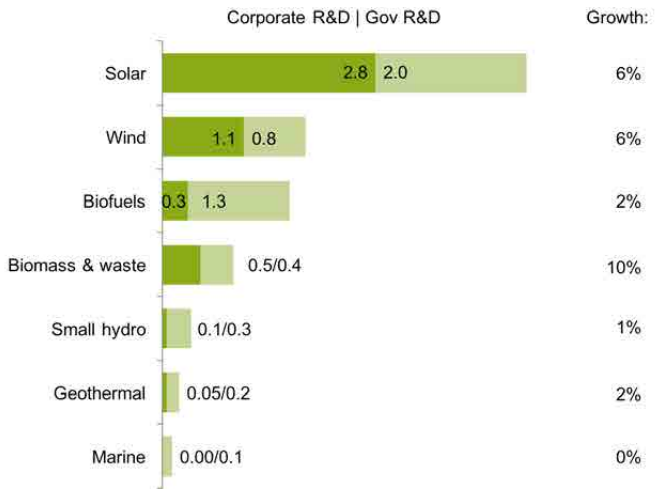
Source: Bloomberg, Bloomberg New Energy Finance, IEA, IMF, various government agencies

Among the regions, Europe maintained the lead it has held since 2010, rising 8% to $2.7 billion (Figure 50), although still 12% short of its 2013 peak. In second place, the U.S. also rose by 8%, to $2.1%. The U.S. remains 33% below its 2009 peak, but has been catching up with Europe more recently: since 2014, U.S. R&D spending has risen 53% whereas Europe's has remained essentially flat. For the first time since 2011, U.S. investment topped that of China, stuck at $2 billion for the last three years.

The lower level of Chinese R&D investment compared to Europe may not indicate a lower real effort but the fact that Chinese researchers are still lower cost than European researchers. In addition, companies in different regions are likely to have different policies on how much development effort is capitalized and therefore broken out, and how much is simply netted off as a cost in the profit and loss account. And the larger technology firms in this sector spread their R&D activities across the geographic regions.

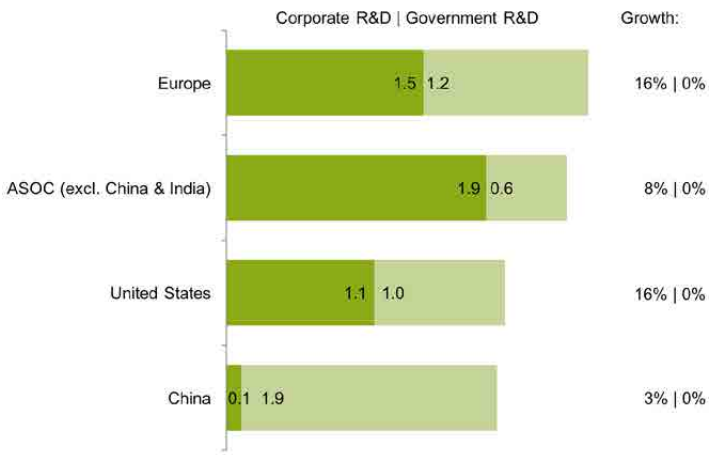
The new record for R&D investment comes amid copious evidence that R&D works. In recent years, the industry has set successive record low prices for renewable energy generation, made possible by the relentless improvement in product technology and production-line efficiency achieved by solar and wind manufacturers. The current global record was established by a power auction in Mexico in November 2017, which commissioned 5TWh at an extraordinary average price of $19.80/MWh. The average solar winning bid was $20.80/MWh and the average for wind was $18.60/MWh. See Executive Summary for more discussion on trends in levelized costs.

FIGURE 49. CORPORATE AND GOVERNMENT RENEWABLE ENERGY R&D BY TECHNOLOGY, 2017, AND GROWTH ON 2016, $BN



Source: Bloomberg, Bloomberg New Energy Finance, IEA, IMF, various government agencies

FIGURE 50. CORPORATE AND GOVERNMENT RENEWABLE ENERGY R&D BY REGION, 2017, AND GROWTH ON 2016, $BN



Source: Bloomberg, Bloomberg New Energy Finance, IEA, IMF, various government agencies

In another sign of the times, in September 2017 the U.S. Department of Energy announced that its Sunshot Program, set up by President Barack Obama in 2011 to cut the cost of utility-scale solar energy by 75%, had hit its target three years early. The Trump administration, hardly known for its support of renewable energy, trumpeted the achievement and announced a new target to halve the cost of utility-scale solar again by 2030, along with fresh funding of $82 million for concentrating solar power.

The Mexico records will almost certainly tumble soon. Analysis by Bloomberg New Energy Finance shows that over the last 40 years solar panels have displayed a 'learning rate' of 28%, meaning that for every doubling of installed capacity the average price fell by well over a quarter. Wind has a learning rate of 19%.[22]

PHOTOVOLTAICS

In solar, manufacturers continue to make dramatic improvements in production efficiency. For example, they have halved the amount of electricity required to make polysilicon in the past five years by investing in larger furnaces and improved processes.[23] They have also cut the cost of cutting silicon ingots into bricks and then wafers by introducing diamond wire saws, which consume less energy than their predecessors, and waste less silicon in the form of 'kerf' or dust. This significantly increases the number of wafers that can be made from a kilogram of silicon, and reduces cost. BNEF analysts expect the cost of cutting mono silicon ingots into wafers will fall 30% over the next two years.[24]

While established manufacturers improve their existing techniques, smaller innovators are working to achieve a step change in efficiency by eliminating whole stages of the production process. One is 1366 Technologies, a U.S. company, which has developed a means of producing photovoltaic wafers directly from molten silicon. Another is NexWafe, a German company whose technology does the same from gaseous source material. Both technologies eliminate several production steps and should reduce cost dramatically, and both companies raised venture capital funding in 2017 (see Chapter 7 on VC/PE for detail).

Factory automation can also make a major difference. At the beginning of 2017, thin-film PV manufacturer First Solar found its factory in Ohio

[22] https://data.bloomberglp.com/bnef/sites/14/2017/09/BNEF-Summit-London-2017-Michael-Liebreich-State-of-the-Industry.pdf
[23] Bloomberg New Energy Finance: Solar Modules to Get Even Cheaper and More Efficient, 30 May 2017
[24] Ibid

deeply undercut by Chinese competition, forcing it to lay off hundreds of workers and re-fit the site with a robotic production line. This now produces a solar panel in three and a half hours, compared to almost three days for a conventional crystalline silicon panel produced in batches.[25] That in turn has reduced the manufacturing cost to as little as 20 U.S. cents per Watt, around 30% lower than the cheapest Chinese equivalent, according to the company.

Solar manufacturers are also constantly improving the design of their products to raise their efficiency and reduce cost. Recent examples include increasing the size of individual cells while maintaining the same number of cells within a panel (by reducing the size of the gap between them), so increasing the power output. Another is to raise the number of 'busbars' – the silver fingers on the surface of the cell that collect the electricity – from four to five, or even to as many as 12. This reduces electrical losses and so increases the cells' output. Yet another is the introduction of new processes to texture the surface of cells to make them less reflective, including reactive-ion etching and metal-catalyzed chemical etching. This increases the amount of light these 'black cells' can absorb and convert into power.[26]

Module manufacturers are now beginning to produce panels with in-built inverters, which convert the panel's DC power to AC for the grid, and optimizers, which use algorithms to extract the maximum output. Traditionally, a solar installation would have a single inverter and optimizer to control all the panels, but installations fitted with these new 'AC' and 'smart' panels will produce more energy overall, and be more resilient to any fault that arises in a single panel. They are also easier to monitor, and to shut down automatically in an emergency – which is now mandatory in many U.S. states. Analysts expect the annual market for AC and smart panels to reach up to 9GW by 2020.[27]

In addition to these incremental improvements, the industry is also converting to higher efficiency cell designs such as 'passivated emitter rear contact', or PERC. Companies and universities are also conducting a huge amount of research on entirely new photovoltaic materials such as perovskites – discussed in detail in these pages last year. Perovskites can be produced with simple chemistry and therefore cheaply, and have made major strides in efficiency in the lab. Developers think they could ultimately achieve 30% or even 40% efficiency, compared to an average of less than 20% today.

WIND

In wind, the main thrust of R&D is to produce ever larger turbines, reduce the cost of offshore foundations, and develop floating turbines. Manufacturers and developers are also increasingly making use of 'big data' to improve both the design process and performance of wind farms.

The largest wind generator today is MHI Vestas' 9.5MW V164 model, but BNEF expects the industry to be installing machines of 10MW in 2022 and 13MW by 2025. Most of these will be installed on conventional monopile or jacket foundation designs adopted from the oil and gas industry. The cost of these foundations is being reduced through tailored designs that cut the amount of steel required. For deeper water, newer suction bucket designs have been developed, although not yet commercialized.

The cutting edge of wind R&D is to develop floating platforms to support wind turbines in deeper waters further offshore. A record 42MW of floating wind capacity was commissioned in 2017, five times the previous total installed capacity, and BNEF analysts expect the annual market to reach 175MW by 2020.

2017 was also a landmark year because Statoil commissioned the world's first floating wind farm with more than one turbine. The 30MW Hywind Scotland project, 25km off the coast of Peterhead, has five Gamesa 6MW turbines with floating spar foundations – which resemble an enormous fishing float – and started generating in October 2017.[28] The project is expected to generate around 140GWh/year, implying a capacity factor of 53%.

[25] http://investor.firstsolar.com/static-files/ee216426-f3a9-4dff-940f-db862cb351f9

[26] Bloomberg New Energy Finance: Solar Modules to Get Even Cheaper and More Efficient, 30 May 2017

[27] Bloomberg New Energy Finance: Module-Level Electronics: Solar Gets Smarter and Safer, 3 January 2018

[28] https://www.statoil.com/en/news/worlds-first-floating-wind-farm-started-production.html

The Hywind project has highlighted some of the challenges of floating wind. Because of additional stresses, the towers need to be 40-75% heavier than normal, for example. And the floating spars are vast: they measure more than 90 metres long and 14 metres wide, and weigh 2,200 tonnes when empty and more than 8,000 tonnes with ballast. This means the industry will need to develop new assembly and transport arrangements to support commercial production.

Several other floating wind developers are using alternative approaches. The French company Ideol will soon launch the world's first (2MW) turbine supported by a floating concrete platform – a rectangular pontoon with an open centre. At an earlier stage of development, Eolink, another French company, has secured funding for sea trials of its Floater design, which involves a turbine supported by a lighter but stronger pyramidal structure instead of a single tower. The company hopes to launch a 1:10 scale model by the end of 2018. And Saitec Offshore has now completed testing of a 1:35 scale model of its Swinging Around Twin Hull design at the Environmental Hydraulics Institute IH Cantabria. The Spanish company now plans to test a 2MW version of the design offshore in the Basque Country.

Another feature of wind R&D is the increasing use of the 'internet of things', and the 'big data' it generates, to improve the performance both of individual turbines and the broader processes of product and project development. One important area is predictive maintenance: heat and vibration sensors fitted to a turbine help project managers to anticipate component failures, for example, a something that GE estimates can reduce operating costs by 10%. Another is accurate wind data: Romo Wind has developed an ultrasonic anemometer called iSpin that it fits to the front of the turbine rotor, the data from which it claims can raise output by 1.8%.

BIOFUELS AND MARINE

The other large sector, biofuels, managed a small increase in R&D investment amid dispiriting conditions. The industry continued to grapple with relatively low oil prices, uncertainty and legal challenge to market rules in the U.S., and the imposition of tariffs by Brazil on imports from the U.S., a move that could provoke retaliation. Against this backdrop, next-generation biofuel developers have failed so far to produce fuel at a competitive price.[29]

Marine energy is another renewables sector with need for R&D spending to cut costs and improve reliability, but progress has been held back in recent years by company failures and a shortage of early-stage investors prepared to take on the risks of ocean-based devices. This is particular true of wave power, which saw 10 or so technology developers raise more than $500 million between them in the 2005-15 period, before a shake-out ensued.

Tidal stream, using devices akin to underwater wind turbines to capture energy from strong tidal flows, has progressed further than wave, with some 15MW of demonstration projects installed by the second half of 2017, in the sea of countries such as the U.K., France, Netherlands and Canada. R&D is going on developing a new generation of machines machines capable of generating larger amounts of electricity per year, on structures that can support several turbines, not just one, on ways of installing and maintaining devices without the need for costly vessels with large cranes, and reducing the amount of steel used per megawatt.

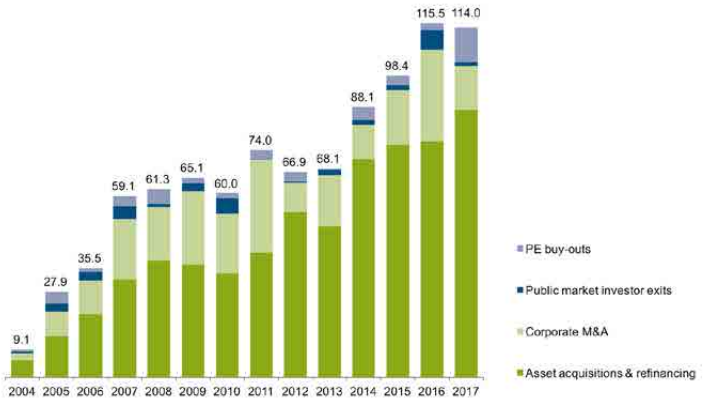
[29] Bloomberg New Energy Finance: 1H 2018 Global Advanced Fuels Market Outlook

ACQUISITION ACTIVITY

- The value of acquisition transactions in renewable energy slipped by 1% to $114 billion in 2017 after four years of growth. Even after this small retreat, acquisitions activity remained 90% higher than in 2010.
- Asset purchases and refinancings remained by far the largest type of acquisition activity, rising 14% to $87.2 billion, while corporate mergers and acquisitions (M&A) fell by more than half to $14.3 billion. Public market investor exits slumped by more than 80% to $1.2 billion, but private equity buy-outs quintupled to $11.2 billion – a record high.
- Wind kept its top spot for acquisitions, although activity fell 12% to $62 billion, while the value of solar deals rose 7% to $43.4 billion. Among the smaller sectors, biomass and waste rose 90% to $4.9 billion, while geothermal soared 15-fold to $1.9 billion from a low base. Small hydro declined, however, falling 26% to $500 million.
- Among asset acquisitions and refinancing, Europe took the top spot with deals worth £37.2 billion, up by more than a quarter, establishing a clear lead over the other regional giant, the U.S., where activity rose 4% to $30.8 billion. The two had been neck and neck in 2016.
- Among the smaller regions, Brazil more than doubled to $6.1 billion, India quadrupled to $1.3 billion from a low base, while China fell by more than 40% to $3.8 billion.

After four years of growth, acquisition transactions in renewable energy fell back 1% in 2017. The largest element, asset acquisitions and refinancing, continued to grow however, up 14% to $87.2 billion (Figure 51), as financial investors continued to be attracted by the predictable long-term yields from renewable generation, and grew increasingly comfortable shouldering the technology risk of major projects. Corporate mergers and acquisitions slumped 52% to $14.3 billion, wiping out a gain of more than two thirds the previous year, while public market investor exits shrank 81% to $1.2 billion, retreating from tthe exceptional peak set in 2016 to more normal levels. Private equity buy-outs shot up 514% to $11.2 billion, largely due to deals for two 'yieldcos'.

FIGURE 51. ACQUISITION TRANSACTIONS IN RENEWABLE ENERGY BY TYPE, 2004-2017, $BN



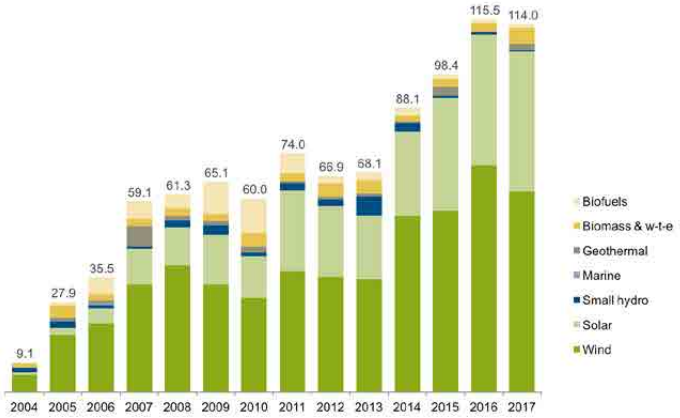
Total values include estimates for undisclosed deals.
Source: Bloomberg New Energy Finance

Most sectors continued to grow, including solar, which gained 7% to $43.4 billion; biomass and waste, up 90% to $4.9 billion; and geothermal, up 15-fold to $1.9 billion (Figure 52). These small absolute gains for the smaller sectors were outweighed by the decline in wind, the largest sector, which fell 12% from its 2016 peak to $62 billion.

Wind also dominated M&A activity, driven by consolidation among manufacturers – with two deals worth more than $1 billion each – and by European utilities moving downstream into project management (Figure 53).

Among the regions, the value of Europe's asset acquisitions and refinancing deals swelled by 26% to reach $37.2 billion, while those of the U.S. gained 4% to $30.8 billion (Figure 54). Large percentage gains were made by Brazil, up 112% to $6.1 billion, and India, which jumped 323% to $1.3 billion.

FIGURE 52. ACQUISITION TRANSACTIONS IN RENEWABLE ENERGY BY SECTOR, 2004-2017, $BN



Total values include estimates for undisclosed deals.
Source: Bloomberg New Energy Finance

ASSET TRANSACTIONS

As always, the largest element of acquisition activity was asset acquisitions and refinancing, and as always its largest component was wind – since the biggest wind projects tend to cost far more than the largest solar ones. Of the top 30 deals in 2017, 23 were wind and only seven solar. The most valuable solar transaction, the refinancing of NextEra Energy's 325MW Silver State South PV plant in Nevada, raised $751 million yet ranked only twelfth largest. The biggest deal overall, in which two Danish pension funds bought 25% stakes in the first two phases of the 660MW Walney Extension Offshore Windfarm, was worth $2.6 billion – five times as much.

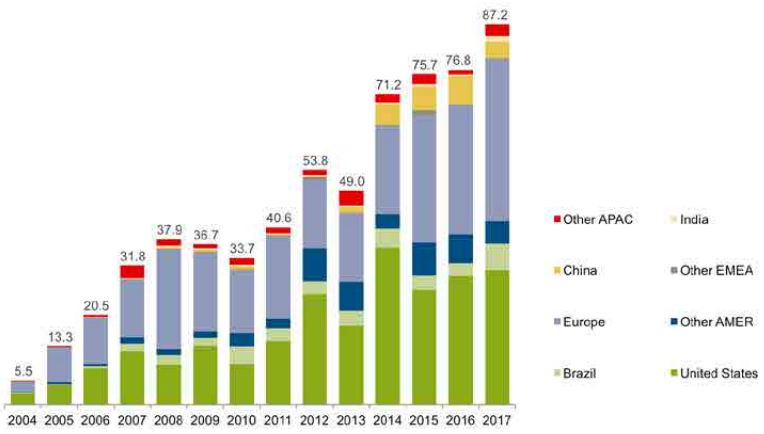
The wind deals were dominated by offshore projects in the North Sea and onshore projects in the U.S. The four largest transactions were for European projects, as were seven of the top 10. After Walney Extension, the next largest deal was the refinancing of the 600MW Gemini Offshore Wind Farm in the Netherlands, in which the owners, Northland Power and Siemens Financial Services, raised $2.1 billion from a consortium of banks. The third largest deal came when Global Infrastructure Partners took a 50% stake in phase two of the 450MW Borkum Riffgrund 2 offshore wind farm for $1.4 billion. The largest U.S. deal was BlackRock's acquisition of a 528MW onshore wind portfolio from First Reserve, the value of which was not disclosed but is thought to have been more than $1 billion. After the Silver State PV Plant deal, the next largest solar deal was Octopus Investments' refinancing of its 522MW portfolio of 74 British PV plants for $609 million.

FIGURE 53. LARGEST CORPORATE M&A DEALS IN RENEWABLE ENERGY IN 2017, $M

Acquirer	Target	Country of target	Sector	Business model	$m
General Electric	LM Wind Power Holding	Denmark	Wind	Wind blade maker	1650
Siemens	Siemens Gamesa Renewable Energy*	Spain	Wind	Wind turbine maker	1117
Shanghai Electric Power	SPIC Jiangsu Electric Power	China	Solar	Project developer	554
Energias de Portugal	EDP Renovaveis	Spain	Wind	Project developer	354
Direct Energie	Quadran	France	Wind	Project developer	353
EDF	Futuren	France	Wind	Project developer	350
FRI-EL Green Power	Alerion Cleanpower	Italy	Wind	Project developer	291
Engie	La Cie Du Vent	France	Wind	Project developer	245
Jera	ReNew Power Ventures	India	Solar	Solar and wind generator	200

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, Bloomberg New Energy Finance

FIGURE 54. ASSET ACQUISITIONS AND REFINANCINGS BY REGION, 2004-2017, $BN



Total values include estimates for undisclosed deals.
Source: Bloomberg New Energy Finance

CORPORATE M&A

In corporate M&A, the two biggest deals were driven by consolidation in the wind sector, where manufacturing capacity far outstripped demand in 2017. General Electric bought its main blade supplier, LM Wind Power, from the private equity firm Doughty Hanson for $1.7 billion. By bringing blade manufacturing and design in-house, the move was aimed at helping GE raise the capacity factors of its turbines and expand its sales across new territories and off shore. Danish company LM has 14 factories on four continents, and has built 195,000 blades, which have been fitted to one fifth of the world's wind turbines.[30]

The other large deal was Siemens' acquisition of Gamesa for $1.1 billion to form Siemens Gamesa Renewable Energy, which creates a 'big four' in turbine manufacturing. The new company is the fourth largest turbine maker by market share behind Vestas, GE, and Goldwind, but has the third largest nacelle manufacturing capacity worldwide. Analysts said that the relative strengths of the two companies were different – Siemens had a strong 3MW platform, which Gamesa lacked; and the Spanish company was the most active non-Chinese manufacturer in Brazil, Mexico, India and China.[31]

[30] https://www.lmwindpower.com/en/about/a-ge-renewable-energy-business
[31] Bloomberg New Energy Finance: Wind Turbine Manufacturers' Strategies, 3 May 2017

These were the two largest transactions by far, but there were a further 18 M&A transactions worth between $100 million and $600 million each. In one notable deal, State Power Investment Corporation of China sold SPIC Jiangsu Electric Power Company, which is developing a 300MW offshore wind farm in Jiangsu, to Shanghai Electric Power for $554 million. In another, the French utility EDF bought a 60% stake in the project developer Futuren, which owns 22 onshore wind projects in France, Germany and Morocco, for $350 million. In a third, Direct Energie, the French international utility founded in 2003, bought the renewable project developer Quadran for $353 million. Quadran builds and operates wind, solar, biomass and hydro plants worldwide.

PUBLIC MARKET EXITS

The collapse of public market investor exits from $6.5 billion in 2016 to $1.2 billion in 2017 was a prominent feature of acquisitions activity last year, but largely explained by a single Danish company: Orsted, formerly known as Dong.

A public market investor exit occurs when an existing investor sells some or all of its stake through a public share flotation, which may or may not also raise new money by selling additional shares. In 2016 the Danish government and Goldman Sachs sold a 17.4% stake in Dong through an initial public offering on the Copenhagen Stock Exchange, to raise just over $3 billion – almost half the total raised through public market investor exits that year. In 2017, Orsted raised a further $939 million through a secondary share placement, which again accounted for most of the funds raised through investor exits. The difference in the size of the two Orsted deals largely explains the overall fall in public market investor exits in 2017.

The success of these share issues shows investors are now comfortable backing a utility that is wholly committed to renewable energy. Ten years ago, Dong (originally standing for Danish Oil and Natural Gas) was one of the most carbon-intensive utilities, but since then the company has reduced its coal consumption by almost three quarters, divested its oil and gas business and dedicated itself to renewable energy. It now has 25% of the offshore wind market, and plans to reduce its emissions 96% by 2023. In 2017, the company renamed itself Orsted, after the Danish scientist who discovered electromagnetism.[32]

[32] https://orsted.com/en/About-us/About-orsted/About-our-name-change

PRIVATE EQUITY BUY-OUTS

While investor exits collapsed in 2017, private equity buy-outs quintupled to $11.2 billion – a record high. Again, a single organization was responsible for much of the activity. Brookfield Asset Management bought majority shares in two yieldcos founded and partially owned by SunEdison, the U.S. solar company that went into insolvency in 2016. The Canadian asset manager bought a 51% stake in Terraform Power, the U.S. yieldco, for $4.7 billion, and another in Terraform Global for $954 million. Together, the deals give Brookfield around 4GW of wind and solar capacity in addition to its extensive existing holdings, which include 8GW of hydro and 2.7GW of storage. The company has cut the dividends paid by the yieldcos and plans to achieve growth organically rather than by acquisition.

Two other major private equity buy-outs were valued at more than $1 billion each. Trina Solar, the world's second largest cell and panel maker in 2016,[33] delisted from the New York Stock Exchange when a group of Chinese investors led by company chairman Jifan Gao bought it out for $1.1 billion. Gao was frustrated that the company's share price did not adequately reflect the value of Trina's business, and said he is planning to list the company's shares in China, where valuations are higher.[34]

In fact, 33 Chinese companies have delisted or announced their intention to delist from U.S. markets, including one other solar firm, JA Solar, and a wind company, Ming Yang Wind Power, which went private in 2016.[35] Not only are valuations higher in China, but the country is now the world's largest solar market. And it seems

[33] Bloomberg New Energy Finance: Who Supplied the World's Solar Market in 2016? 31 May 2017
[34] Bloomberg News, 24 January 2018
[35] Bloomberg New Energy Finance: Chinese Firms Go Home for Better Valuations, 29 March 2017

Chinese companies no longer feel the need to list in the U.S. – as they once did – to demonstrate that their brands are trustworthy.

In the other large private equity buy-out, American energy company AES partnered with Alberta Investment Management to buy FTP Power, a privately held project developer, for almost $1.6 billion. The target company, which is popularly known as sPower, has 1,274MW of solar and wind capacity operating or under construction, with a project pipeline of 10GW.

Among the smaller sectors, geothermal's 19-fold rise to $1.9 billion was largely explained by two big deals in Indonesia, both led by Star Energy Group. It refinanced the 227MW Star Wayang Windu Geothermal Project with $440 million in debt from an international banking consortium, and secured $309 million to buy the 647MW Darajat Salak Star Energy Geothermal Portfolio from another group of banks. Similarly, the 90% increase in biomass and waste volumes to $4.9 billion was largely due to three deals: the refinancing of two waste-to-energy plants, one in Dublin and the other in Amsterdam, which raised $525 million and $352 million respectively, and the Marguerite Fund's acquisition for $111 million of a 30MW biomass portfolio in Portugal.

Overall, the patterns in acquisition activity in 2017, with record asset acquisitions and refinancing, but a plunge in corporate M&A, and large, opposite movements in the value of public market exits and private equity buy-outs, suggested two messages. One was that the precise timing of large deals makes a big difference to the smaller categories. The second, and more interesting, was that, when companies are taken over in renewable energy, they are at least as likely to be project platforms such as TerraForm Power as they are to be technology firms such as LM Wind Power.

GLOSSARY[36]

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.
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.
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.
GREEN BOND	A bond issued by a bank or company, the proceeds of which will go entirely into clean energy and other environmentally-friendly projects. The issuer will normally label it as a green bond.
INITIAL PUBLIC OFFERING (IPO)	A company's first offering of stock or shares for purchase via an exchange. Also referred to as "flotation".
INVESTMENT TAX CREDIT (ITC)	Allows investment in renewable energy in the US to be deducted from income tax.
LEVELISED 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.
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.
PRODUCTION TAX CREDIT (PTC)	The support instrument for wind energy projects at federal level in the US.
PUBLIC MARKETS	All money invested in the equity of publicly quoted companies developing renewable energy technology and generation.
RENEWABLE PORTFOLIO STANDARD (RPS)	A regulation that requires that a minimum of electricity or heat sold is from renewable sources. Also called Renewable Electricity Standard (RES) at the US federal level and Renewables Obligation in the UK.
TAX EQUITY	Tax equity investors invest in renewable energy projects in exchange for federal tax credits.
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.

[36] 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.

UN ENVIRONMENT

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