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

GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2017

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NEW ENERGY FINANCE

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Cover photo courtesy of Enel. It shows Fontes dos Ventos hybrid project, Brazil.

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JOINT FOREWORD FROM ERIK SOLHEIM, PATRICIA ESPINOSA AND UDO STEFFENS

ERIK SOLHEIM

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UDO STEFFENS

The pursuit of clean energy is at the heart of world's aspirations for a better future, as reflected in the 197 countries that have signed up to the Paris Agreement on Climate Change. Moving from fossil fuels to renewable sources such as solar and wind is key to achieving social, economic and environmental development. It will change the lives of 1.2 billion people who struggle through life with no electricity. It will create new jobs and commercial opportunities. And it will slash the air pollution that claims millions of lives each year. The annual Global Trends in Renewable Energy Investment report supports that transformation by demonstrating the progress and potential of this dynamic and fast growing sector.

Successive editions of the report during the last decade show strong support from private investors. This trend continued in 2016, with investment in renewable energy capacity outstripping that in fossil fuel generation for the fifth year in a row. Excluding large hydro, some 138 gigawatts of new power capacity came online; almost 11 gigawatts more than in the previous 12 months.

The cost of achieving this was 23 per cent less than in 2015, partly due to the falling cost of clean technology. For example, the average dollar capital expenditure per megawatt dropped by over 10 per cent for solar photovoltaics and wind. Investors got more bang for their buck.

Take the Adani Group, which is just one of many companies taking advantage of the cheaper set-up costs. It has completed a massive solar plant in India, where generating energy from renewables now costs almost the same as traditional methods. The plant in Tamil Nadu covers 10 square kilometres and can power 150,000 homes. As well as making money, this will help India meet its commitment to the Paris Agreement, by generating 40 per cent of its electricity from non-fossil-fuel sources by 2030. This project created 8,500 jobs in the building phase. This is a clear example of a private company seeing and seizing the chance to do good business and build a sustainable future.

It's a story being repeated around world as public and private sectors grasp a profitable and mutually beneficial opportunity, which will help create a more equitable, stable and peaceful world. We urge investors, business leaders and policy makers to study this report, because profit does not have to be a dirty word. A rapid shift to clean renewable energy is not only slowing climate change, tackling pollution and ending the suffering of vulnerable communities, but boosting long-term economic prosperity and stability.

ERIK SOLHEIM

Head of UN Environment

PATRICIA ESPINOSA

Executive Secretary

United Nations Framework Convention on Climate Change (UNFCCC)

UDO STEFFENS

President

Frankfurt School of Finance & Management

"Ever-cheaper clean tech provides a real opportunity for investors to get more for less,"

said Erik Solheim, executive director of UN Environment.

"This is exactly the kind of situation, where the needs of profit and people meet, that will drive the shift to a better world for all."

"The investor hunger for existing wind and solar farms is a strong signal for the world to move to renewables,"

said Prof. Dr. Udo Steffens, president of Frankfurt School of Finance & Management, commenting on record acquisition activity in the clean power sector, which rose 17 per cent to $110.2 billion.

"The question always used to be 'will renewables ever be grid competitive?',"

said Michael Liebreich, chairman of the Advisory Board at BNEF.

"Well, after the dramatic cost reductions of the past few years, unsubsidised wind and solar can provide the lowest cost new electrical power in an increasing number of countries, even in the developing world – sometimes by a factor of two.

"It's a whole new world: even though investment is down, annual installations are still up; instead of having to subsidise renewables, now authorities may have to subsidise natural gas plants to help them provide grid reliability."

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METHODOLOGY AND DEFINITIONS

All figures in this report, unless otherwise credited, are based on the output of the Desktop 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 Desktop collates all organisations, projects and investments according to transaction type, sector, geography and timing. It covers many tens of thousands of organisations (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 2017 Global Trends report concentrates on renewable power and fuels – wind, solar, biomass and waste, biofuels, geothermal, marine and small hydro-electric projects of less than 50MW.

It does not cover larger hydro-electric dams, of more than 50MW, except briefly in the Executive Summary and Chapter 5. 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 a section 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 REN21. 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 2017 report contains revisions to a number of investment figures published in the 2016 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 2015 and before that have since come to light.

DEFINITIONS

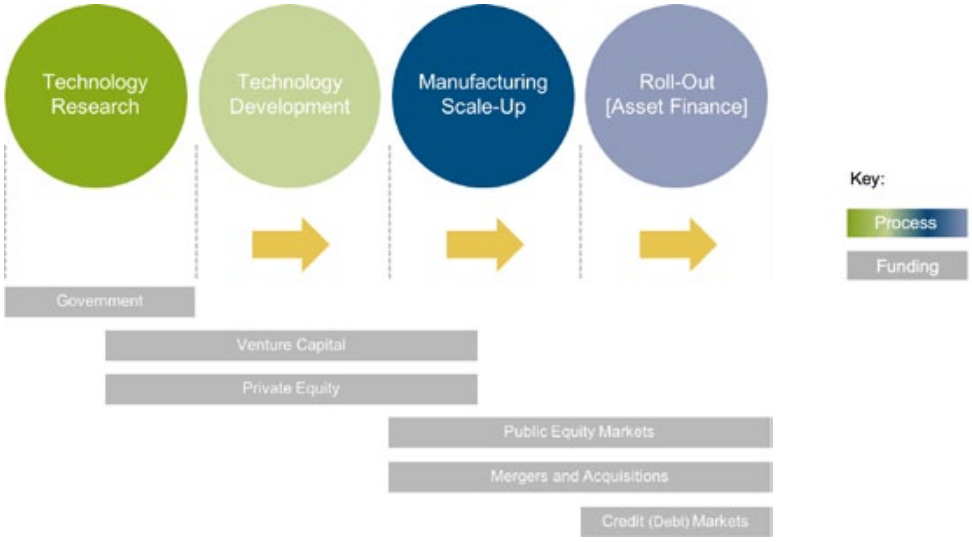
Bloomberg New Energy Finance tracks deals across the financing continuum, from R&D funding and venture capital for technology and early-stage companies, through to asset finance of utility-scale generation projects. Investment categories are defined as follows:

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.



The Renewables Global Status Report is the sister publication to Frankfurt School-UNEP Global Trends in Renewable Energy Investment. The latest edition will be released June 2017. REN21's multi-stakeholder network collectively shares its insight and knowledge to help produce the GSR each year. Today the network stands at 800 renewable energy, energy access and energy efficiency experts. These experts engage in the GSR process, giving their time, contributing data and providing comment in the peer review process. The result of this collaboration is an annual publication that has established itself as the world's most frequently referenced report on the global renewable energy market, industry and policy landscape. In 2016 it was referred to as the gold standard to which other data collection efforts can evolve.

KEY FINDINGS

- "More for less" was the story of renewable energy in 2016. Global new investment in renewables excluding large hydro fell by 23% to $241.6 billion, the lowest total since 2013, but there was record installation of renewable power capacity worldwide in 2016. Wind, solar, biomass and waste-to-energy, geothermal, small hydro and marine sources between them added 138.5GW, up from 127.5GW in the previous year.

- This 2016 gigawatt figure was equivalent to 55% of all the generating capacity added globally, the highest proportion in any year to date. Investment in 'new renewables' capacity was roughly double that in fossil fuel generation in 2016, for the fifth successive year. The proportion of global electricity coming from these renewable sources rose from 10.3% in 2015 to 11.3% in 2016, and prevented the emission of an estimated 1.7 gigatonnes of CO2.

- There were two main reasons for the fall in investment in renewables in 2016. One was lower costs, with average dollar capital expenditure per MW down by more than 10% for solar photovoltaics, onshore wind and offshore wind, improving the competitiveness of those technologies. The other was not so positive – there was a marked slowdown in financings in China, Japan and some emerging markets during the course of the year.

- Overall, renewable energy investment in developing countries fell 30% to $116.6 billion, while that in developed economies dropped 14% to $125 billion. China saw investment plunge 32% to $78.3 billion, breaking an 11-year rising trend. Mexico, Chile, Uruguay, South Africa and Morocco all saw falls in investment of 60% or more, on a mixture of scheduled pauses and delays with auction programmes and financings. Jordan was one of the few new markets to buck the trend, investment there rising 148% to $1.2 billion.

- Among developed economies, the US saw commitments slip 10% to $46.4 billion, as developers took their time to build out projects to benefit from the five-year extension of the tax credit system. Europe enjoyed a 3% increase to $59.8 billion, led by the UK on $24 billion and Germany on $13.2 billion, down 1% and 14% respectively. Japan slumped 56% to $14.4 billion.

- Europe's investment owed its resilience to record commitments to offshore wind, totalling $25.9 billion, up 53% thanks to final investment decisions on mega-arrays such as the 1.2GW Hornsea offshore wind project in the UK North Sea, estimated to cost $5.7 billion. Not all of 2016's offshore wind boom was in Europe – China invested $4.1 billion in the technology, its highest figure to date.

- The most hopeful sign last year for the future greening of the global electricity system was a succession of winning bids for solar and wind, in auctions around the world, at tariffs that would have seemed inconceivably low only a few years ago. The records set last year were $29.10 per MWh for solar in Chile and $30 per MWh for onshore wind in Morocco, but there were other eye-catchingly low outcomes to auctions from Dubai to India, and Zambia to Mexico and Peru.

- Availability of finance does not appear to be a bottleneck to investment in renewables in most countries. Indeed, investor hunger for what many regard as mature technologies helped to fuel record acquisition activity in the clean power sector worldwide last year, totalling $110.3 billion, up 17%. Purchases of assets such as wind farms and solar parks reached a highest-ever figure of $72.7 billion, while corporate takeovers reached $27.6 billion, some 58% more than in 2015.

- New investment in solar in 2016 totalled $113.7 billion, down 34% from the all-time high in 2015, due in large part to sharp cost reductions – and to real slowdowns in activity in two of the largest markets, China and Japan. India saw the construction of the Ramanathapuram solar complex in Tamil Nadu, billed as the world's largest ever PV project at some 648MW.

- Wind followed closely behind solar, at $112.5 billion of investment globally, down 9% despite the boom in offshore projects. However, while solar capacity additions rose in the year to a record 75GW, sharply up from 56GW, wind capacity additions fell back to 54GW in 2016 from the previous year's high of 63GW.

- The smaller sectors of renewable energy had mixed fortunes in terms of investment last year. Biofuels fell 37% to $2.2 billion, the lowest for at least 13 years, biomass and waste held steady at $6.8 billion and small hydro at $3.5 billion, while geothermal rallied 17% to $2.7 billion and marine edged down 7% to $194 million.[1]

- One of the up-and-coming innovations in renewable power is the siting of two different technologies in the same location, to make use of shared land, grid connections and maintenance, and to reduce intermittency. Some 5.6GW of these 'hybrid' projects have been built or are under development worldwide, including hydro-solar, wind-solar, PV-solar thermal, solar thermal-geothermal and biomass-geothermal. Hybrids are examined in this report's Focus, Chapter 4, starting on page 44.

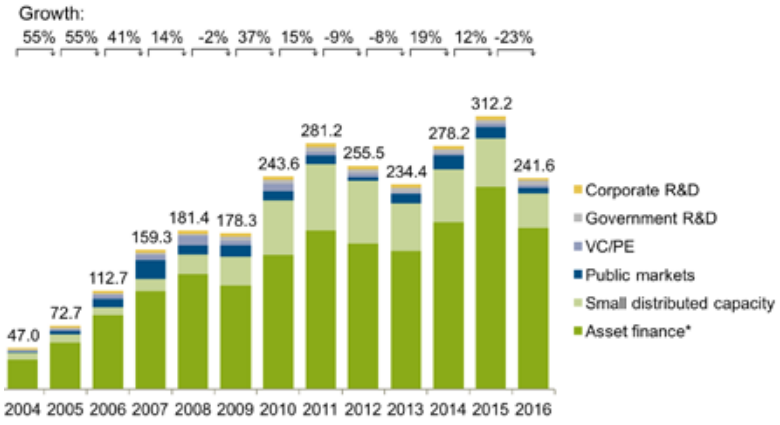
[1] Investment in large hydro-electric dams is not included in the headline figures in this report. Final investment decisions in this technology are estimated to have been worth $23.2 billion in 2016, down 48%.

EXECUTIVE SUMMARY

In 2016, the advance of renewable energy slowed in one respect, and speeded up in another. Investment in renewables excluding large hydro fell by 23% to $241.6 billion, but the amount of new capacity installed increased from 127.5GW in 2015 to a record 138.5GW in 2016. Together, the new renewable sources of wind, solar, biomass and waste, geothermal, small hydro and marine accounted for 55.3% of all the gigawatts of new power generation added worldwide last year. More solar gigawatts were added (75GW) than of any other technology for the first time. A major reason why installations increased even though dollars invested fell was a sharp reduction in capital costs for solar photovoltaics, onshore and offshore wind. On a less positive note, there were clear signs as 2016 went on of slowing activity in two key markets, China and Japan.

Figure 1 shows the trend of global new investment since 2004 in renewable energy (excluding large hydro-electric projects of more than 50MW). The dollars committed per year increased roughly fivefold from the start of the period until 2010, and have since oscillated between $234 billion and $312 billion. The 2016 investment total was once again in that range, although it was down 23% from the record established in 2015. The drop between 2015 and last year is, in fact, the sharpest seen at any time in that sequence.

FIGURE 1. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY ASSET CLASS, 2004-2016, $BN



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

Source: UN Environment, Bloomberg New Energy Finance

Why did investment fall in 2016? There were several reasons, one of the most important of which was lower dollar-denominated costs. The average capital cost for PV projects starting construction in 2016 was 13% lower than in 2015, while for onshore wind the drop was 11.5% and for offshore wind 10%.[2] A section later in this Executive Summary examines the growing cost-competitiveness of wind and solar in more detail.

A second reason was one of timing. A lot of projects in wind and solar were financed in late 2015 and only commissioned in 2016, in which case the investment dollars associated with them were recorded in the earlier year and the GW addition in the later one. Indeed, the 2015 global investment

[2] Bloomberg New Energy Finance, Levelised Cost of Electricity Market Outlooks, H1 2015, H2 2015, H1 2016 and H2 2016.

figure shown in this report represents a 9% upward revision over the one shown in last year's Global Trends report, the revision made because of new information becoming available.

A third issue was that an underlying slowdown in activity did set in, in some key markets, during the course of 2016. In particular, the Chinese solar market decelerated sharply, after a hectic first half that saw 22GW installed, to a second half with 8GW installed. Japanese solar slowed, from 11.5GW in 2015 to 9.2GW installed in 2016.

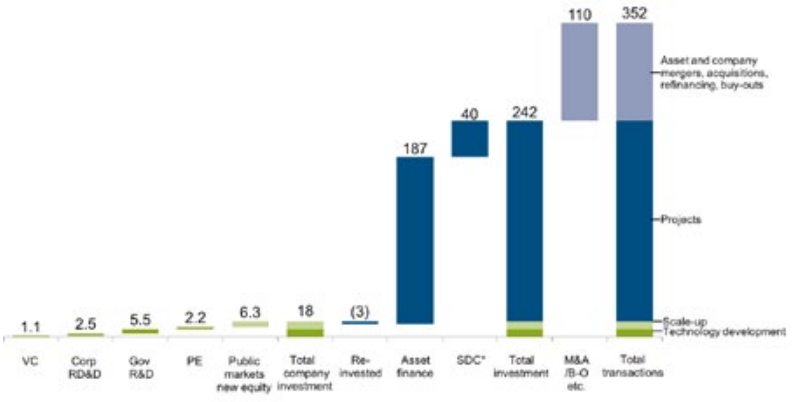
Finally, several up-and-coming renewable energy markets in the developing world produced record investment figures in 2015 but then saw sharp falls in 2016 in response to scheduled pauses, or delays, in their auction schedules. As Chapter 1 explains, South Africa, Mexico, Morocco and Chile – all $2 billion-plus investment locations in 2015 – fell into this category in 2016.

There was one important influence pushing global investment in renewables last year the other way – up – and that was an unprecedented surge in financings for offshore wind projects. These sea-based arrays typically have a much higher capital costs per MW than onshore wind farms, compensating for that to some extent by generating for a higher proportion of the year. In 2016, investment decisions in offshore wind totalled $30 billion, up 41% from the previous year, with no fewer than 14 projects each worth between $500 million and $5.7 billion getting the go-ahead in the UK, Germany, Belgium, Denmark and China.

WHERE THE MONEY WENT

Figure 2 shows the types of investment that made up the total financing for renewables in 2016. The left side of the chart shows early-stage and corporate-level investment: including venture

FIGURE 2. GLOBAL TRANSACTIONS IN RENEWABLE ENERGY, 2016, $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

FIGURE 3. GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2016 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	2015-16 Growth %	2004-16 CAGR %
1 Total Investment															
1.1 New investment	47.0	72.7	112.7	159.3	181.4	178.3	243.6	281.2	255.5	234.4	278.2	312.2	241.6	-23%	15%
1.2 Total transactions	56.8	99.1	148.5	217.9	240.9	242.5	302.4	354.2	322.1	300.5	364.8	406.3	351.9	-13%	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	2.5	0.9	1.1	1.6	1.1	-30%	9%
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	5.5	25%	9%
2.1.3 Corporate RD&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	2.5	-40%	2%
2.2 Scale-up															
2.2.1 Private equity expansion capital	0.3	1.0	3.1	3.5	6.9	3.1	5.5	2.4	1.7	1.4	1.8	1.9	2.2	17%	17%
2.2.2 Public markets	0.3	3.6	9.3	21.4	10.8	12.7	10.8	9.9	4.0	10.3	15.9	13.3	6.3	-53%	30%
2.3 Projects															
2.3.1 Asset finance	33.7	53.0	85.5	114.9	135.6	120.5	155.1	183.5	169.4	159.3	194.4	237.4	187.1	-21%	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	-53%	-
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	55.5	39.8	-28%	14%
Total Financial Investment	34.6	58.0	98.3	139.4	153.0	136.1	172.5	196.7	174.9	170.8	209.8	248.1	193.8	-22%	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	64.1	47.8	-25%	12%
Total New Investment	47.0	72.7	112.7	159.3	181.4	178.3	243.6	281.2	255.5	234.4	278.2	312.2	241.6	-23%	15%
3 M&A Transactions															
3.1 Private equity buy-outs	0.8	3.7	1.9	3.4	5.1	2.2	1.9	3.0	3.3	0.5	4.2	3.4	3.4	-2%	12%
3.2 Public markets investor exits	0.4	2.4	2.8	4.0	0.9	2.5	4.9	0.2	0.4	1.7	1.7	1.8	6.7	269%	26%
3.3 Corporate M&A	2.3	7.6	11.2	20.4	16.9	21.9	19.3	29.4	9.8	16.5	11.4	17.5	27.6	58%	23%
3.4 Project acquisition & refinancing	6.3	12.6	19.9	30.9	36.4	37.6	32.7	40.3	53.1	47.4	69.2	71.3	72.7	2%	23%
4 New Investment by Sector															
4.1 Wind	19.6	28.5	39.7	61.1	74.8	79.7	101.6	84.2	84.4	89.0	108.5	124.2	112.5	-9%	16%
4.2 Solar	11.2	15.9	21.9	38.9	61.3	64.0	103.6	154.9	140.6	119.1	143.9	171.7	113.7	-34%	21%
4.3 Biofuels	4.0	9.9	28.6	27.4	18.4	10.2	10.5	10.6	7.2	5.2	5.3	3.5	2.2	-37%	-5%
4.4 Biomass & w-t-e	8.3	9.8	12.8	23.0	17.5	15.0	16.6	19.9	14.9	12.4	10.8	6.7	6.8	0%	-2%
4.5 Small hydro	2.7	7.4	7.5	6.4	7.6	6.2	8.1	7.5	6.4	5.6	6.4	3.5	3.5	0%	2%
4.6 Geothermal	1.2	1.2	1.4	1.7	1.7	2.8	2.9	3.9	1.6	2.9	2.9	2.3	2.7	17%	7%
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	-7%	16%
Total	47.0	72.7	112.7	159.3	181.4	178.3	243.6	281.2	255.5	234.4	278.2	312.2	241.6	-23%	15%
5 New Investment by Geography															
5.1 United States	5.7	11.9	29.3	39.3	35.8	23.9	35.3	49.6	40.6	33.8	38.4	51.4	46.4	-10%	19%
5.2 Brazil	0.9	2.7	5.1	9.8	11.5	7.8	7.4	10.3	8.1	4.4	8.2	7.1	6.8	-4%	18%
5.3 AMER (excl. US & Brazil)	1.8	3.3	3.7	4.8	5.9	5.5	12.4	9.5	10.4	12.3	14.0	13.1	6.1	-54%	10%
5.4 Europe	25.0	33.1	46.8	67.4	81.3	82.5	113.9	123.8	88.9	59.4	63.0	58.1	59.8	3%	6%
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	8.4	11.4	7.7	-32%	24%
5.6 China	3.0	8.7	11.1	16.6	25.3	38.1	41.4	46.0	58.3	63.3	87.3	115.4	78.3	-32%	31%
5.7 India	2.8	3.2	5.4	6.8	5.7	4.2	9.0	13.7	8.0	6.6	8.4	9.6	9.7	0%	11%
5.8 ASOC (excl. China & India)	7.2	9.0	10.1	12.8	13.6	14.5	20.0	25.1	30.9	45.3	50.5	46.1	26.8	-42%	12%
Total	47.0	72.7	112.7	159.3	181.4	178.3	243.6	281.2	255.5	234.4	278.2	312.2	241.6	-23%	15%

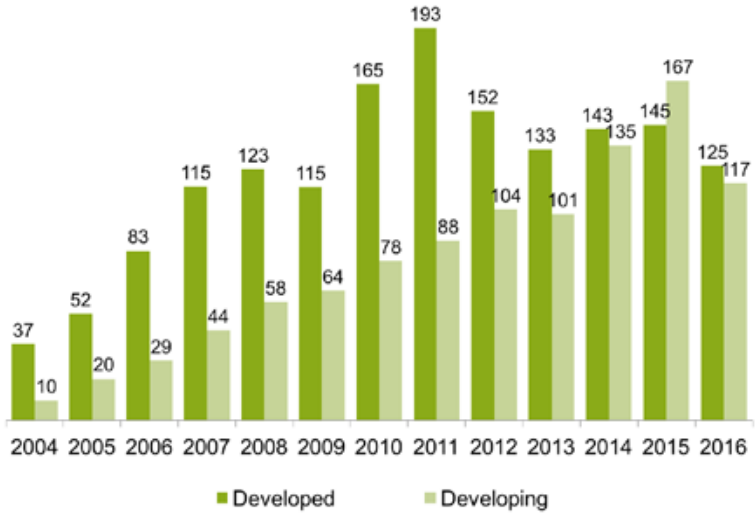
New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals
Source: UN Environment, Bloomberg New Energy Finance

capital, private equity and public market funding of specialist renewable energy companies, and corporate and government research and development. The biggest slice of total investment was, as before, asset finance of utility-scale projects such as wind farms and solar parks, at $187.1 billion. Small distributed capacity (rooftop and other small solar projects of less than 1MW) contributed $39.8 billion, taking us to the new investment total for the year of $241.6 billion.

There was then a record $110.3 billion of acquisition deals, including purchases of renewable energy generating plants, refinancings and corporate mergers and takeovers, taking the total value of transactions in renewables to $351.9 billion. This acquisition boom is discussed in detail in Chapter 10 of this report, but the overriding message appeared to be that 'new renewables' are becoming ever more mainstream – so, for instance, wind turbine manufacturers were consolidating in a search for market share, and new owners were emerging for operating-stage wind and solar assets.

Figure 3 provides a more detailed breakdown of both new investment and acquisition activity in 2016, and in every prior year since 2004. It shows how different regions have performed over the period, Europe for example seeing a peak in new investment at $123.8 billion in 2011, at the time of the German and Italian solar booms, and a flattish trend at a lower level in recent years, with 2016 seeing a figure of $59.8 billion, up 3% on 2015.

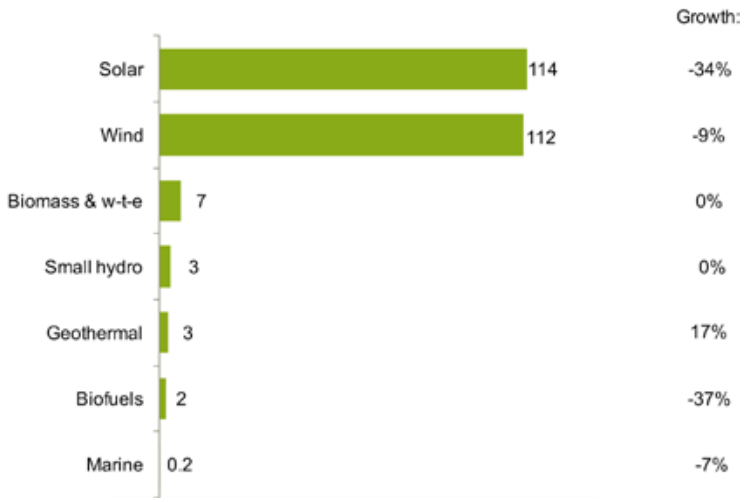
FIGURE 4. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY: DEVELOPED V DEVELOPING COUNTRIES, 2004-2016, $BN



New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals. Developed country 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, 2016, AND GROWTH ON 2015, $BN



New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals

Source: UN Environment, Bloomberg New Energy Finance

It also shows the importance of China to global investment. The world's most populous country committed $78.3 billion to renewables last year, but this was down 32% on 2015's record, reflecting a combination of lower costs per MW and a dip in activity as grids concentrated on integrating capacity already built and after the previous feed-in tariff expired in mid-year. US investment fell 10% in 2016 to $46.4 billion (see Chapter 1 for detailed analysis). This was in line with its average for the previous five years.

One of the surprises of 2016 was that developed economies regained their lead over developing countries in renewables investment (see Figure 4). Both groups saw a fall in the value of financings, but the developing economy total dropped more sharply, by 30%, to $116.6 billion. Not every developing country saw investment falter – India was firm at $9.7 billion, and Jordan saw a 148% jump to $1.2 billion, but the $37.1 billion drop in China dwarfed everything else. The richer countries suffered a 14% fall in investment to $125 billion, with falling PV costs and weaker activity in Japanese solar two of the main factors.

Figure 5 highlights the way renewable energy investment continues to be dominated by just two sectors – solar and wind. Both suffered declines in dollar investment in 2016, solar down 34% to $113.7 billion and wind down 9% to $112.5 billion. The smaller sectors had mixed fortunes last year, geothermal seeing a 17% increase to $2.7 billion, while biomass and waste marked time at $6.8 billion and small hydro at $3.5 billion. Biofuels fell 37% to $2.2 billion, its lowest figure during the whole 2004-16 period and only 8% of its 2006 peak.

Looking at particular types of investment within those total figures, Figure 6 splits out the money flowing from venture capital and private equity funds into specialist renewable energy firms. This was $3.3 billion in 2016, down 4%. As usual, solar made up most of the total, at $2.3 billion, although this was down 2% year-on-year. The trends in VC/PE financing are explored in Chapter 8.

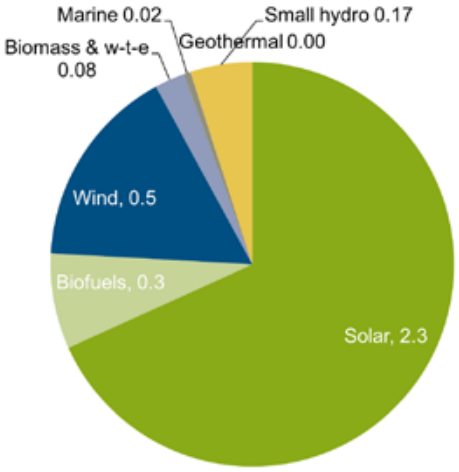
Figure 7 splits out public markets investment by sector in 2016. Overall, this fell 53% to $6.3 billion, partly due to a downturn in equity raising by 'yieldcos', or quoted funds set up to own renewable energy projects. Wind accounted for $4.3 billion of the public market activity, up 66%, while solar fell 83% to $1.7 billion. The main deals and developments of the year are explained in Chapter 7.

Renewable energy capacity investment – in other words, asset finance of utility-scale projects plus money committed to smaller systems – is shown by sector in Figure 8. Solar systems of one size or another attracted $107.6 billion, down 32% from 2015, but this total was narrowly trumped by wind, which drew $107.9 billion, down 12%. Figure 8 shows, for comparison, that estimated asset finance for large hydro-electric projects in 2016 was $23.2 billion, down 48%. This was only a fraction of the wind and solar numbers, but much larger than the remaining renewable energy sectors. Large hydro is not covered in this report, except as part of the overall power generation mix in Chapter 2 and in a separate box in Chapter 5.

DOWNWARD SPIRAL ON COSTS

The most exciting development in renewable energy over recent years has been the rapid progress made in reducing the 'levelised', or all-in, costs of generation from solar PV and wind.[3] In the second half of 2016, levelised costs for PV without tracking varied greatly by country and project, but the central estimate was

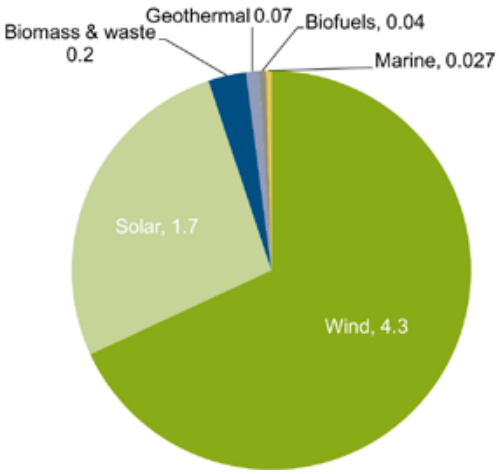
FIGURE 6. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2016, $BN



VC/PE new investment excludes PE buy-outs. Total values include estimates for undisclosed deals

Source: UN Environment, Bloomberg New Energy Finance

FIGURE 7. PUBLIC MARKETS NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2016, $BN

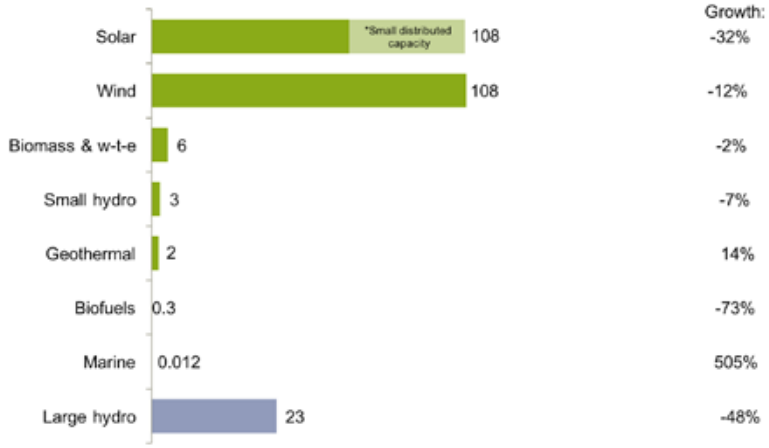


Source: UN Environment, Bloomberg New Energy Finance

[3] Levelised costs of electricity include the costs of capex, finance, operating and maintenance, development and fuel.

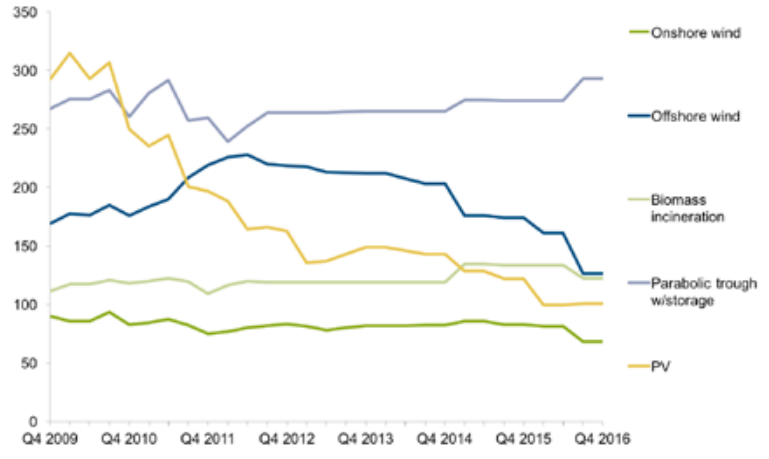
$101 per MWh, down 17% in just one year. Onshore wind's central levelised cost estimate was $68 per MWh in H2 2016, down 18% in a year, while that for offshore wind was $126, down 28%. Figure 9 shows that while electricity from PV and onshore wind have been getting cheaper and cheaper since 2009, biomass incineration and solar thermal have made little or no progress.

FIGURE 8. RENEWABLE ENERGY ASSET FINANCE AND SMALL DISTRIBUTED CAPACITY INVESTMENT BY SECTOR, 2016, AND GROWTH ON 2015, $BN



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

FIGURE 9. LEVELISED COST OF ELECTRICITY FROM SELECTED RENEWABLE ENERGY SOURCES, Q3 2009 TO H2 2016, $ PER MWH



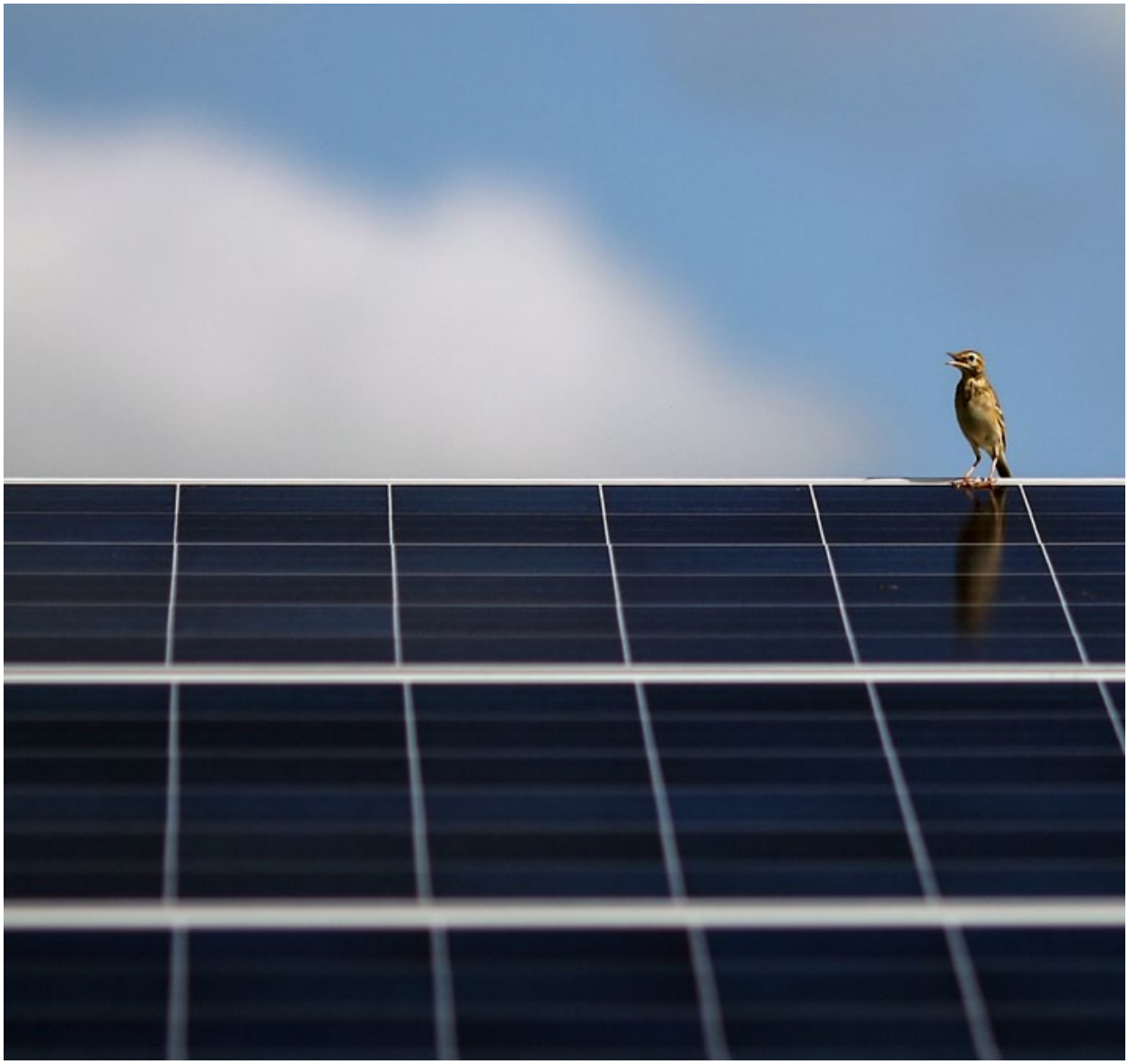
Solar thermal is parabolic trough with storage, PV is crystalline silicon with no tracking
Source: Bloomberg New Energy financea

How have PV and wind improved their competitiveness so much? One reason has been cheap financing in many countries (see Chapter 3) – particularly important for technologies where the overwhelming part of lifetime costs are upfront rather than in the operating phase. Another has been the improving efficiency of wind and solar equipment, and better knowhow on how to locate and to maintain it. Capacity factors (the percentage of electricity that a power plant produces during a year compared to the theoretical maximum that the device could generate under constantly perfect conditions) have increased, in the case of onshore wind from 12% on average globally in 1997 to 25% in 2015. The average efficiency for crystalline-silicon PV mono cells increased from 17.5% in 2010 to 19.8% in 2015.[4]

The most important reason, however, has been lower dollar-denominated capital expenditure, or capex, costs per megawatt. The fact that the US currency has been strong in the last two years has played a part in cutting costs in other countries when converted into dollars. But the bulk of the reduction in costs has been a real one, visible in almost any currency.

In 2016 alone, average capex for crystalline silicon PV without tracking dropped by 13%, to $1.2 million per MW, while the equivalents for onshore and offshore wind fell by 11.5% and 10% respectively, to $1.6 million and $4 million per MW. Manufacturers have played an important role in this. In offshore wind, for instance, projects used in 2009 to be built with 3MW machines, 80 metres high, now some are being constructed with 8MW devices, 220 metres high. In solar PV, over-supply along the supply chain from silicon wafers to

[4] Bloomberg New Energy Finance, Research Note, PV efficiency improvements in 2015 and forecasts, April 2016.



modules has forced manufacturers to cut prices to sell stock. Further down the supply chain, declining civil engineering and installation outlays for projects have also been important.

Lower total capex costs were responsible for part of the $70.6 billion fall in global renewable energy investment last year. Of that figure, an estimate would be that around $27 billion of that total decline reflected reduced upfront per-MW costs for PV, onshore wind and offshore wind. Breaking that down, between a third and a half of the 31% fall in PV capacity investment last year was due to lower unit costs and just over half of onshore wind's 22% drop.[5]

Both capital costs per MW and levelised costs per MWh have been squeezed down by competition, and this process has been accelerated by the spread of auctions as a prime method for countries to allocate new generating capacity. Last year brought a hectic series of milestones for declining costs, emerging from auctions around the world – to take a few, $60 per MWh for solar in Rajasthan, India, in January; $30 per MWh for wind in Morocco, in January; $37.70 per MWh for wind in Peru, in February; $40.50 for solar in Mexico, in March; $29.90 for solar in Dubai, in May; $60 for solar in Zambia, in June; $80 for offshore wind in the Netherlands, in July; $29.10 for solar in Chile, in August; $55 for offshore wind in Denmark, in November.[6]

[5] The other main factors were a sharp fall in public markets investment, lower asset finance of solar thermal, a shift in the mix between small-scale and utility-scale PV, and an underlying slowdown in financings in a number of markets since 2015.

[6] These results are not 100% comparable to each other, since auctions vary on whether the cost of transmission is included, whether tariffs are index-linked and how long they run, and when projects need to be built.

FUTURE CAVEATS

Renewables excluding large hydro have gone from being labelled as 'alternative energy' and a niche choice for wealthy countries only 10 years ago, to the majority (55.3% in 2016) of new generating capacity installed worldwide, as Chapter 2 describes. Wind and solar are undercutting coal or gas – or both – in terms of levelised costs, in an increasing number of countries.

That, however, does not mean the future will necessarily be plain sailing for renewables. Wind and solar remain vulnerable to unfriendly twists in policy, or to measures that set out directly to protect coal and gas. Their competitiveness could be eroded, for a time at least, if there was a sharp, upward turn in the international interest rate cycle, perhaps in response to a shift in US economic policy. Demand for all new generating technologies could be dampened if electricity consumption grows much less than expected.

Finally, the structure of electricity markets continues to be a challenge not just for renewable energy developers but also for energy ministries around the world. There is the issue of how to reward flexible generation and storage, so that the system is always able to respond when wind and solar generation drops.

There is also the issue of how investors in new, unsubsidised wind and solar projects can de-risk future revenues in an unsubsidised era.

INVESTMENT BY TYPE OF ECONOMY

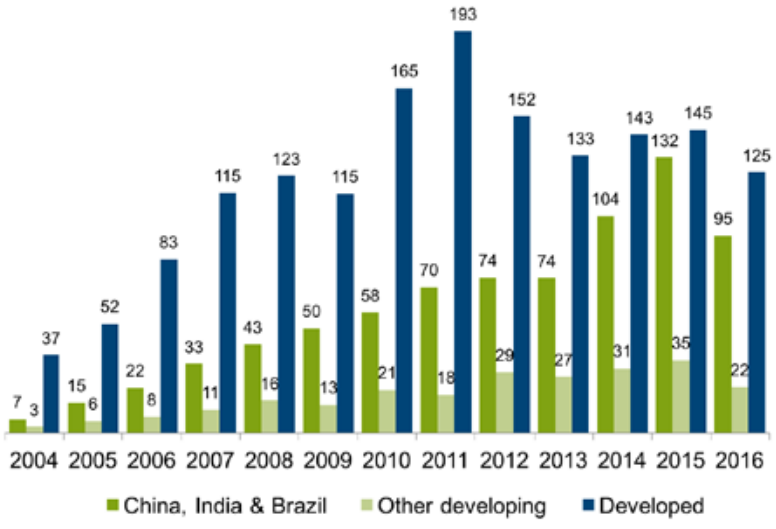
- Sharply contrasting trends were seen in renewable energy investment last year, between types of economy, regions and individual countries, although the impact of lower costs for wind and solar was felt everywhere.
- Dollar investment in developed economies fell by 14% to $125 billion in 2016, some 52% of the world total, with a 10% decline in the US, a 3% increase in Europe, and a 56% drop in Japan.
- The 'big three' developing economies of China, India and Brazil saw a combined 28% setback in dollar investment to $94.7 billion, but this disguises different trends in each. China was down by almost a third, Brazil 4% lower and India held steady.
- 'Other developing countries' saw a significant reverse (of 37% to $21.9 billion) in investment in 2016. Delays in policy support afflicted South Africa, Mexico and Brazil, while project timing issues limited dollar commitments in Morocco, Chile and Pakistan. However, there was higher investment in some other countries, with Jordan one of the star performers.
- Among the developing nations pursuing policies that could lead to increasing renewables investment in 2017 and beyond were India, Argentina, Egypt and United Arab Emirates.

DEVELOPED VERSUS DEVELOPING ECONOMIIES

If 2015 was the year that developing economies spectacularly overtook developed countries in terms of total investment in renewable energy excluding large hydro, then 2016 was the year that they unexpectedly lost that lead. As Figure 4 in the Executive Summary of this report shows, investment in developing countries dropped by 30% last year to $116.6 billion, while that in the richer nations fell 14% to $125 billion.[7]

A slightly different view of the split is presented in Figure 10. This divides developing countries into the 'big three' of China, India and Brazil on the one hand, and the remainder on the other. It highlights just how important the

FIGURE 10. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY: SPLIT BY TYPE OF ECONOMY, 2004-2016, $BN



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

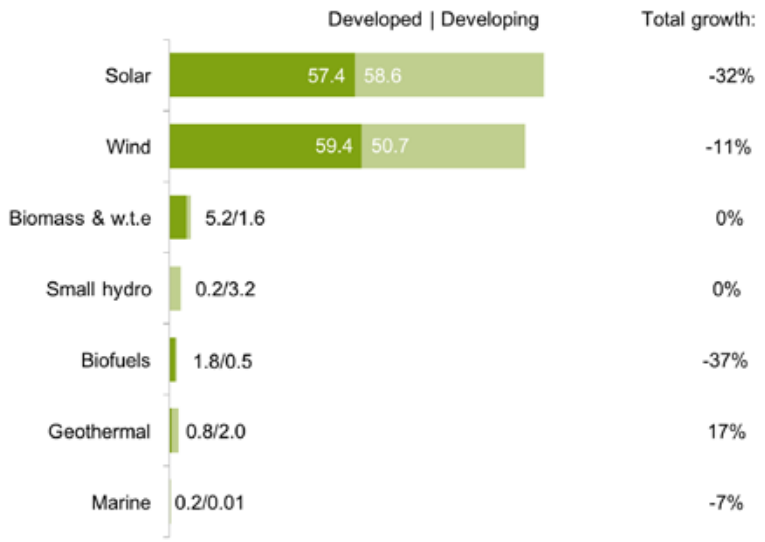
Source: UN Environment, Bloomberg New Energy Finance

[7] In this report, developing economies are defined as non-OECD countries plus Turkey, Chile and Mexico.

big three have been in investment terms in the last decade, but also reveals that both groups saw major reductions in dollar commitments in 2016. China, India and Brazil, as a group, accounted for investment of $94.7 billion, down 28%, while the 'other developing' economies managed $21.9 billion, down 37%.

The latter fall was perhaps the most surprising aspect of global renewable energy investment in 2016. 'Other developing' economies had seen their total climb fairly smoothly over the years, reaching $34.9 billion in 2015, with countries such as South Africa, Turkey, Chile, Mexico, Uruguay, the Philippines, Morocco and Pakistan becoming billion-dollar, or multi-billion-dollar, contributors. This fitted in with their rising demand for electricity, and their excellent natural resources for wind and solar deployment.

FIGURE 11. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY: DEVELOPED V DEVELOPING COUNTRIES, 2016, AND TOTAL GROWTH ON 2015, $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.

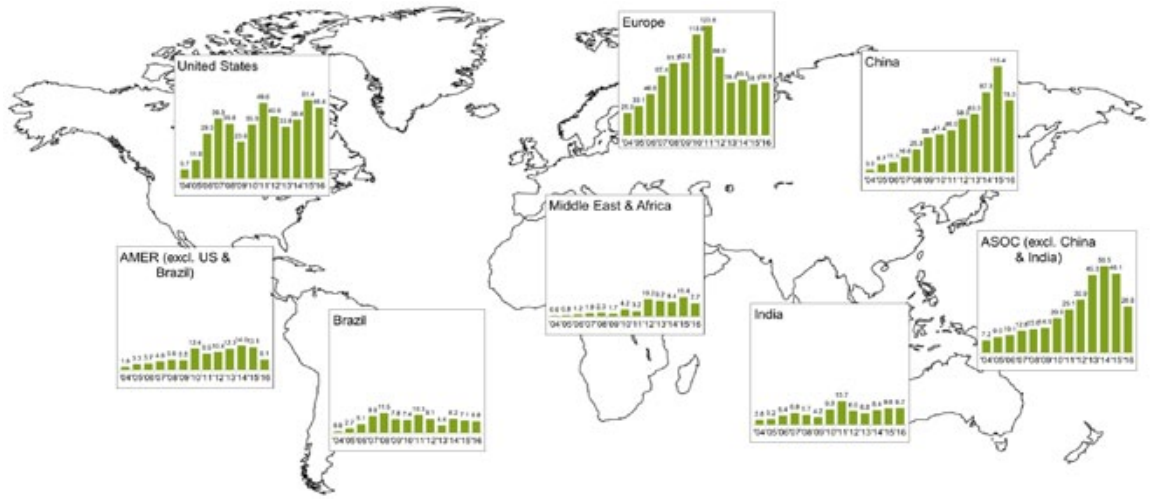
Source: UN Environment, Bloomberg New Energy Finance

However, there was a marked blip in that trend in 2016, with all those named countries seeing sharp falls in investment. The reasons in the case of each country are explored in detail later in this chapter, but there were some common factors, notably lower dollar costs for the projects that were financed and delays either in auction programmes or in the securing of debt and equity for projects that won capacity in auctions. Not all of the 'other developing' economies suffered falls in investment last year. Notable exceptions included Jordan, Egypt and Bolivia (see commentary later in the chapter).

Figure 11 shows the developed/developing country split on investment by sector. In 2015, developing economies including the big three accounted for more than half of global investment in both wind and solar, but in 2016 they lost the lead in wind and only narrowly maintained it in solar. Developed nations saw investment in wind of $59.4 billion, up 11% thanks in large part to their bumper year for offshore projects, against $50.7 billion for developing countries, down 28%. In solar, developed countries invested $57.4 billion, down 31%, and developing nations $58.6 billion, down 34%.

Other sectors tend to show consistent leads over the years – for developing economies in geothermal and small hydro, and developed nations in biomass and waste-to-energy. The lead in biofuels has alternated over the years, depending on whether the US or Brazil was dominant in terms of new projects in a particular period. In 2016, developed countries maintained their advantage in biomass and waste, with $5.2 billion against $1.6 billion for emerging economies, and took the lead in biofuels, with $1.8 billion against $453 million. Geothermal saw developing countries ahead as usual, $2 billion to $775 million, as did small hydro, $3.2 billion against $229 million.

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

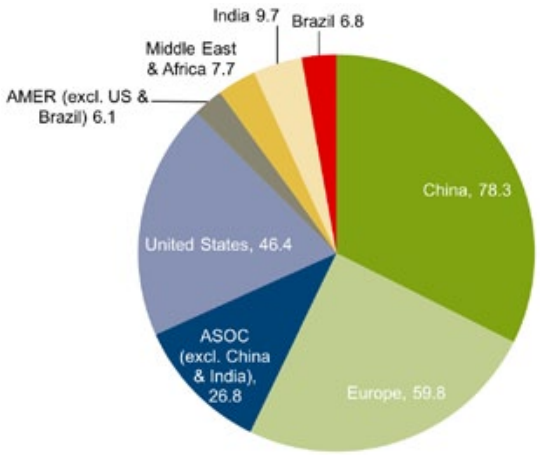
MAIN CENTRES

Renewable energy investment in 2016 showed contrasting trends between regions, and between the leading countries. Figure 12 shows the trends over the last 13 years in each of the regions. The US continued to be a strong centre for investment, its figure of $46.4 billion being roughly in line with its average since 2011, albeit 10% down on the 2015 record.

China was again the biggest location for dollar commitments, but its total of $78.3 billion was down 32% from 2015 and the lowest since 2013. This broke a 12-year sequence of rising investment year-by-year. India, arguably one of the most exciting markets for the next few years, recorded $9.7 billion in 2016, no more than on a par with 2015 and its average since 2010. Brazil bumps along from year to year in Figure 12 without much sign of an upward trend, and in fact last year's figure of $6.8 billion was down 4% and the second-lowest since 2006.

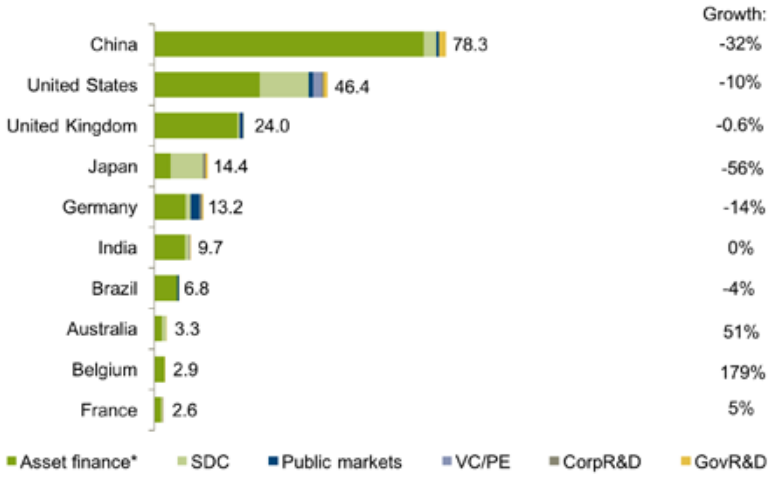
The chart shows that investment in Europe has stabilised in recent years after falling from peaks above $100 billion per year during the German and Italian solar booms of 2010-11. In 2016, it totalled $59.8 billion, up 3% on the previous year, with financing of offshore wind projects and the new equity raised by Innogy as it floated on the Frankfurt stock market two of the main features. See more on Innogy's share issue in Chapter 7.

FIGURE 13. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY REGION, 2016, $BN



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

FIGURE 14. NEW INVESTMENT IN RENEWABLE ENERGY BY COUNTRY AND ASSET CLASS, 2016, AND GROWTH ON 2015, $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

Figure 14 breaks down the picture into the 10 leading countries for investment in 2016. The top seven are in the same order as in 2015, except that Japan's sharp fall in dollars committed pushes it from third, down below the UK into fourth place. All of those top seven saw lower investment last year than in the previous year, other than India, where it was steady. However, the size of the drops varied greatly, with the UK and Brazil down less than 5% at one extreme and China and Japan both down more than 30% at the other. The bottom three places of the top 10 changed radically in 2016, with Chile, South Africa and Canada dropping out, to be replaced by Australia, Belgium and France.

The Middle East and Africa last year had its lowest level of renewables investment since 2011, the latest figure, of $7.7 billion, being some 32% below 2015. As described below, much of this dip was due to pauses in financing in both South Africa and Morocco.

The other two regions in Figure 12 both saw sudden interruptions in 2016 to previously strong growth trends. The Americas excluding the US and Brazil suffered a 54% slump in investment to $6.1 billion, its lowest for nine years, while Asia-Oceania excluding China and India had a 42% setback to $26.8 billion, its weakest figure since 2011. As described below, several Western Hemisphere countries had fewer financings in 2016, including Canada, Mexico, Uruguay and Chile, for different reasons. A sharp drop in Japan was the dominant reason for the reduction in investment in ASOC (Asia Oceania) excluding China and India.

The relative shares of the main regions in global investment in 2016 are shown in Figure 13. China accounted for 32% of all financings of renewable energy excluding large hydro, and Europe 25%. The US was another 19% and Asia-Oceania excluding China and India was 11%. India, Other Americas, Brazil and Middle East and Africa made up 4%, 3%, 3% and 3% respectively.

DEVELOPED ECONOMIES

The US has been in the top two or three countries for renewable energy investment ever since 2004. It was the largest of all in 2011, the peak year for the Obama administration's 'green stimulus' – as programmes such as the Treasury grant scheme and the federal loan guarantee reached expiry. Last year saw no abrupt change in this trend, with US financings down 10% at $46.4 billion but above the equivalent outturns for 2013 and 2014.

Figure 15 shows the split by sector and by type of investment. US renewable energy investment tends to be more diverse than that of most other countries and regions, with strong showings by public markets, venture capital and private equity, and small-scale projects, as well as by utility-scale asset finance. In 2016, there was strong growth in small distributed capacity investment, with $13.1 billion of rooftop and other small PV projects going ahead, up 33% on 2015.

Utility-scale asset finance was down just 2% at $29.8 billion, with wind and solar each contributing $14.7 billion. The five-year extension to the Production Tax Credit for wind and the Investment Tax Credit for solar, agreed unexpectedly in

FIGURE 15. RENEWABLE ENERGY INVESTMENT IN THE US BY SECTOR AND TYPE, 2016, $BN

	Asset finance	Re-invested Equity	SDC	Public markets	VC/PE	CorpR&D	GovR&D	Total
Solar	14.7	-0.8	13.1	0.2	1.7	0.3	0.1	29.3
Wind	14.7	-0.6	-	1.1	0.2	0.0	0.1	15.5
Biofuels	0.1	-	-	0.0	0.3	0.1	0.6	1.0
Geothermal		-	-			0.0	0.1	0.1
Biomass & w.t.e	0.2	-	-		0.1	0.0	0.1	0.4
Small hydro	0.1	-	-		0.0	0.0	0.0	0.1
Marine		-	-	0.0	0.0	0.0	0.0	0.1
Total	29.8	-1.5	13.1	1.3	2.3	0.5	1.0	46.4

Source: UN Environment, Bloomberg New Energy Finance

FIGURE 16. RENEWABLE ENERGY INVESTMENT IN EUROPE BY SECTOR AND TYPE, 2016, $BN

	Asset finance	Re-invested Equity	SDC	Public markets	VC/PE	CorpR&D	GovR&D	Total
Solar	1.6	-0.1	6.7	1.0	0.4	0.2	0.5	10.2
Wind	40.6	-0.2	-	2.8	0.1	0.2	0.2	43.8
Biofuels			-	0.0		0.2	0.4	0.6
Geothermal	0.8		-			0.0	0.1	0.8
Biomass & w.t.e	3.9	0.0	-	0.0	0.0	0.1	0.1	4.2
Small hydro	0.0		-			0.0	0.0	0.1
Marine		-	-	0.0	0.0		0.1	0.1
Total	46.9	-0.3	6.7	3.8	0.5	0.8	1.4	59.8

Source: UN Environment, Bloomberg New Energy Finance

Congress in December 2015, underpinned investor interest in US renewables throughout last year – although its long duration also meant that some developers decided to take their time before pressing ahead with new projects.

However, public markets investment in the US plunged 87% to just $1.3 billion, the lowest for five years. SunEdison, the giant solar developer that raised $2 billion on its own in 2015, entered bankruptcy proceedings last year; and the 'yieldco' funds that own operating-stage renewable energy projects found it hard to raise new equity in 2016 after a share price collapse late in the prior year. There is more discussion of the yieldco rollercoaster in Chapters 3 and 7.

Venture capital and private equity investment in specialist US renewable energy firms was $2.3 billion, down 2%, while corporate and government research and development spending was down 24% and up 51% respectively, at $498 million and $1 billion.

Figure 16 shows the equivalent breakdown for Europe. More than in the case of the US, overall investment was dominated by asset finance, making up $46.9 billion out of $59.8 billion. Remarkably little ($1.6 billion, down 75%) of this asset finance was solar, while biomass and waste-to-energy made up $3.9 billion, up 14%, and wind dominated with $40.6 billion, up 10%. The onshore wind element of the latter was actually down 26% at $14.8 billion, but this drop was more than offset by offshore wind, up 53% to $25.9 billion.

Small distributed capacity in Europe attracted $6.7 billion in 2016, down 18%, with Germany, the UK and the Netherlands the three biggest contributors to that figure. Public markets investment leapt 170%, largely thanks to the $2.2 billion of new money raised by Innogy, the offshoot of German utility RWE, in its initial public offering. VC/PE investment was $516 million, almost exactly double the 2015 number, while corporate and government R&D were $780 million and $1.4 billion respectively, down 37% and up 24%.

Among individual European countries, the UK was the biggest investor in renewables for the second successive year. Asset finance contributed $22.5 billion to the UK's $24 billion total investment, with four giant offshore wind projects – Hornsea (1.2GW), Beatrice Cape (588MW), East Anglia One (714MW) and Burbo Bank Extension (258MW) – amounting to $14.2 billion of that. Each of these had clinched tariff support either through the expiring Renewable Obligation Certificate scheme or the first instalments of the new Contract-for-Difference (CfD) programme, before a hiatus in renewables policy that set in after the May 2015 general election. The Tees project, at 299MW and $841 million, heralded as the world's biggest dedicated biomass plant, also secured a CfD.[8]

Germany was the second-largest of the European markets, with investment of $13.2 billion. Within this, asset finance was $8.4 billion, down 34%, dominated by offshore and onshore wind. Three offshore arrays, the 450MW Borkum Riffgrund, 396MW Merkur and 385MW Arkona Becken Sudost all reached final investment decision, for a combined total of $5.1 billion. Outside offshore wind, one issue that may have caused some developers to hold back in 2016 was uncertainty over Germany's switch from feed-in tariff support to auctions. Auctions for PV were held last year, and the country may have 2-3 rounds for onshore wind in 2017.

In Figure 17, there is a big gulf between investment levels in the two biggest European markets, the UK and Germany, and eight other countries that recorded commitments of between $1.3 billion and $2.9 billion. However, even among that latter group, there were some sizeable projects financed in 2016, including the Norther and Rentel offshore wind farms off Belgium, at 370MW and $1.3 billion, and 309MW and $1.2 billion respectively, and the Horns Rev 3 offshore array off Denmark, at 406MW and $1.1 billion.

FIGURE 17. TOTAL RENEWABLE ENERGY INVESTMENT IN EUROPE BY COUNTRY, 2016, $BN AND CHANGE ON 2015

	2016	% growth on 2015
United Kingdom	24.0	-1%
Germany	13.2	-14%
Belgium	2.9	179%
France	2.6	5%
Denmark	2.5	128%
Norway	2.2	1419%
Italy	1.8	31%
Sweden	1.7	117%
Turkey	1.5	-51%
Netherlands	1.3	-2%

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

[8] Tees' CfD was secured in the in the so-called FIDeR round in 2014 that preceded the first full CfD auction in early 2015.

Other technologies also produced some bumper financings. The 1GW Fosen wind portfolio in Norway, at $1.3 billion, was the biggest onshore wind deal anywhere in the world in 2016, and the Amagervaerket biomass plant in Denmark, at 150MW and $739 million the second largest biomass undertaking globally.

FIGURE 18. TOTAL RENEWABLE ENERGY INVESTMENT IN MAJOR DEVELOPED ECONOMIES, 2016, $BN, AND CHANGE ON 2015, $BN

	2016	% growth on 2015
Japan	14.4	-56%
Australia	3.3	51%
South Korea	1.4	-10%
Canada	1.7	-54%
Israel	1.2	80%

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

Figure 18 shows renewable energy investment in five other developed economies in 2016. Australia and Israel both enjoyed increases in commitments. The latter owed much of its tally to one solar thermal project, the Ashalim II Sun Negev complex, at 110MW and $805 million. Australia financed a wider range of projects, particularly in wind, the largest two being the 270MW CWP Sapphire installation at $438 million and the 175MW White Rock plant at $326 million, both in New South Wales.

Canada experienced a 54% drop in renewable energy investment to $1.7 billion, its lowest since 2004 and far below the figures of $5-6 billion that were prevalent in the early years of this decade. The only project financed of more than 100MW was the 224MW Nicolas-Riou onshore wind farm in Quebec. Ontario, which had been the mainstay of Canadian green power investment in prior years, announced the suspension of phase two of its Large Renewable Procurement programme in 2016 in the face of an overcapacity of generating plants. Meanwhile, Alberta under a new government has shifted towards renewables and is planning to procure 5GW of clean power through auctions – but this will result in investment further down the line, and did not feature in the 2016 data.

South Korea's investment of $1.4 billion was dominated by small-scale solar, totalling $1 billion, on a par with 2015. Its $14.4 billion neighbour, Japan, has also been solar-focussed in recent years, peaking at 11.5GW of new build in 2015, making it easily the second biggest PV market in the world after China. In 2016, there was a pronounced slowdown in activity in Japan in the face of grid access difficulties and also a shift in policy from generous feed-in tariffs towards auctions. In addition, the unit price of Japanese PV fell sharply in 2016, as the lower system prices prevalent in other countries finally arrived in its market. Small-scale capacity investment fell particularly heavily, by 69% to $8.5 billion, the lowest since 2011, while asset finance – mainly of solar but to a lesser extent of wind and biomass – slipped 4% to $4.4 billion. The largest financing in Japan in 2016 was $243 million for the 81MW Karumai East PV project.

CHINA, INDIA, BRAZIL

Figure 19 shows the detail of renewable energy investment in the big three developing economies in 2016. Chinese investment, at $78.3 billion, was dominated by asset finance of $72.9 billion, down 34%, with small-scale PV project development of $3.5 billion, up 32%, and government R&D of $1.9 billion, up 7%, making up most of the rest.

Solar and wind were closely paired in terms of both overall investment, and the asset finance category, with small hydro the only other sector to break the $1 billion barrier. China had a runaway solar installation boom that extended through the final months of 2015 until the middle of last year, before a reduction in the feed-in tariff, weaker-than-expected electricity demand growth and high levels of curtailment put the brakes on deployment. The change of pace was sudden, with 22GW installed in the first half of the year (some of it financed in 2015) and only 8GW in the second half.

In wind, the issues that affected solar were also influential although there was not the same sharp change in trend during 2016. China installed some 23GW of wind capacity in 2016, the second-highest ever behind 2015's 29GW. On 7 November, the country's National Energy Administration announced a reduction in its wind

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

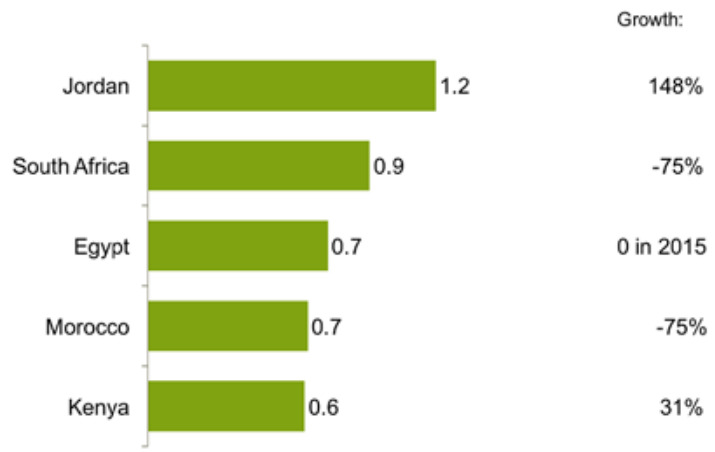
	China	India	Brazil
Solar	39.9	5.5	1.0
Wind	35.0	3.8	5.4
Biofuels	0.1	0.0	0.4
Geothermal	0.0	0.0	0.0
Biomass & w.t.e	0.7	0.1	0.0
Small hydro	2.6	0.3	0.1
Marine	0.0	0.0	0.0
Total	78.3	9.7	6.8

Source: UN Environment, Bloomberg New Energy Finance

installation target for 2020 from 250GW to 210GW, reflecting the challenges of curtailment and a persistent undershoot in electricity demand growth.

India is still a much smaller renewables market than China, but it has potential to be arguably the fastest growing over the next few years. On taking power, Prime Minister Narendra Modi set an ambitious target of 175GW gigawatts of renewables excluding large hydro by 2022, with 100GW of that being solar, up from 10GW installed at the end of 2016. Progress last year towards that target was relatively slow, with just $5.5 billion invested in new solar capacity. Most of this solar was awarded through auctions, but during 2016 the auction process took longer than hoped to roll out in some states, and even those projects that did win capacity did not necessarily achieve financial close before the end of the year. There were also delays in getting India's rooftop PV programme moving towards its own target of 40GW.

FIGURE 20. RENEWABLE ENERGY INVESTMENT IN MIDDLE EAST AND AFRICA BY DEVELOPING COUNTRY, 2016, AND CHANGE ON 2015



Source: UN Environment, Bloomberg New Energy Finance

Wind was the recipient of $3.7 billion of asset finance in India during 2016. The official target for wind is 60GW by 2022, but India already has 28GW installed, so the addition in the next five years is much less than for solar. Wind investment may speed up in early 2017 to catch the expiry of incentives at the end of the first quarter, but for most of last year activity was held back by low power prices, difficulties in agreeing power purchase deals, and the fact that many developers were more interested in solar, which often has a lower-cost advantage in India over wind.

In Brazil, a year of economic recession and political upheaval was a less than ideal backdrop for renewable energy development, and in December the energy ministry cancelled its only auction of 2016 for wind and solar, blaming weak power demand. Development bank BNDES also signalled that it would reduce its lending to the infrastructure sector, including clean energy. Given these problems, it was no surprise that asset finance of wind projects in Brazil fell by 15% to $4.9 billion in 2016. This was partially offset by a 75% rise in solar asset finance to $1 billion.

OTHER DEVELOPING ECONOMIES

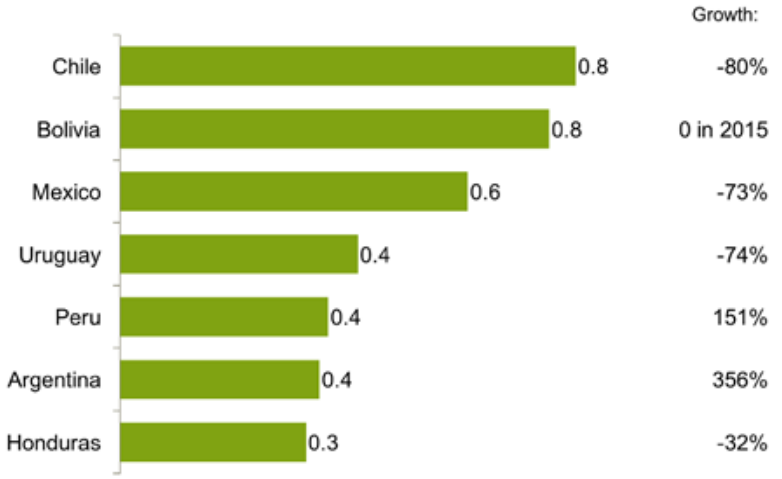
Investment levels in the Middle East and Africa were disappointing in 2016, even though there were several eye-catching positive developments. One was the first-ever renewable energy auction in Zambia in June. Part of a World Bank-organised programme, this produced winning bids for 73MW of solar power at the cheapest prices yet seen in Africa. And in the United Arab Emirates in May, developers agreed to build 800MW of solar for the Dubai Electricity & Water Authority for a then-record-low price of $29.90 per MWh.

Figure 20 displays the countries where actual financings – as opposed to auction wins (which tend to pre-date the former by several months, if not longer) – took place and aggregated at more than $500 million in 2016. Jordan was the top location, attracting $1.2 billion of investment as it tried to boost power capacity to meet demand and also reduce exposure to volatile imported fossil fuel costs. This total was up 148% on 2015, and split mainly between wind at $616 million and solar at $507 million. The country has benefited from smooth access to finance from development banks

such as the European Bank for Reconstruction and Development and the World Bank's International Finance Corporation. One of the main challenges remains grid access, but Jordan is trying to alleviate this with its 'Green Corridor' project to increase transmission capacity.

South Africa and Morocco were both strong performers in terms of investment in 2015, but fell back heavily last year. South Africa saw a pause in its programme of renewable energy auctions, as state utility Eskom indicated reluctance to sign fresh power purchase agreements (PPAs) until it got guidance from the government on the prices it could charge customers. Asset finance there last year was dominated by the $756 million agreed for the 100MW Kathu solar thermal plant in the Northern Cape.

FIGURE 21. RENEWABLE ENERGY INVESTMENT IN LATIN AMERICA BY COUNTRY (EXCLUDING BRAZIL), 2016, $BN, AND CHANGE ON 2015



Source: UN Environment, Bloomberg New Energy Finance

Morocco hit the headlines with a world-record-low auction winning bid for onshore wind of $30 per MWh in January 2016, and the ball was set rolling on fresh PV auctions and for the development of a 400MW hybrid PV-solar thermal plant at Midelt. However, during 2016 itself, there was a lull in projects reaching the financial close milestone, save for the 202MW Aftissant wind project, at an estimated $312 million.

Egypt and Kenya both enjoyed higher investment in 2016, in the former case from a zero start in 2015. Egypt's electricity ministry announced the launch of Round 2 of its feed-in tariff programme in September last year, after a patchy response to the first round held in 2015. In November, the government agreed $662 million of PPAs for solar projects, most of which were not financed before the end of the year. Investment in 2016 was led by $362 million for the 200MW Gulf of Suez wind farm. In Kenya, the regulator began moves to switch from a feed-in tariff system to auctions. Asset finance of renewables in the country was sluggish last year, except for a $403 million package for the latest, 140MW stage of the Olkaria geothermal project.

Figure 21 shows similarly tepid investment totals for Latin American countries excluding Brazil. There were hopeful developments, notably in Argentina, which held two clean energy tenders during the year, contracting 2.4GW of capacity. There was only a minor hint of the coming upswing in renewable energy investment in that country during 2016, with asset finance at $362 million. Even so, that was the highest figure since 2011. Bolivia had its strongest year for renewables since at least 2004 thanks to the provision of $612 million for the 100MW ENDE Laguna Colorada geothermal installation.

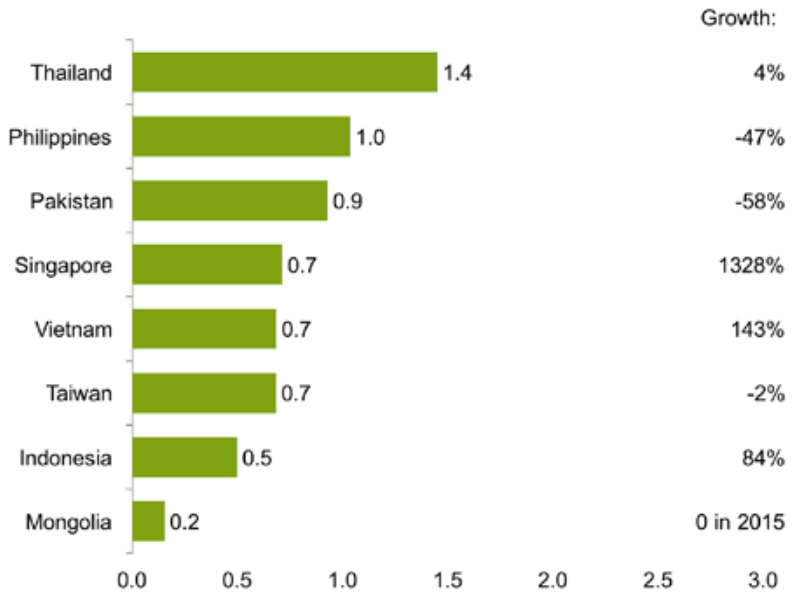
Disappointments came in Chile, Mexico and Uruguay, which all recorded falls in investment of at least 70%. Chile's renewable energy drive ran into transmission bottlenecks and a sharp drop in wholesale power prices. There was also concern about whether projects winning auctions at aggressive prices would struggle to find financing. The country achieved fame in 2016 by establishing a new world record for low tariffs, of $29.10 per MWh in an auction in August, for 254GWh of solar.

Fresh auctions are set to happen in Chile in 2017, but fellow South American country Uruguay may have had the best years of its renewable energy programme after growing its wind market to near-saturation. Mexico, meanwhile, has the potential

to return to the multi-billions of dollars of renewable energy investment of 2015, once projects that won capacity in the 2016 auction reach the financing stage ahead of commissioning in 2018-19. Energy reform, good for the clean power sector in the medium term, contributed to a hiatus in financings of wind and solar projects last year, although one large wind farm – the 200MW, $369 million EDP Coahuila project – did reach that milestone.

Finally, Figure 22 sets out the main developing countries in Asia-Oceania for renewable energy investment in 2016. Thailand took pole position once again, the solar-dominated total of $1.4 billion being its highest figure since 2013. Vietnam is emerging as a significant wind market, and saw $682 million of asset finance in that technology last year, the largest contributor to which was $247 million for the 100MW Cong Ly Ngoc Hien project. Its government said in October that it was considering increasing the feed-in tariff for wind to attract more investment, and in May last year General Electric said it planned to develop 1GW of wind power in Vietnam by 2025.

FIGURE 22. RENEWABLE ENERGY INVESTMENT IN NON-OECD ASIA (EXCLUDING CHINA AND INDIA), 2016, AND CHANGE ON 2015



Source: UN Environment, Bloomberg New Energy Finance

The Philippines remains an active renewable energy market, with a 5GW pipeline of wind, solar geothermal, biomass and small hydro projects under development. However, in 2016 solar made up almost all of the $1 billion capacity investment there, as developers rushed to take advantage of a feed-in tariff before it ran out of quota. Indonesia, meanwhile, announced new feed-in tariffs for solar in July 2016, with a minimum local content requirement, but then postponed the programme.

Pakistan is seeing strong interest in renewables, as the country of 230 million people seeks to meet rising electricity demand. The 58% fall in investment there in 2016 may not be more than a blip: since last year's Global Trends report, Bloomberg New Energy Finance raised sharply its estimate for Pakistan in 2015 to $2.1 billion, based on new information disclosed in the last 12 months. Both solar and wind saw significant new projects financed last year, the largest being the CWE Jhampir wind park at 99MW and $229 million. The country is also seeing activity in off-grid, with Asian Development Bank pledging $325 million in loans for small hydro and rooftop solar in Khyber Pakhtunkhwa province late last year.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PUTTING RENEWABLE ENERGY INTO PERSPECTIVE

- Renewable energy excluding large hydro accounted for 55.3% of the new electricity generating capacity added worldwide in 2016, the highest proportion in any year to date and the second successive year it has exceeded 50%.
- Last year, for the first time, there were significantly more gigawatts of solar power added than of any other generating technology. Trailing behind solar, in order of net GW installed, were wind, coal, gas, large hydro, nuclear and biomass.
- Renewable energy excluding large hydro produced an estimated 11.3% of the world's electricity in 2016, up from 10.3% in 2015 and 6.9% five years earlier, in 2011. Last year's renewables generation prevented the emission of some 1.7 gigatonnes of carbon dioxide.
- Even though investment in renewables capacity fell by 23% in 2016 in dollar terms, it was still roughly double that in new fossil fuel power stations, and more than seven times the amount committed to new nuclear plants.
- 2016 was a particularly strong year for investment in energy smart technologies. Asset finance for smart meters and energy storage, plus equity raised for specialist companies in energy efficiency, storage and electric vehicles, totalled a record $41.6 billion last year, up 29%.
- Despite the record installation of renewables, and the unprecedented activity in energy smart technologies, overall energy-related carbon dioxide emissions continue to run at more than 32 gigatonnes per year. CO2 levels in the atmosphere in January 2017 were up 3.6 parts per million from a year earlier, at 406.1ppm.

GLOBAL GENERATION MIX

Figure 23 shows the impact of the investment in renewables described in Chapter 1 on the overall mix of the world's power generation fleet. For the second year running, renewables excluding large hydro made up the majority of the new capacity added globally. The 138.5GW of new wind, solar, biomass and waste, geothermal and small hydro plants were equivalent to 55.3% of new gigawatt additions for all generating technologies, the highest proportion ever.

The other two lines on the chart give an idea of how far renewables still have to go if they are to become dominant in world electricity. Renewables excluding large hydro accounted for 16.7% of the installed GW capacity globally and, more significantly, just 11.3% of total electricity generation in 2016.

The reality of the electricity sector is that power stations have lives of 20, 40 and even 60 years or longer (in the case of hydro-electric plants), and so changing the generating mix in favour of renewables is a slow process, not a quick one. In addition, wind and solar plants have lower capacity factors – they produce electricity only when weather or daylight conditions are right – than what is possible with coal, gas, biomass, geothermal, nuclear or hydro-electric installations.[9] So gains for renewables in the share of electricity generated will tend to be slower than gains in the share of GW capacity.

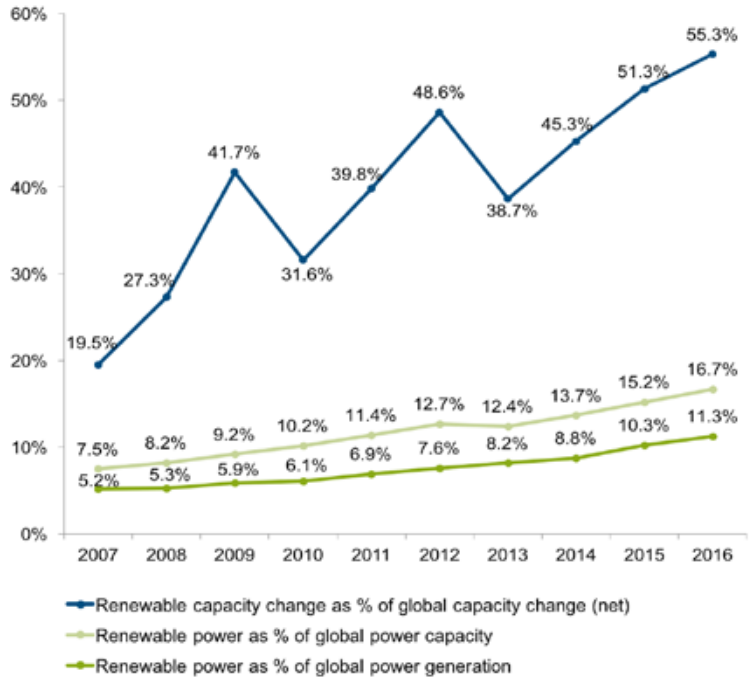
[9] Average capacity factors for a solar PV plant in a sunny country are 15-25%. Those for an onshore wind project in a good location may be 25-35%, and for an offshore wind array, 40-50%.

The 11.3% of electricity produced from wind, solar, biomass and waste-to-energy, geothermal, small hydro and marine meant that the world's power system emitted 1.7 gigatonnes of CO2 fewer than it would have done if none of that renewables capacity existed.[10] In plain speak, the world's problem with emissions would be significantly worse if these green power assets had not been built.

Figure 24, however, confirms that countries are continuing to add coal- and gas-fired capacity as well as zero-carbon plants. In 2016, as well as 138.5GW of 'new renewables', the world's fleet of large hydro-electric dams of more than 50MW increased by an estimated 15GW, and its stock of nuclear plants by 10GW – making the zero-carbon net addition 163GW.[11]

The total capacity of coal-fired power stations meanwhile went up by 54GW, and that of gas-fired generators by 37GW. In fact, both these numbers are more complicated than they look at first sight, because they are net figures, representing the difference between the new assets coming on stream in 2016 and old ones being shut down. Bloomberg New Energy Finance estimates that the world commissioned some 87GW of coal plants, and decommissioned 33GW, in 2016 – with, in general, most of the new coal assets being in developing countries and most of the closures in developed economies.

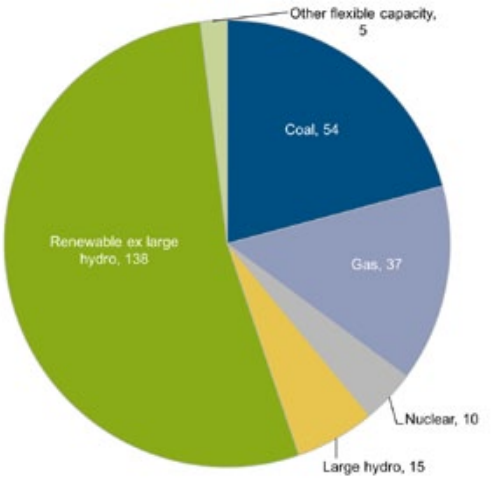
FIGURE 23. RENEWABLE POWER GENERATION AND CAPACITY AS A SHARE OF GLOBAL POWER, 2007-2016, %



Renewables figure excludes large hydro. Capacity and generation based on Bloomberg New Energy Finance totals

Source: Bloomberg New Energy Finance

FIGURE 24. NET POWER GENERATING CAPACITY ADDED IN 2016 BY MAIN TECHNOLOGY, GW



Source: Bloomberg New Energy Finance

[10] This is estimated by taking the International Energy Agency's figure for world power sector emissions in 2014, extrapolating that to 2016 using the IEA's World Energy Outlook forecast for emissions growth per year to 2020, to give a figure of 13,395Mt. Then we assume that the 11.3% of generation met by renewables last year was instead met by the same generating mix as the remaining 88.7%. If that was the case, total power sector emissions would have been 15,101Mt. Therefore, the emissions avoided through renewables excluding large hydro totalled 15,101 minus 13,395, or 1,706Mt.

[11] Note that the figures in Figure 24 do not give exactly the 55.3% number in Figure 23 for renewable energy excluding large hydro as a share of total additions. This is because included in the arithmetic for Figure 23, but not shown in Figure 24, is a 9GW reduction in oil-fired generating plant.

COMPARING INVESTMENT

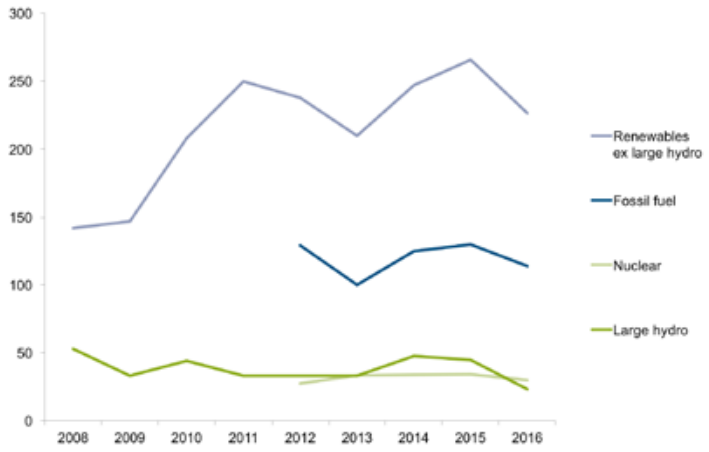
Renewables continue to attract far more dollars of investment than do fossil fuel generating plants, as Figure 25 shows. This is partly a reflection of green power's gradually growing share of world capacity and generation, and partly a reflection of the fact that almost all the cost of a project to produce power from wind, solar, geothermal and small hydro is upfront. Generally speaking, fossil fuel plants are cheaper to build but have much higher running costs, since the fuel has to be purchased on an ongoing basis.

Nevertheless, there is a persistent, large gap between the dollars committed to building renewable power plants ($226.6 billion in 2016) and those committed to constructing fossil fuel capacity (an estimated $113.8 billion).[12] The other two technologies were even further behind – large hydro attracted final investment decisions last year worth an estimated $23.2 billion, and nuclear $30 billion.[13]

Overall, renewables excluding hydro accounted for 58% of the dollars committed to new generating capacity worldwide in 2016, and large hydro-electric projects of more than 50MW another 6%.

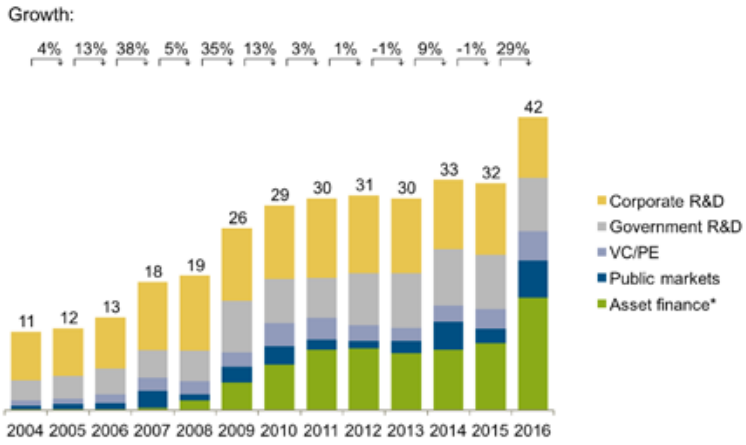
In Figure 25, the fossil fuel line is only shown for the years since 2012, because of a shortage of data using the same methodology for years before that.

FIGURE 25. INVESTMENT IN POWER CAPACITY – RENEWABLE, FOSSIL-FUEL AND NUCLEAR, 2008-2016, $BN



Source: Bloomberg New Energy Finance

FIGURE 26. GLOBAL NEW INVESTMENT IN ENERGY-SMART TECHNOLOGY BY TYPE, 2004-16



*Energy storage and smart metering asset finance only. Total values include estimatesfor undisclosed deals

Source: UN Environment, Bloomberg New Energy Finance

ENERGY SMART TECHNOLOGIES

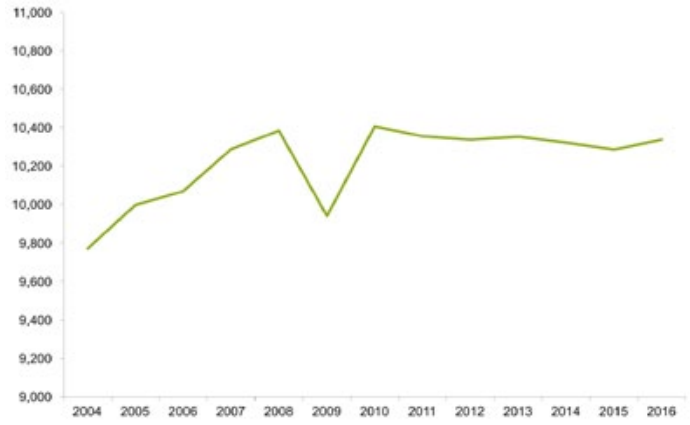
Investing in renewables is only one strand of the effort to limit global emissions. There are other steps that can be done on generation, such as coal-to-gas switching and investment in other zero-carbon sources such as nuclear. However, just as important is limiting the growth in demand for energy by investing in technologies that are more efficient in their use of electricity, heat and fuel.

Figure 26 shows that investment in energy smart technologies, or EST, jumped 29% in 2016 to a new

[12] Note that the $226.6 billion figure for renewables is power capacity investment only. The $241.6 billion total investment figure shown in the Executive Summary of this report also includes corporate-level investment, government and corporate research and development spending, and asset finance of biofuel plants.

[13] Note that, in the case of nuclear, the estimate shown is based not on final investment decisions like the other technologies, but on capex per year. This reflects the extreme length of nuclear capital spending programmes, and the high risk of cost over-runs and delays. So, for instance, the estimate spreads the $25 billion investment in the 3.2GW Hinkley Point C reactor in the UK over many years, rather than attributing it all to 2016. EDF and the UK government both gave it the go-ahead in the second half of last year.

FIGURE 27. ELECTRICITY SUPPLIED IN OECD COUNTRIES, 2004 TO 2016, TWH



Figures for full-year 2016 were not available when this report went to press, so the 2016 figure shown is the 12 months to November 2016

Source: International Energy Agency, Monthly Electricity Statistics

global record of $41.6 billion. This aggregate covers public markets, venture capital and private equity investment in companies active in energy efficiency, demand response, energy storage and electric vehicles; plus corporate and government R&D in all those areas; plus asset finance of smart meters and energy storage projects excluding pumped hydro.[14]

Last year, there was a record $14.4 billion invested in smart meters, up 63% on 2015. This dominated the $16 billion figure for asset finance in energy smart technologies.[15] There was also an all-time high for public markets investment in EST companies, of $5.3 billion, up 152%, with two electric car makers, Tesla and BYD, accounting for no less than $3.8 billion of that. VC/PE investment in energy smart technology firms was up 50% at $4.2 billion worldwide, while government R&D was down 2% at $7.5 billion and corporate R&D down 15% at $8.6 billion.

The high investor interest in electric cars came as these vehicles enjoyed a sharper increase in global sales than most commentators had expected at the start of 2016. In the end, electric vehicle sales jumped 55% last year to 695,000, equivalent to 1.1% of total new car sales in the markets tracked by Bloomberg New Energy Finance.

[14] The methodology is to include equity issues both by companies specialising in EST, and by those with a wider scope but where the specific fundraising is aimed at expanding their activities in EST.

[15] Note that there are many hard-to-quantify areas of energy efficiency investment not included in this total: for instance, industrial capital spending to reduce electricity consumption, and the insulation of buildings.

ELECTRICITY DEMAND

Electricity demand growth in developed economies has consistently fallen short of expectations since the 2008 financial crisis, and in recent years has started to do so too in a growing number of developing countries. The reasons are likely to be partly to do with shifts in the structure of economies (away from heavy industry and towards services), and partly to do with the spread of more efficient devices, from LED lighting to modern refrigerators and computers.

Figures from the IEA show that electricity supplied in OECD countries was 9,468TWh in January-November 2016, up 0.5% compared to a year earlier but only 1.3% above its level in the first 11 months of 2007 – even though those same OECD nations as a whole enjoyed GDP growth of 10.4% between 2007 and 2016.[16] Figure 27 shows the annual trend from 2004 to 2016, highlighting both the impact of the 2008-09 recession and the change of trajectory since then.

In China, electricity output growth in 2014 was 3.8%, in the following year 0.5% and last year back up to 5%.[17] However, these figures were far below the official rate of economic growth, at 7.2%, 6.8% and 6.8% in those three years. In India, estimates are that electricity demand growth was at a middling 4.3% in 2015-16 compared to the previous year, less than half the projected growth rate of 8.7%. Demand growth in the current year (2016-17) is also trailing projections, and supply of power is expected to exceed demand, though millions of people continue to remain without power.

[16] http://stats.oecd.org/

[17] http://stats.gov.cn

EMISSION AND CLIMATE TRENDS

The steady growth in deployment of renewables, the spread of energy smart technologies such as efficient lighting, and the softer-than-expected trend on electricity demand, are limiting the growth of world energy sector emissions.

UN Environment's Emission Gap Report 2016, published last November, said: "In 2015 global CO2 emissions stagnated for the first time and showed signs of a weak decline compared to 2014 (of 0.1%). This was preceded by a slowdown in the growth rate of CO2 emissions, from 2% in 2013 to 1.1% in 2014." However, the same report also warned: "The world is still heading for a temperature rise of 2.9 to 3.4 degrees Celsius this century, even with Paris pledges."

Some individual countries have performed well recently in terms of emission reduction. The Energy Information Administration said in October that carbon dioxide emissions from US energy consumption, including transport as well as power, were 2,530 megatonnes in the first six months of 2016, and on course to be 5,179 megatonnes for the whole year. This would be 14% less than in 2007, and the lowest since 1992.[18]

UK total net CO2 emissions were 383.8 megatonnes in the year to the second quarter of 2016, down 29% from 2007 and 36% from the peak year of 1991.[19] In the case of China, the International Energy Agency said in March 2016 that emissions dropped 1.5% in 2015, defying the agency's prediction from 2010 that Chinese emissions would grow 1.6% per year between 2008 and 2035.[20]

However, forecasts on global emissions are bleak. Most expect rising electricity demand in emerging economic regions such as India and South East Asia to lead to greater coal-fired generation, and to higher CO2 output. Meanwhile, energy-related emissions from transport and industry will continue to rise, they say.

The IEA, for instance, stated in November that it expects global energy-related emissions to rise from 32,175 megatonnes in 2014 and 32,795Mt in 2020, to 36,290 megatonnes in 2040, an increase of 13% over 26 years. BP's Energy Outlook 2017, published in February this year, came up with the same percentage increase but over a shorter period, 2015-35, in its base-case scenario. It added: "This is far in excess of, for example, the IEA's 450 Scenario which suggests carbon emissions need to fall by around 30% by 2035 to have a good chance of achieving the goals set out in Paris."[21]

Recent statistics have shown significant increases in CO2 in the atmosphere, and in global temperatures. The US National Oceanic & Atmospheric Administration (NOAA) says that the average CO2 content of the atmosphere at Mauna Loa, Hawaii in January 2017 was 406.1 parts per million, up 3.6ppm compared to a year earlier and up 36.8ppm, or 10%, since January 2000.[22]

Global temperatures in 2016 were also higher than for any year on record, according to preliminary analyses by NASA and the NOAA, published in January 2017. The US organisations said that average temperatures last year were 0.98 degrees Centigrade warmer than the 1951-80 mean.

This was the third year in a row to set a new record for global surface temperatures, with 2014 some 0.75 degrees and 2015 some 0.86 degrees above that benchmark. One earlier year that saw a temperature spike was 1998, at 0.63 degrees above the 1951-80 average, but that figure has been clearly exceeded in each of the last three years.[23]

[18] http://www.eia.gov/todayinenergy/detail.php?id=28312

[19] https://www.gov.uk/government/statistics/uk-greenhouse-gas-emissions-quarterly-official-statistics-q2-2016

[20] https://www.iea.org/newsroom/news/2016/march/decoupling-of-global-emissions-and-economic-growth-confirmed.html

[21] https://www.bp.com/content/dam/bp/pdf/energy-economics/energy-outlook-2017/bp-energy-outlook-2017.pdf

[22] ftp://aftp.cmdl.noaa.gov/products/trends/co2/co2_mm_mlo.txt

[23] https://data.giss.nasa.gov/gistemp/tabledata_v3/GLB.Ts+dSST.txt

DELIVERING INVESTMENT

- Investment in renewable energy depends on mechanisms that can underpin returns and limit risks for project developers, and it depends on the availability of finance. This chapter looks at those areas.
- Auctions around the world are taking over from subsidy programmes as the main way of allocating renewables capacity. They are also delivering cost reductions, with the record-low tariff agreed in 2016 being one of $29.10 per MWh for a solar project in Chile.
- Corporate power purchasing agreements were arranged on some 4.3GW of renewable energy capacity worldwide in 2016, down 18% from 2015's record but including the highest contributions yet from both Europe and Asia.
- Institutional investors made a record $2.8 billion of direct equity commitments to European renewable energy projects last year. In the US, institutions and companies provided $13.7 billion of tax equity finance for clean power projects in 2016, up 8% on the previous year.
- Green bond issues to finance a broadly defined range of environmental projects, including renewable energy, totalled a record $95.1 billion in 2016, up 99%. These included the first ever sovereign green bond, issued by Poland.

This chapter examines what makes possible the flow of money into renewable energy projects. It starts by highlighting policy instruments, and specifically the transition from subsidies to auctions. It also looks at corporate power purchasing agreements, or PPAs, in which companies are increasingly signing deals to buy renewable electricity from projects. They are doing this either to underline to customers and investors their sustainability credentials, or to lock in a particular power price to protect themselves from the risk of higher prices in the future.

The rest of the chapter examines the flows of finance to renewable energy projects around the world in 2016, from utilities, institutional investors and debt providers. Which projects, sectors, countries and regions received those asset finance dollars is analysed in detail in Chapter 5.

FROM SUBSIDIES TO AUCTIONS

The roll-out of green power since the early years of this century has been closely associated with subsidies. Renewables are not the only sector of energy to have benefited from policy support – for instance, nuclear has often been subsidised around the world, and oil and gas exploration in the US benefits from a tax shelter called 'percentage depletion'. The International Energy Agency estimated in its World Energy Outlook 2016 that total global fossil fuel subsidies were $325 billion in 2015, down from nearly $500 billion in 2014 but still more than double the $150 billion spent on subsidies to renewable energy.

The generosity of the subsidies for renewables has been declining as technologies such as wind and solar have become more cost-competitive. The German feed-in tariff for PV installations of less than 10kW, for example, was EUR 127 per MWh between October and December 2016. This compared to a level of EUR 518 for a similarly-sized installation in 2006, and EUR 287 per MWh in the middle of 2011.

Feed-in tariffs guaranteed that renewable energy projects would receive a set price per kWh for their electricity generation, that price being well above wholesale power prices. This approach was

followed in countries such as Germany, Spain and France, and in China and parts of Canada. An alternative instrument was the green certificate, favoured in the UK and the joint Sweden-Norway market. Projects such as wind farms would qualify to receive a certificate in return for each MWh produced. The value of that certificate could go up and down depending on market forces, and it would form part of the revenue for the project, on top of wholesale electricity prices.

In the US, a third mechanism was dominant, and this was the tax credit. The Production Tax Credit for wind and Investment Tax Credit for solar would give rise to a credit that could be used by a company providing 'tax equity' finance for the project, to reduce the tax on its corporate profits. In December 2015, the US Congress voted to extend the PTC and ITC until 2020.

The last few years, however, have brought the spread of auctions as a way for governments and regulators to allocate renewable energy capacity, with developers bidding against each other for the right to develop projects. After early adoption in Brazil, and then South Africa, auctions have spread to the rest of South America, other parts of Africa, India and the Middle East, and to European countries such as the UK, Germany, Netherlands, Denmark, Spain and Italy.

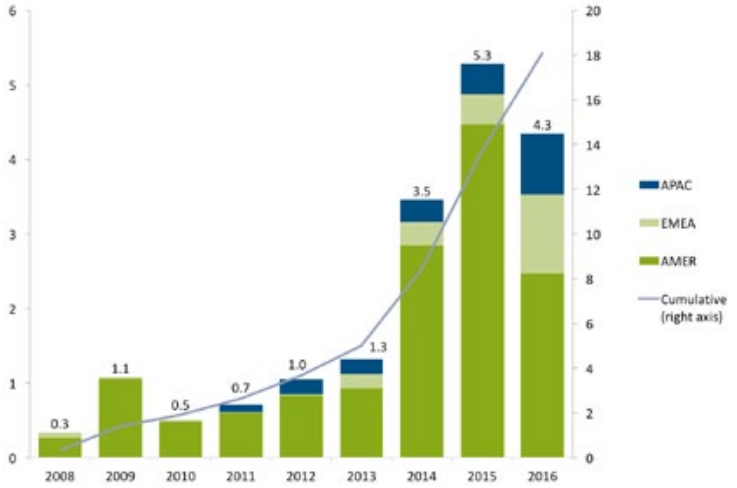
All auctions select the bidders that submitted the lowest offers in terms of tariff per MWh, but the details vary. For instance, some link that tariff to inflation and some do not, and some have an early deadline for building and commissioning the projects, while some do not. Research by Bloomberg New Energy Finance suggests that, on average, there is a 30% reduction in renewable energy project tariff when a country shifts from a feed-in tariff or green certificate programme to its first auction.[24]

Wind in Italy was a recent example of this tendency. In a December 2016 auction, the onshore wind segment was nearly 2.5 times oversubscribed and the winning bid price for the 800MW of onshore wind projects was a 40% discount on the reference price – the maximum possible discount. As such, projects will earn a tariff of just EUR 66 per MWh, some EUR 7 per MWh below BNEF's estimate of the average levelised cost of electricity for onshore wind in Italy.

As noted in the Executive Summary of this report, auctions around the world have produced some hitherto unimagined tariffs for solar and wind projects in the last year – the lowest of 2016 being Solarpack's deal last August in Chile to sell power from a 120MW PV project at $29.10 per MWh. Also last year, Morocco established a new record for wind, at $30 per MWh, in an 850MW tender.

[24] BNEF Research Note: Auctions and prices, 30 October 2015. https://www.bnef.com/core/insight/13183

FIGURE 28. VOLUME OF NEW CORPORATE POWER PURCHASING AGREEMENTS SIGNED, 2008-2016, GW



Includes government or university offtakers in addition to private sector offtakers. APAC capacity is estimated. Mexico PPAs use the off-taker maximum capacity volumes
Source: Bloomberg New Energy Finance

CORPORATE PPAs

Companies wishing to buy green electricity have various options, including installing PV panels on their warehouse roofs or, in some countries, buying renewable energy certificates on the markets, boosting the revenues for clean energy plants.

However, corporate power purchase agreements have become the focus of much attention by some of the largest global companies, including Google, Microsoft and Amazon. They come in two flavours – either 'private-wire' PPAs, in which a power cable is literally fed into a nearby corporate site, allowing the latter to buy its electricity directly; or or 'virtual' PPAs, in which the company guarantees the owner of the renewable project a certain fixed price for the electricity it sells to the grid, and can thus claim credit for bringing renewable energy onto the grid. This earns it a 'guarantee of origin', proving that its electricity came from green sources.

Last year was the second highest on record for signed PPA volume, its total of 4.3GW worldwide being 20% down on 2015's record but more than 12 times the figure in 2008. Figure 28 shows this global trend, and also the way the geographical mix has shifted from one dominated by the US and Mexico, to one also involving rising participation from Europe and Asia. AMER refers to the Americas, EMEA to Europe, Middle East and Africa, and APAC to Asia-Pacific.

The three largest deals of last year were Amazon's first PPA in Texas signed with Lincoln Clean Energy for a 228MW wind farm, Google's contract with Enel Green Power for 200MW from the Cimarron Bend wind farm in Kansas, and Amazon's arrangement with EverPower Wind Holdings for a 189MW project in Ohio. In Europe, one of the biggest was an innovative 'consumer-to-business' PPA for a 102MW onshore wind project in the Netherlands between a community co-operative and a consortium of Akzo Nobel, DSM, Google and Philips.

INVESTMENT SOURCES – UTILITIES

As Chapter 5 highlights in more detail, most utility-scale renewable power projects are financed either on-balance-sheet by a utility, energy company or large developer, or with a mixture of equity and debt provided directly to the project itself.

Utilities continued to be major providers of on-balance-sheet finance and project-level equity in 2016. Nine of the largest European utilities invested a total of $11.5 billion in renewables in 2015 according to their annual accounts, and were on track to invest $10.2 billion in 2016, judging from their interim and quarterly statements.[25] Enel was on course to be the largest investor among the nine last year, followed by Iberdrola and Dong Energy.

[25] Note that these figures reported by the utilities represent spending on projects in particular years, and are therefore calculated on a different basis from the BNEF data in this report. In BNEF data, total project capex is recorded at the time of final investment decision.

Among the many utilities backing big projects around the world in 2016 were Dong Energy financing Germany's Borkum Riffgrund II offshore wind plant, E.ON building the 228MW Bruenning's Breeze onshore wind farm in Texas, Southern Company buying a controlling stake in the 100MW Boulder Solar I solar park in Nevada, and Engie supplying the equity for the 100MW Kathu solar thermal project in South Africa. Fortum of Finland said it would spend up to $457 million on building solar plants in India.

Utilities were far from the only sort of large company to fund renewables in 2016. Oil giant Shell won a contract in December to build the 680MW Borssele III and IV offshore wind projects off the Netherlands, together with partners Eneco, Van Oord and Mitsubishi. In India, CLP Holdings, the former China Light & Power, bought a 49% stake in the 100MW SE Solar project. China Gezhouba, a large construction group, said in December it would invest $360 million to build the Tongliao PV project in Inner Mongolia.

INVESTMENT SOURCES – INSTITUTIONS

Institutional investors have become another key source of equity finance for projects, particularly in recent years. This can happen in a variety of ways, two of which are direct investment by institutions in project equity, and indirect investment through a pooled vehicle such as a 'yieldco'.[26]

Looking at the first of these, institutions such as pension funds and insurance companies committed an estimated $2.8 billion to European renewable energy projects in 2016. This was on a par with the record figure set in 2014, more than double the 2015 outturn and nearly 10 times the total in 2010.

Examples of this activity in 2016 included German insurer Talanx, plus three German and Finnish pension funds, contributing $484 million of equity to the 1GW Fosen wind portfolio in Norway, and Danish pension fund Pensionskassernes putting in 50% of the equity for the 299MW Tees biomass project in the UK. Also active once again in direct investment was German insurance company Allianz, which backed onshore wind farms in Finland and France in 2016.

Aggregate figures for other regions are not available, but direct investment deals are being done outside Europe by institutions. One big transaction was the acquisition in January 2016 by Canadian pension funds Ontario Teachers and Public Sector Pension Investment Board along with Banco Santander of 392MW of Brazilian wind parks for $494 million.

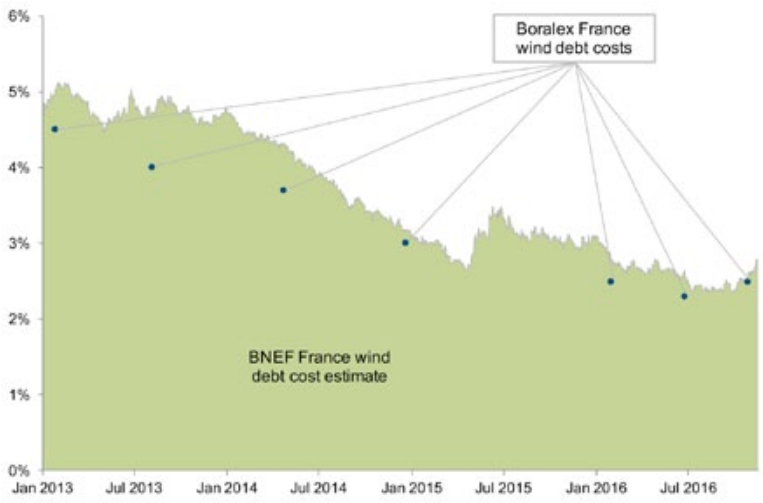
In the US, many of the institutional moves take the form of 'tax equity', as opposed to conventional equity, transactions. Tax equity is a security created to take advantage of the PTC and ITC tax credits for wind and solar mentioned in the section on policy support above. Last year, some $13.7 billion of tax equity was provided for US renewable energy by institutions, banks and corporations. This compared to $12.7 billion in 2015.

Among the tax equity transactions of note, Allianz and Mitsubishi UFJ Financial Group invested in the 225MW Great Western wind farm in Oklahoma in December, and two months earlier Bank of America and Bank of New York Mellon invested in three NextEra Energy wind projects in Kansas, totalling 415MW.

Turning to investment in projects via pooled funds, yieldcos and quoted project funds on both sides of the Atlantic raised some $1.9 billion from the stock market, down from a record $7.3 billion in 2015. That 74% plunge in fundraising followed a crisis of confidence in US yieldcos in late 2015 and early 2016 caused by investor doubts about their growth prospects and worries about the effect of the bankruptcy of SunEdison on the two yieldcos it started, TerraForm Power and TerraForm Global.

[26] Yieldcos and quoted project funds take large stakes, or 100% ownership, of renewable energy projects and hold them for the long term, distributing most of the project cash flows back to their own investors.

FIGURE 29. ESTIMATED ALL-IN COST OF DEBT FOR ONSHORE WIND PROJECTS IN FRANCE, 2013 TO 2016



Source: Bloomberg New Energy Finance, statements by Boralex

There is further discussion of yieldcos and quoted project funds in Chapter 7.

Also raising money last year for deployment in the equity of clean energy projects were a number of specialist private funds, including the Allianz Renewable Energy Fund, which had secured $374 million by the time of its final close, and the SUSI Renewable Energy Fund II, which closed with $291 million. Both will invest in wind and solar in Europe.

INVESTMENT SOURCES – DEBT

Debt makes up the majority of the capital required on most renewable energy projects that are funded using project finance structures. In developed markets, it is normal for project-level debt to meet 75% to 80% of the cost of an onshore wind installation, and equity the remainder. A solar project may get a similar debt proportion, while biomass and offshore wind projects will typically get less, at perhaps 65% to 70% debt, because of higher perceived risk.

In 2016, the cost of debt fell in some parts of the world as the markets responded to sluggish economic growth combined with low inflation and unexpected political events such as the UK's vote to leave the European Union. This low-priced financing environment helped to support demand for loans from renewable energy project developers and owners.

To take one country as an example, the all-in cost of 15-year debt on an onshore wind project in France started 2016 at 3.1% (far below the 5%-plus figures that prevailed in 2010-12) and fell to 2.4% in September last year.[27] It then started to edge back up, reaching 2.8% towards the end of the year. These figures include the bank margin, underlying market interest rate and the cost of a swap to fix borrowing costs during the term of the loan. Backing this up, Canadian infrastructure investor Boralex said it financed wind farms in France for 15 years on an all-in cost of debt as low as 2.5% in January 2016, and 2.3% in June. Similar projects were getting loans at all-in rates of 3-4% in the 2013 to 2014 period (see Figure 29).[28]

In India, the central bank's repo rate was cut by 25 basis points in the summer, helping to shave overall debt costs there, while in China central bank rates that provide a component of lending costs to projects stayed steady at 4.35% during the year. The US was one of the few major economies where official short-term rates increased (from 0.5% to 0.75% in December), and the long-term borrowing cost set by its 10-year bond yield climbed from a low of 1.4% in July to 2.4% by the end of the year.

Bank lending to renewable energy continued at high levels in 2016, contributing to the $86.4 billion of non-recourse project finance deals for new installations (see Chapter 5 on Asset Finance), as well as backing part of the $72.7 billion of asset acquisitions and refinancings (see Chapter 10 on Acquisition Activity).

One example of a big commercial bank loan for a renewable energy project in 2016 was a $1.3 billion package put together in August for the financing of the 400MW Merkur offshore wind project in the German part of the North Sea. The array of 6MW turbines attracted 10 banks from Germany, Netherlands, France, Sweden and Japan. In

[27] Bloomberg New Energy Finance estimates.

[28] http://www.boralex.com/newsfeed/press-releases

Southeast Asia, the developers of the 120MW Tuas waste-to-energy plant in Singapore secured $477 million of 27-year debt from four Malaysian and Japanese banks when the financing closed in May.

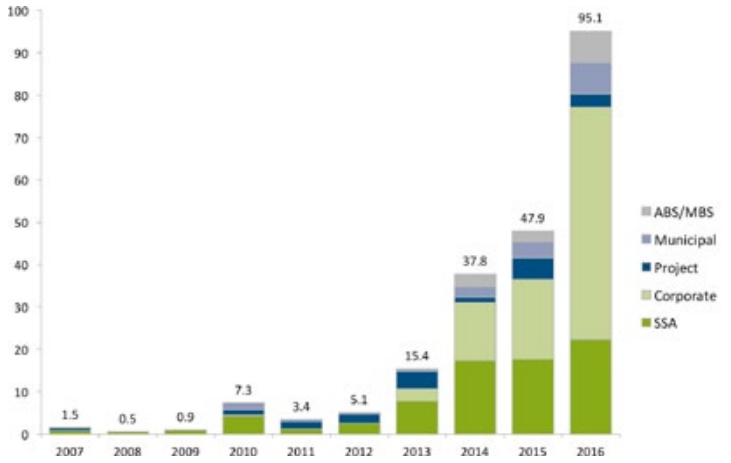
Development banks have been another important piece of the financing jigsaw for renewables throughout the last decade. Only a few of these lenders had released figures for their lending to renewables in 2016 by the time this chapter of the Global Trends report was completed.

Among the biggest players that had published data, Germany's KfW said that it provided the euro equivalent of $39 billion for "environmental and climate protection financing", including $8 billion for renewable energy and $23.5 billion for energy efficiency. The overall environmental and climate category was up 20% in euro terms compared to 2015. The Asian Development Bank approved $3.7 billion in climate finance investments in 2016, a 42% increase from the previous year, to support efforts in developing member countries.

GREEN BONDS

Green bonds are a growing asset class for investors around the world. This label includes 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 almost doubled to $95.1 billion, as Figure 30 shows.

FIGURE 30. TOTAL GREEN BOND ISSUANCE BY CATEGORY, 2007 TO 2016, $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 most eye-catching feature of this surge in 2016 was a leap in issuance in China to $27.1 billion, overtaking the US on $15.5 billion. Another headline was the world's first sovereign green bond, a $783 million issue by the Polish government in December, to finance a collection of 'climate-centred' projects.

That phrase highlights an important point about green bonds. They have a much looser scope than, for instance, renewable energy as defined in this report. Green bonds can be used to finance not just new clean energy generation but also energy efficiency, transmission, water, waste management and, sometimes, climate change adaptation. So the amount of money raised by green bonds cannot be compared to total new investment in renewable energy in 2016 of $241.6 billion.

Project bonds are usually deployed to refinance a project after a construction period that is paid for with equity and bank loans, or financed on balance sheet. Issuance of green project bonds in 2016 was $3.1 billion, down from $5.1 billion in 2015, with the largest being a $633 million issue to refinance the 100MW Kingston solar project in Canada.

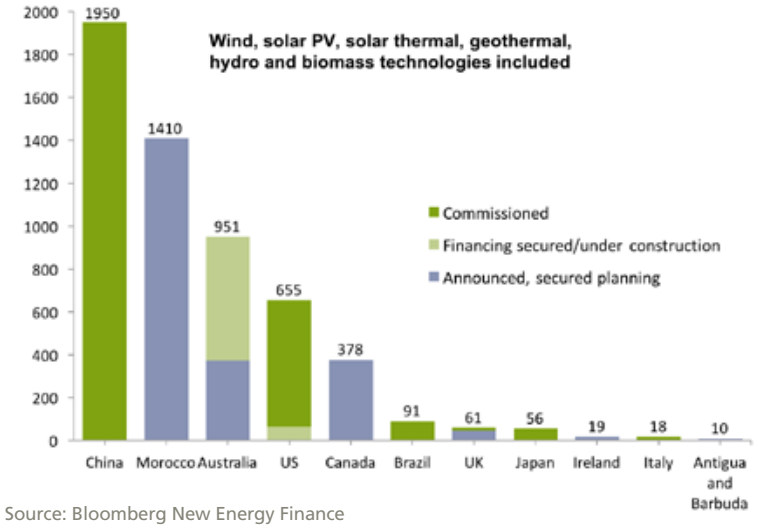
FOCUS ON HYBRID PROJECTS

- Hybrid renewable energy projects put together in one location solar and wind, for instance, or solar thermal and geothermal. So far, some 5.6GW of hybrid projects, each of more than 10MW, have been built or are under development worldwide.
- The potential is for this number to grow significantly in the years ahead, as developers take advantage of synergies from co-locating two or more technologies.
- Among the attractions are the potential to share one grid connection, to produce more electricity from each hectare of land, to reduce overall intermittency, and to economise on operating and maintenance costs.
- The challenges include greater risk of curtailment if both renewable sources are generating at the same time, and a lack of familiarity with hybrid projects on the part of equity and debt providers.
- Mini-grids in developing countries and on islands provide a particular opportunity, with wind, solar or wave paired with batteries or even diesel back-up generators.

The Global Trends report has concentrated for the last 11 years on utility-scale and small-scale renewables projects in their own discrete locations. That has been by far the dominant model for siting green power projects, but things are beginning to get more complicated. In last year's report, we looked at the potential for pairing wind or solar projects with storage. This year's Focus Chapter looks at the potential for pairing renewable energy projects with each other.

As has become clear in recent years, the possibilities for hybrid projects are many. Solar could be retrofitted to a site that already has a wind farm, or floating solar could be retrofitted on a hydro-electric reservoir. Solar thermal already has been paired with geothermal, to increase the temperature of the steam driving a turbine, and so has biomass. Tidal stream just offshore could be paired with wind just onshore.

FIGURE 31. RENEWABLE ENERGY HYBRID PROJECTS OVER 10MW BY COUNTRY, MW



Source: Bloomberg New Energy Finance

Bloomberg New Energy Finance estimates that by early 2017, some 20 renewable energy hybrid projects of a combined 10MW or more had been built or are being developed around the world. They have a total capacity of 5.6GW, with roughly half that capacity already in place, and half announced or under construction.[29]

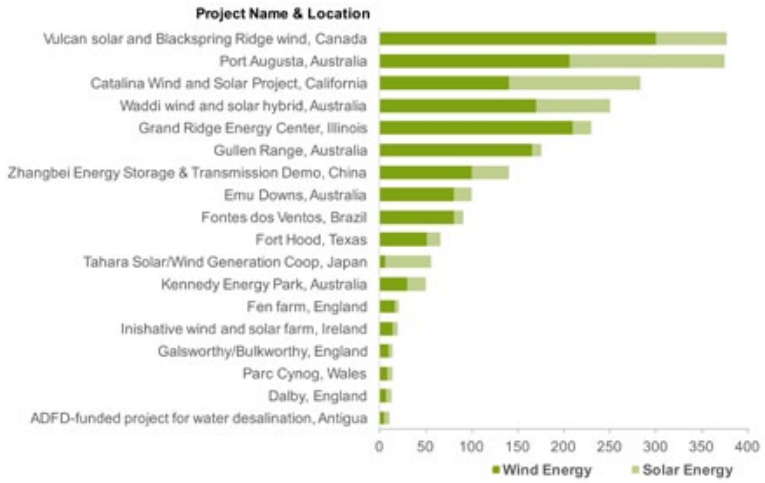
Figure 31 shows the capacity of renewable energy hybrid projects so far built or announced worldwide,

[29] The investment value of these projects is hard to estimate since, in some cases, one of the two technologies has been in place on site for many years. Developers of new projects have often not disclosed the total capital cost. However, to build single-technology renewable energy plants totalling 5.6GW would be likely to cost somewhere either side of $10 billion, depending on the technology chosen.

and their country of location. China has the most capacity already built – including the 1.3GW Longyangxia hydropower plant on the Yellow River that stabilises the output curve of a 530MW solar PV plant.

Australia is another of the leading nations, with the 50MW Kennedy Energy Park complex (30MW of wind and 20MW of solar), the 100MW Emu Downs project (80MW of wind and 20MW of solar) and the 176MW Gullen Range configuration (166MW and 10MW) all financed and being built, and the 375MW Port Augusta project (206MW and 169MW) announced. Morocco's agency for sustainable energy, known as Masen, has plans for a combined PV and solar thermal project on 3,000 hectares near Midelt, with capacity of up to 830MW.

FIGURE 32. WIND, SOLAR POWER CO-LOCATED PROJECTS WITH OVER 10MW OF CAPACITY, MW



Source: Bloomberg New Energy Finance

Figure 32 shows a list of selected wind-solar hybrid projects, some of them already commissioned, some still under development, with the relative contribution of each technology to the overall capacity. In the majority of these cases, the dominant role is with the wind turbines, and the secondary role with the solar panels.

HYBRID ATTRACTIONS

Combining two or more power generation technologies at the same site is one way to reduce the intermittency of renewable energy and improve its competitiveness as the industry matures and becomes less dependent on subsidies.[30] The aim would be for hybrid projects to perform at a higher capacity factor than the 10-25% generally associated with PV or 20-35% with onshore wind, and to deliver a more consistent supply of power to the grid.[31]

Co-located, or hybrid, wind and solar projects are becoming more common due to the natural synergies of the sun and wind. In many temperate countries, wind speeds pick up at night and drop off in the day when solar irradiation is more plentiful. Seasonal variations can also support co-location. Winter in the northern hemisphere tends to bring stronger wind speeds, whereas summer heralds more sun. Therefore, combining wind and solar resources can strengthen a plant's overall generation profile to better match grid needs. Co-located wind and solar plants in southern Europe would generate power for more than 70% of the time, according to a study by the Massachusetts Institute of Technology.[32]

Vattenfall's Parc Cynog wind farm in Wales recorded a 10-percentage-point improvement in capacity factor after a 5MW solar PV array was added to complement the existing 8.4MW of wind turbines, according to Claus Wattendrup, director of business development at the Swedish utility. Meanwhile, Enel Green Power's 80MW Fontes dos Ventos wind park in Brazil shares a grid connection with the nearby 11MW solar park, resulting in more stable power production.

Hybrid projects may also offer the opportunity to reduce capital expenditure per MW, compared to building two separate units. Depending on the project in question, everything from the substation to the transmission line, grid connection, transformers, cabling and monitoring

[30] This chapter uses a wide definition of hybrid, to include technologies that share the same site, those that are adjacent and share grid connection and management, and those that are geographically close and are managed in tandem to increase or balance electricity generation.

[31] There are also a few hybrid renewable-fossil fuel generating plants around the world, for instance solar thermal and gas-fired generation. We have not covered these in this chapter.

[32] Characterisation of the Solar Power Resource in Europe and Assessing Benefits of Co-Location with Wind Power Installations by Cedric Bozonnat and C. Adam Schlosser.

systems can be shared between two or more technologies – reducing cost and improving project competitiveness. Developing a new-build hybrid project also allows developers to streamline development costs and environmental approvals.

Sharing the cost of operation and maintenance equipment and onsite staff could be advantageous – in some cases a single workforce can be used for cleaning, security and system monitoring. Total savings on capital expenditure for a co-located project are estimated at 3-13% and for operating expense 3-16%, according to a study completed by technical consultancy Aecom for the Australian Renewable Energy Agency (Arena).[33]

Developers of the 10MW Gullen Range solar farm near Canberra, Australia, saved an estimated AUD 6 million ($5 million) by placing solar panels adjacent to the 165MW wind farm, according to Arena. This equated to a 20% reduction for the project. In Wales, Vattenfall's Parc Cynog hybrid project achieved a cost reduction of 10% on project capex through sharing a grid connection, according to Vattenfall.

Where competitive tenders to procure power are technology-agnostic, hybrid power projects can be used as a lever to reduce costs, according to General Electric. Enel has said it intends to propose hybrid projects this year at auctions in Brazil, Mexico, the US and India. And in the Netherlands, Vattenfall intends to bid into a power auction with a proposed new solar plant integrated with an existing wind farm.

For auctions where developers bid to provide power during certain time periods, as is the case in Chile, proposing a hybrid project with a more consistent power profile could prove advantageous as it would cover more time blocks than a single technology alone. This may encourage the distribution companies that are contracting the power to look more favourably upon those particular projects.

A third benefit to aggregating power generation units at the same site is that higher overall production can be achieved. At a 13MW geothermal plant owned by Enel in Italy, commissioned in 2015, a biomass furnace increases the temperature of steam entering the power plant by more than half to as much as 380 degrees Centigrade, boosting efficiency. The 5MW biomass unit cost EUR 15 million, and it is designed to increase the geothermal plant's output by 30GWh per year.

Enel uses a similar logic at its Stillwater hybrid plant in Nevada, commissioned in 2016. There, three co-located technologies – 26MW of solar PV, 2MW of solar thermal and 33MW of geothermal – improve the efficiency of the overall plant. The heat produced by the solar thermal plant augments the input temperature of the geothermal unit, helping to deliver more production when thermal efficiency is at its lowest and during peak hours of demand.

An advantage of combining wind and solar power is being able to use the frequency converter in a wind turbine to turn direct current (DC) solar power into the alternating current (AC) needed to transport electricity on grid systems, according to wind energy developer, Mytrah Energy. This eliminates the need for additional solar inverters, which typically make up around 10% of the capex costs of a new solar plant, and also reduces the operations and maintenance costs on two sets of inverters.

At Tata Power's Whalvan hydro-electric dam near Mumbai, specially-designed solar panels float on the water surface and tap into the dam's underutilised transmission grid. They have been up and running for one year or more and have shown they can increase overall site capacity by 30%. The facility is designed so that the hydro power can run at full capacity during the monsoon season and solar can complement the rationed hydro-power when the rains dry up.

Almost all hydro-electric dams under a latitude of 40 degrees north could be suitably partnered with floating solar, and the potential scope in India alone is around 30GW, according to Sunengy, the Sydney-based floating solar developer that installed the Whalvan prototype.

[33] http://www.aecom.com/au/wp-content/uploads/2016/03/Wind-solar-Co-location-Study-Final.pdf

HYBRID CHALLENGES

In countries where policy support for larger-scale (above 5MW) onshore wind and solar PV has been withdrawn, such as the UK, it can be difficult to make the economics of a hybrid project add up. Vattenfall has identified a couple of wind projects in the UK where adding solar PV would be viable, but relying on wholesale power prices alone would not be sufficient, it says.

Another potential hurdle to overcome is arranging the appropriate land leases for a new solar farm. Many wind turbines are installed on agricultural land and have a relatively small footprint, whereas solar farms can spread more densely across the same acreage – making it a complex and expensive task to arrange permitting rights with the landowner. It is also important to ensure that wind turbines do not place solar panels in shade. Research by Reiner Lemoine Institut and Solarpraxis showed that production loss from shading is as low as 1-2% on average.

Although sharing grid connections can be a clever move in areas where these are in short supply, it can also mean that curtailment is needed at times when the technologies are generating power simultaneously. It was found that a solar farm sized at 25-50% of a wind farm's capacity would result in 5% total curtailment, in a study of 10 wind farms conducted by Arena. Advance analysis of the potential curtailment is therefore needed to determine the optimum size of the installations to be built.

Where the power assets making up a hybrid project are owned by different parties, it is also imperative to determine the dispatch priority were any curtailment to occur. It is often the preferred choice that any curtailment sits with the bottom line of the new solar project in the case of an existing wind plant.

Lack of familiarity with hybrid projects among equity and debt providers could also make it difficult to arrange non-recourse debt financing. Developers that have entered the sector so far – such as Enel and Vattenfall – have financed their projects on their balance sheets, but developers who require non-recourse debt financing could find this difficult to source, at least in the early stages of the market. "Co-located deals have different revenue streams, costs, maintenance and operating drivers. It's not always straightforward," said bank and asset manager Investec.

That said, for hybrid projects where a second technology is added to a site already hosting the first technology, environmental and meteorological studies for the location will have already been undertaken and community members approached. This may help with de-risking the project for investors.[34]

[34] An example would be adding solar PV to an existing wind farm, or to a hydro-electric reservoir. A greenfield project is where the two technologies are built together on a new site.

SOUTH ASIA

India is one step ahead in creating a policy framework to incentivise hybrid wind and solar projects. Strong monsoon winds blow from late afternoon to early morning during the summer, while the sun shines for around 300 days per year from early morning to around 6pm. The argument for wind and solar hybrid projects is therefore an appealing one, and the government aims to build 10GW of such plants by 2022.

India's Ministry for New and Renewable Energy has issued a guideline on how best to integrate wind and solar energy, and a handful of states have since produced draft policies, expected to be implemented in spring 2017.

Andhra Pradesh's policy proposes that new-build wind and solar hybrid projects either receive a feed-in tariff for all their output, or arrange a power purchase agreement, or PPA, with a private off-taker. These corporate PPAs are likely to drive the hybrid market in the near term because a commercial and industrial tariff is almost 20% higher than tariffs paid by the electricity grid.

Goldman Sachs-backed RenNew Power Ventures, together with Hero Future Energies and Greenko, are among Indian power producers interested in pursuing hybrids in the southern part of the country in order to supplement variable renewable power sources. About 70% of the 10GW of privately-owned wind generation in India would be suitable for adding solar to the mix, according to wind turbine maker Gamesa.

The company expects hybrid projects to make up 50-60% of its sales over the next three years. Suzlon Energy, an India-based turbine manufacturer, sees wind and solar hybrid plants as a "huge opportunity" due to "the complementary cycles of generation and the better utilisation of the installed infrastructure", according to a statement by Tulsi Tanti, its chairman, in the company's 2016 annual report. However, the opportunity will take one to two years to translate into commercial scale largely due to the fact that India still awaits a dedicated policy for hybrids, he said.

Pakistan, too, recognises the benefit of co-locating solar and wind projects, following the country's installation of more than 1GW of wind, solar and biomass resources in recent years. Pakistan's Alternative Energy Development Board "would encourage operators of wind power projects in Sindh to install at their site solar panels to generate additional megawatts of clean power on [a] more stable and reliable pattern", said Amjad Ali Awan, chief executive of the board in January 2017.

MICROGRIDS AND STORAGE

Complementing a hybrid renewable generation project with energy storage capacity can reduce curtailment, and allow excess power to be put aside and sold when power prices are higher. The business case for this improves when the difference between low-demand and peak power prices is substantial, because otherwise the cost to store the energy can outweigh the final payment.

Microgrids are particularly popular in remote areas like islands that are without access to a national electricity transmission network. The island of El Hierro in the Canary Islands, Spain has a 34MW microgrid, where energy is generated by wind turbines when wind resources are plentiful and otherwise by diesel. Any surplus electricity is used to pump water uphill and into an extinct volcanic crater where it is stored until finally released downhill to power hydro turbines. Wind and diesel power are also used in Antarctica on Ross Island, where the generation units are complemented by 0.5MW of flywheel energy storage. In the Portuguese Azores Islands in the Atlantic and Necker Island in the Caribbean, solar panels are added to a wind and battery storage mix.

Microgrids are also used by businesses, universities and military bases to provide reliability of power in case of grid defects, and sometimes to reduce the cost of power by replacing electricity from the grid at peak times of the day. For example, the University of Ontario in Canada has installed a 5MW microgrid, where solar PV, diesel and lithium-ion batteries work in tandem, while the US Army has a 2.6MW diesel, wind and flow battery microgrid at its military base in Hawaii.

Substantial cost reductions in solar PV and lithium-ion batteries are enabling clean energy microgrids to be built in less developed, remote regions that are otherwise devoid of electricity or dependent on expensive diesel generation. In Southeast Asia, the cost of generating electricity through a privately-owned diesel supply ranges from $0.25 to $0.90 per kWh for five to eight hours' use per day. Adding solar PV to the mix brings this cost down to $0.25-$0.45/kWh for 24/7 supply, according to microgrid developer WEnergy Global. The Singapore-based company said it secured financing in 2016 for its Sabang hybrid project in the Philippines that will consist of solar PV, diesel and batteries.

On Alaska's Kodiak Island, diesel power, energy storage and hydro stabilise the high penetration of variable wind power connected to the island's 79.2MW microgrid. And in Western Australia, plans are for the Carnegie Garden Island facility in Western Australia to combine 1MW of wave energy with 2MW of solar PV and battery storage. Developed by Carnegie Clean Energy and ABB, it is scheduled to be commissioned in 2017.

ASSET FINANCE

- Asset finance of new renewable energy projects (excluding large hydro) fell to $187.1 billion in 2016, some 21% less than the record reached in 2015, due to lower costs per MW in wind and solar, and a slowdown in two key regions, China and Latin America.
- Investments in utility-scale renewable energy are still dominated by wind and solar. The two leading sectors accounted for $175.7 billion, or 94% of the total, in 2016.
- Offshore wind was the star sub-sector in 2016, its record asset finance total of $30 billion including the go-ahead for the biggest project yet, the 1.2GW Hornsea array off the UK coast.
- China accounted for $37.6 billion of the $50.3 billion global decline, its asset finance total dropping 34% to $72.9 billion last year. The US and Europe held almost steady in 2016, at $29.8 billion and $46.9 billion respectively.
- The Americas excluding the US and Brazil saw asset finance fall by 55%, as Chile, Uruguay, Mexico and Canada all took a pause in their funding of new renewable energy capacity.

Asset finance of utility-scale renewable energy projects of more than 1MW totalled $187.1 billion in 2016, down 21% on the record figure of $237.4 billion reached in 2015.[35] These tallies exclude hydro-electric projects of more than 50MW – there is a box on large hydro at the end of this chapter.

Figure 33 shows the main split within last year's $187.1 billion asset finance total. On-balance-sheet financing of projects by utilities and energy companies amounted to $94.7 billion, down 20% on the 2015 figure, while non-recourse project finance came to $86.4 billion, down 24%. The latter category consists typically of packages of equity and debt linked to the project vehicle, not to the corporate entity developing the project. In non-recourse deals, debt almost always makes up the majority of the finance for the project, and equity the minority.

The chart also shows a category of 'bond and other' financings, amounting to $6 billion, down 10% on 2015. This includes leasing, where the renewable energy equipment is owned by a bank and leased by the developer, and also a relatively small number of bond issues on behalf of new-build projects.

FIGURE 33. ASSET FINANCE INVESTMENT IN RENEWABLE ENERGY BY TYPE OF SECURITY, 2004-2016, $BN

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

[35] The 2015 asset finance total has been revised up from the one shown in last year's Global Trends report, to reflect new information on projects reaching final investment decision.

More typically, bonds are used to refinance projects that started off being funded on balance sheet, rather than to provide the initial pot of money that enables them to proceed. Finally the 'bond/other' category includes a number of deals where information is scarce and it has not been possible so far to allocate the financing either to on-balance-sheet or to non-recourse project finance.

The balance between the two main categories has varied from year to year, and there has not yet been a year in which non-recourse project finance has been larger in dollar terms than on-balance-sheet financing. Generally, though, the non-recourse element has tended to increase its share gradually: from 15% in 2004 and 26% in 2005, to a high of 48% in 2015. It slipped back to 46% of the total in 2016, but this may be a one-year blip rather than a change of trend.

The period shown in the chart has been one in which wind and solar technologies have come down sharply in price, and also established long track records of generation. That has enabled banks, in particular, to get comfortable with the risks of lending to projects, and has tended to boost the amount of non-recourse finance available.

REGIONS

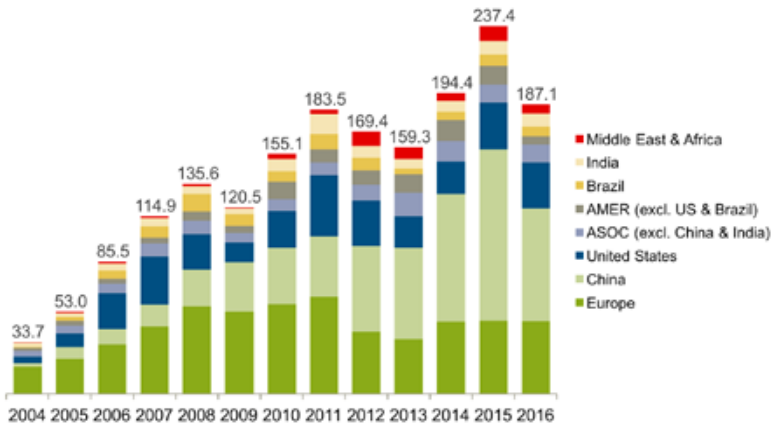
Asset finance of renewable energy projects continued in 2016 to rely heavily on China, which accounted for 39% of the global total,[36] against 25% for Europe and 16% for the US. However, the Chinese contribution was well down compared to 2015, both in money terms (at $72.9 billion, down from $110.5 billion) and as a proportion of the world total (it was 47% of the global figure in 2015).

Among the big-ticket Chinese projects financed in 2016 were four offshore wind farms, each of between 252MW and 302MW, with estimated capital costs in the $648 million to $810 million range. In solar, the 300MW Jiangsu Dison Silink Wuzhong Hongsipu Agricultural PV plant raised $506 million, and in onshore wind, the 300MW SDIC Hami Jingxia Number 5 project took an estimated $465 million.

Figure 34 shows the regional profile for asset finance over the years. Europe was the second most important region in 2016, contributing $46.9 billion, just 1% down on 2015. Ten of the largest 11 projects financed in Europe in dollar

[36] Bloomberg New Energy Finance's New Energy Outlook, or NEO, for 2016 puts all hydro at 16% of world electricity generation. Taking small hydro projects off this figure would leave large hydro at 13-14%.

FIGURE 34. ASSET FINANCE INVESTMENT IN RENEWABLE ENERGY BY REGION, 2004-2016, $BN



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

terms in 2016 were in offshore wind, which saw a 53% surge in final investment decisions to $25.9 billion (see next section). Solar asset finance in Europe slumped 75% to $1.6 billion, while the equivalent for onshore wind retreated 26% to $14.8 billion and that for biomass and waste rose 14% to $3.9 billion.

The US came third among the regions last year, accounting for $29.8 billion, down 2% on the previous 12 months. Wind asset finance in the US rose 5% to $14.7 billion, while solar attracted the same dollar figure, but this was 6% down on 2015. Out of the top 14 projects financed in 2016, 12 were in onshore wind and two in solar. Congress' vote in December 2015 to extend the key tax credits for wind and solar for five years was a morale-booster for the two sectors rather than the trigger for a short-term boom in 2016.

Among the other regions shown in the chart, India saw a 4% slip in asset finance in 2016 to $8.4 billion, and Brazil a 17% setback to $6.1 billion. A highlight in India was the construction of the Ramanathapuram solar complex in Tamil Nadu, billed as the world's largest ever PV project at some 648MW. This is treated as several distinct projects in the investment data in this report, different stages representing anywhere between 10MW and 256MW, and financed partly in 2015 and partly in 2016. Brazil's asset finance last year was led by $486 million for the 333MW Copel Cutia wind portfolio.

The Other Americas region – excluding the US and Brazil – suffered a 55% knockback in asset finance to $5.5 billion, with sharp reductions in funding activity for projects in Mexico, Chile, Uruguay and Canada (see discussion in Chapter 1 on the impact of the timing of auction rounds). Mexico was down 80% at $443 million, Chile down 79% at $829 million, Uruguay 73% lower at $454 million and Canada down 56% at $1.3 billion. There was growth in asset finance in a few other countries, such as Bolivia, Argentina and Peru, but from a small base in the previous year. Bolivia saw the most asset finance of these three, at $777 million, up from zero in 2015, mainly thanks to the financing of the 100MW ENDE Laguna Colorado geothermal undertaking.

The Middle East and Africa region saw asset finance fall 36% to $6 billion, with South Africa accounting for most of that reduction (down 76% at $894 million, due to a gap in its auction schedule). Morocco was another to endure a slow year in 2016, its funding of renewable energy projects dropping 69% to $660 million, but there were increases elsewhere – Israel up 254% at $948 million, Kenya up 41% at $648 million, Egypt up from almost nothing to $745 million and Jordan 163% higher at $1.1 billion. Smaller renewable energy markets such as these are likely to be more volatile year-to-year because of the timing of financial close for particular, big projects.

The Asia-Oceania region excluding China and India was much steadier, its asset finance total edging up just 1% to $11.4 billion. Japan was the biggest single feature in that, accounting for $4.4 billion, down 4%. There were year-on-year increases for Australia, up 127% at $2 billion; Thailand, up 13% at $1.4 billion; Vietnam, up 144% at $682 million; and Singapore, up nearly sevenfold at $551 million.

The Philippines saw asset finance slip 47% to $1 billion, while Pakistan experienced a steep reversal, down 80% at $288 million. However,

that country's 2015 asset finance figure has been revised sharply upwards since last year's Global Trends report – so the two-year total of $1.7 billion actually looks impressive compared to earlier periods.

Figure 35 lists the top 10 countries in the world for renewable energy asset finance. It shows that the global picture remained highly lopsided in 2016, with just three countries reaching double figures in terms of dollar commitments – China with $72.9 billion, down 34%, the US with $29.8 billion, down 2%, and the UK with $22.5 billion, up 2%.

There is then a group of nations in the several-billion-dollars category for 2016, led by India and Germany, with Brazil and Japan. Next is a handful of developed economies – Belgium, Denmark, Norway, Australia and France – all near to or above the $2 billion mark. Only after that did last year start to show some of the 'up-and-coming' medium-sized emerging markets for renewables, such as Turkey, Jordan, the Philippines, South Africa, Bolivia, Chile and Egypt. The reasons why asset finance paused in several of these promising markets in 2016 are explored in Chapter 1.

Some striking contrasts can be seen at the sectoral and sub-sectoral levels in Figures 36 and 37. In the first chart, the dominance of wind and solar is clear in the money invested in utility-scale renewable energy. Out of $187.1 billion total asset finance in 2016, the two leading sectors accounted for $175.7 billion, or 94%.

Wind saw $107.9 billion of asset finance committed last year, down 12% on the previous year. However, as Figure 37 highlights, there was a huge contrast at the sub-sector level. Investment in new onshore wind capacity worldwide fell 23% to $77.9 billion, its lowest since 2013. But investment in new offshore wind arrays jumped 41% to $30 billion, the highest ever and twice the figure for just two years before. Offshore wind accounted for 16% of global renewable energy asset finance in 2016, up from 9% in 2015.

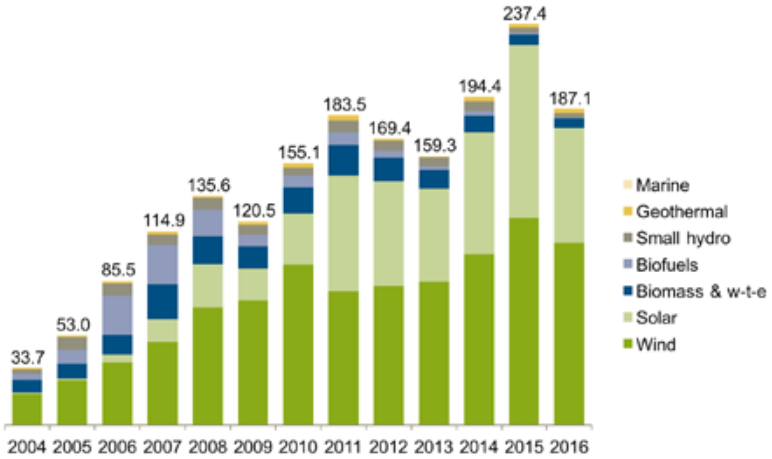
The biggest onshore wind project financed by far last year was the 1GW Fosen complex in Norway, at $1.3 billion. The equity for Fosen will be funded by developer Statkraft, utility Troenderenergi and Nordic Wind Power, a company backed by Credit Suisse, one German insurer and three German and Finnish pension funds. The debt comes from Swedish lender SEB, covered by Danish export credit house EKF.

FIGURE 35. ASSET FINANCE BY TOP 10 COUNTRY, 2016, AND CHANGE ON 2015, $BN

	2016	% growth on 2015
China	72.9	-34%
United States	29.8	-2%
United Kingdom	22.5	2%
India	8.4	-4%
Germany	8.4	-34%
Brazil	6.1	-17%
Japan	4.4	-4%
Belgium	2.7	196%
Denmark	2.4	190%
Norway	2.1	8761%

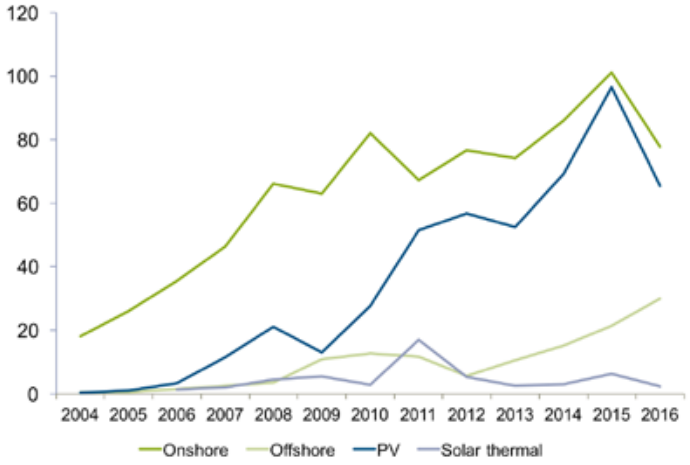
Top 10 countries. Total values include estimates for undisclosed deals
Source: UN Environment, Bloomberg New Energy Finance

FIGURE 36. ASSET FINANCE INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2004-2016, $BN



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

FIGURE 37. ASSET FINANCE OF WIND AND SOLAR PROJECTS WORLDWIDE, BY SUB-SECTOR, 2004-2016, $BN



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

Three US onshore wind financings are estimated to have broken the $500 million barrier last year – the 400MW Enel Cimarron Bend project in Kansas, the 324MW Pattern Broadview plant in New Mexico, and the 278MW E.ON Twin Forks installation in Illinois.

However, the offshore wind deals of 2016 were much larger. The 1.2GW Hornsea array off the coast of England, at an estimated $5.7 billion, will be the largest single project investment ever in renewable energy (outside large hydro). Financed initially on-balance-sheet by developer Dong Energy, Hornsea is due to be completed in 2020.

There were 13 other offshore wind financings in 2016 that fitted into a range between $500 million and $3.9 billion, led by two other giant UK projects (588MW Beatrice Cape and 714MW East Anglia One). Also included in the 13 were three large German arrays, two in Belgium, one more in the UK and four in China. The largest of the Chinese undertakings was the 300MW Hebei Construction Laoting plant, at an estimated $810 million. Many of the offshore wind projects will use turbines of a size hardly imagined a decade ago: East Anglia One, for instance, will use 102 machines of 7MW each, while Germany's 396MW Borkum Riffgrund will use turbines of just over 8MW each.

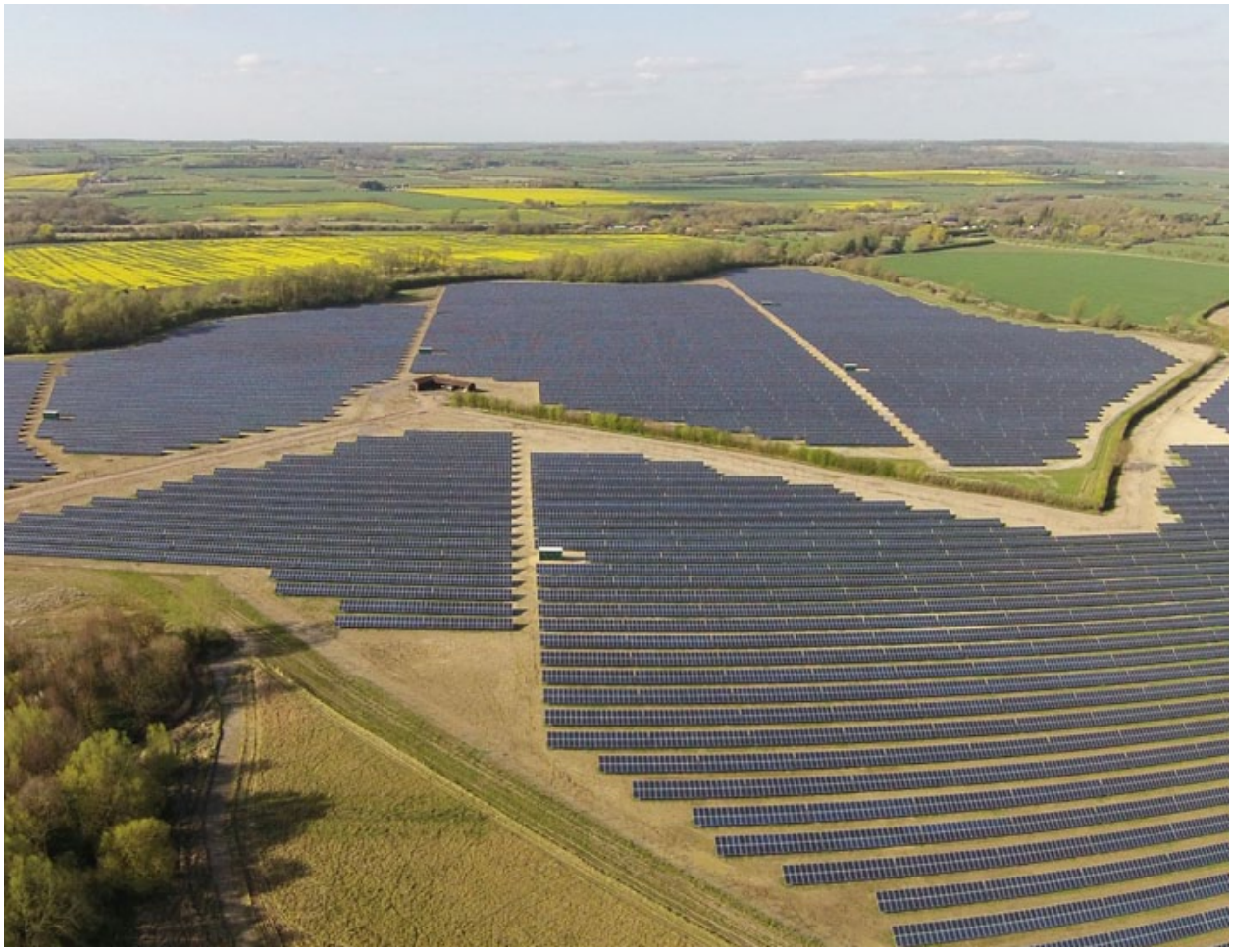
Solar asset finance fell 34% in 2016 to $67.8 billion, its lowest figure since 2013. However, a record number of gigawatts of new PV capacity were added globally last year, so the main reason for the decline was lower unit costs in that technology, as noted in the Executive Summary of this report. Within the solar sector, funding of utility-scale PV projects slipped by 32% to $65.5 billion while financing of solar thermal, or CSP, plants fell 64% to $2.3 billion.

Solar thermal has failed to keep up with the steep cost reductions achieved in PV and, for that reason, has been pushed to the fringes in terms of global project development. There were just three significant ones getting the go-ahead last year: the 110MW Ashalim II Sun Negev complex in Israel, at $805 million, the GDF Suez Kathu plant in South Africa, at $756 million for 100MW, and the PowerChina Northwest Hami project in China, at an estimated $227 million for 50MW. The first two will use parabolic trough technology, the last is a solar tower.

In PV, the average ticket size was smaller but there were far more projects reaching financial close. Among the biggest were the 31 Dominion SBL portfolio in the US, at an estimated $702 million for 580MW, and the 300MW Jiangsu Dison Silink Wuzhong Hongsipu Agricultural project, at $506 million.

The only sector to see an increase in asset finance in 2016 was geothermal, with a 14% rise to $2.5 billion. The level of investment in new geothermal capacity worldwide has been relatively consistent over the last eight years, averaging $2.2 billion, so last year's total is unlikely to mark any new trend.

The largest geothermal plants reaching financial close in 2016 were the ENDE Laguna Colorada project in Bolivia, at 100MW and $612 million, and the KenGen Olkaria V undertaking in Kenya, at 140MW and $403 million. Japan was



instrumental in the financing of both these projects, its government agreeing a credit line for the Bolivian installation and the Japan International Cooperation Agency signing a loan deal with KenGen for the latter. There were also $100 million-plus projects financed in Turkey, Iceland and Honduras.

Small hydro projects (greater than 1MW and less than 50MW) attracted $2.9 billion of asset finance in 2016, down 7% from the previous year. This sector has been on a gradual declining trend in terms of new investment since it peaked at $7.3 billion in 2005. One reason is that many of the best opportunities for building small hydro plants have now been exploited. Nevertheless, the Chinese market remains active and, elsewhere, there were significant projects reaching financing close, including the 39MW LG International Hasang dam in Indonesia, at $148 million, and the 30MW Androscoggin River plant in the US, at $62 million.

A much more dramatic shrinkage has affected the biofuels sector in recent years. It was the second-biggest sector of renewables after wind during the 2006-07 period, but asset finance of new fuel production plants has since slumped – from more than $23 billion in each of those two years, to just $272 million in 2016. Last year's figure was 73% down on 2015. The largest biofuels asset financing of 2016 was the Fiagril Lucas Do Rio Verde ethanol installation in Brazil, at $115 million.

Biofuels have retreated into insignificance as an area for new investment for three main reasons. The first is that the few countries with mandates for particular levels of biofuel use in the vehicle fuel system, such as the US and Brazil, already have sufficient capacity to meet these. Second, hopes for a boom in second-generation biofuels, using non-food plant matter, have never been realised, largely due to high costs. Third, biofuels have come to be seen in many countries as a less effective way of reducing transport emissions

than the shift to electric cars. However, there are areas of continuing interest, including biofuels for aviation.

Marine energy saw almost no asset finance in 2016, but the potential remains for it to feature in some significant projects in the future. Last year, construction continued on demonstration tidal stream projects off the north coast of Scotland, off Brittany and in the Bay of Fundy off Nova Scotia, and efforts were underway to finance larger projects in UK, Irish and French waters.

There was also political debate in the UK over the proposed 320MW lagoon at Swansea Bay, and there are a number of other tidal range projects in development in the same country. The wave sector remained well behind tidal stream and tidal range in terms of project development in 2016, after a series of company failures in the preceding years.

The biomass and waste-to-energy sector remained a firm third behind wind and solar in 2016 in terms of global asset finance, although its total of $5.7 billion was down 2% on 2015 and far below the peak figure of $20.6 billion reached in 2007.

Developed countries dominated the financing of biomass and waste installations in 2016. The largest projects to get the go-ahead were the 299MW Tees pellet and woodchip burning plant in the north of England, at $841 million, and the 150MW Amagervaerket woodchip combined-heat-and-power installation in Copenhagen, at $739 million. In waste-to-energy, the biggest financing was $548 million, for the 120MW Hyflux & Mitsubishi Tuas incinerator in Singapore.

LARGE HYDRO-ELECTRIC PROJECTS

Large hydro is an important contributor to electricity generation, making up 13-14% of the global total, thanks to projects built any time from early in the Twentieth Century through to the recent spurt in development, led by China. However, it is not included in the main figures in this report. One reason for this is that there are sustainability or geopolitical concerns over some (but certainly not all) large hydro projects. Another is that it is difficult to measure large hydro investment with the same accuracy as that in other renewable energy sectors because of the very long timescales involved – sometimes 10 years or more from start of construction to commissioning – and the risks of substantial delay.

Some organisations estimate large hydro investment by taking the amount of new capacity commissioned each year and then multiplying that by historical cost figures for those projects. This approach is adopted by, among others, the International Energy Agency in its World Energy Outlook and by the Chinese government.

That is a very different methodology from the one used by Bloomberg New Energy Finance for the figures used in this report. The BNEF database counts asset finance dollars at the moment the 'final investment decision' is made for the project, in other words just ahead of the start of main construction. This gives a forward-looking view on activity in clean energy. Doing the same for large hydro is challenging, given the tendency of many developers to begin early construction activity at the location for a dam, years before the financing package is finalised.

With that proviso, BNEF estimates that large hydro-electric projects of more than 50MW attracted $23.2 billion of final investment decisions in 2016, down 48% from the 2015 total of $44.9 billion. The lower figure last year reflected a lull in underlying activity (reported also by the big hydro-electric turbine manufacturers), and the absence of a mega-project to compete with 2015's go-ahead for the 10.2GW, $15.3 billion Wudongde dam in China.

Nevertheless, even a shrunken 2016 asset finance total of $23.2 billion would put large hydro far above the other renewable energy sectors in investment terms, other than wind and solar, as Figure 8 in the Executive Summary shows. The $23.2 billion represented the funding for 12.6GW of large hydro capacity, compared to 27.1GW financed in 2015.

Topping the list of biggest hydro projects financed last year was the 2.2GW Caculo Cabaca dam in Angola, at an estimated $4.5 billion. In December 2016, a consortium of lenders led by Industrial and Commercial Bank of China agreed to provide $4.1 billion to the country's Ministry of Energy and Water to meet the lion's share of capital costs. Also prominent was the go-ahead last April for the 1.2GW Suwalong dam on the Jinsha River in China, developed by China Huadian Corporation. And in October 2016, the 670MW Nam Theun 1 project in Laos reached a key milestone, with the award of its electromechanical equipment contract to Andritz.

The international Hydropower Association estimated in March this year that global hydro capacity, including projects of less than 50MW and pumped storage plants, reached almost 1.25TW at the end of 2016.[37]

[37] IHA: 2017 Key Trends in Hydropower.

SMALL DISTRIBUTED CAPACITY

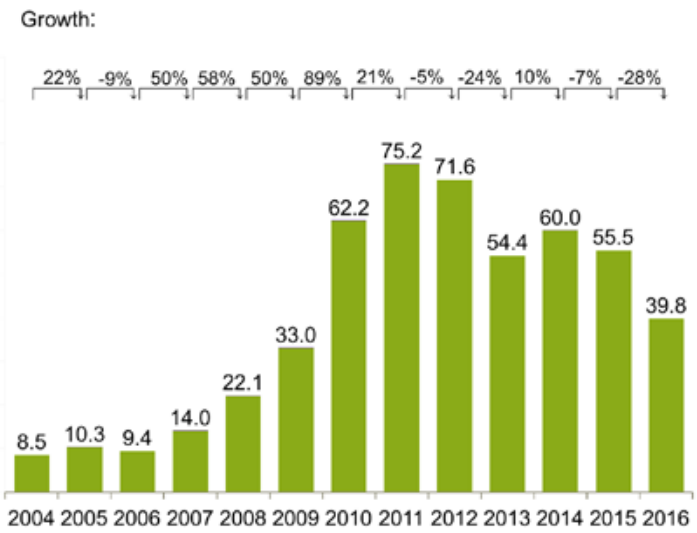
- Investment in small-scale renewable power projects of less than 1MW declined 28% in 2016. A total of $39.8 billion was channelled into predominantly solar PV systems of less than 1MW.
- The price of small-scale solar systems fell in many countries. Despite growing demand, the market will remain oversupplied in 2017, potentially leading to further price declines.
- The US took the top investment spot with $13.1 billion, followed by Japan with $8.5 billion (down from $27.1 billion in 2015) and China on $3.5 billion.
- India's small-scale solar sector looks set for lift-off, driven by the government's ambitious target to install 40GW of rooftop solar by 2022.

Investment in small-scale renewable power projects sank to its lowest level since the start of the decade. A total of $39.8 billion was channelled into predominantly rooftop and small ground-mounted solar PV systems of less than 1MW in 2016. This was a decline of 28% on the previous year's $55.5 billion and well below the totals recorded during the peak of the German and Italian PV booms in 2011 and 2012. Figure 38 sets out Bloomberg New Energy Finance annual small-scale investment data back to 2004.

Less money was available in 2016, but this did not derail the sector's development efforts. Indeed, PV installers added around 20GW of new residential and commercial capacity, about the same volume as in 2015. This was partly thanks to lower PV system costs in certain key markets, which enabled developers to build out more capacity for the same money. For instance, US PV installers SolarCity, SunRun and Vivint all dropped their prices in 2016, while in Australia and Germany they remained largely constant. For a recent history of residential PV system costs, see Figure 39.

Panel prices fell further than expected in 2016 thanks to fierce competition among component manufacturers, technological advances and a supply glut that intensified with a cooling in the Chinese solar boom in the second half of the year. By the end of November 2016, Chinese crystalline silicon PV module prices had fallen by an average of 13% since the start of the year, while those made in Germany were down 15%, according to data published by Pvxchange. A further 20%

FIGURE 38. SMALL DISTRIBUTED CAPACITY INVESTMENT, 2004-2016, $BN



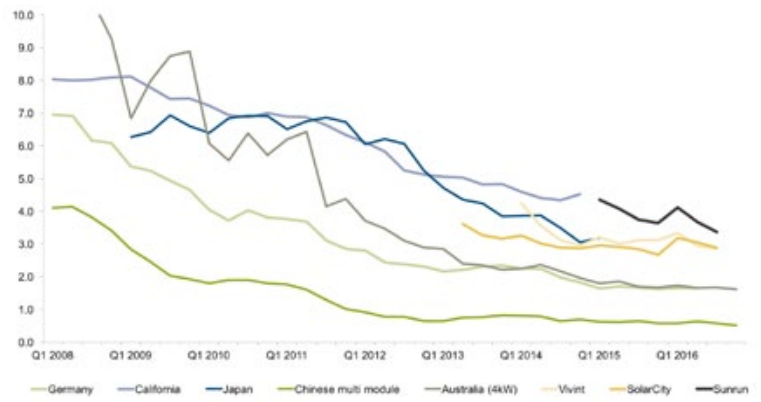
Represents investments in solar PV projects with capacity below 1MW
Source: Bloomberg New Energy Finance

decline is forecast for 2017 as the market for modules is unlikely to absorb the current 10-20% manufacturing overhang.[38]

As well as priming the pumps for PV in well-off countries such as the US and Australia, falling prices have put solar technology within reach of many more households and small businesses in developing economies. Exports of PV modules and cells from China to emerging countries and island nations reached $3 billion in the first nine months of 2016, representing a 20% increase over the same period in 2015. This is equivalent to an estimated 6.8GW of PV modules. See the next section for further discussion of recent growth of small-scale PV in emerging markets.

Harder to predict and perhaps more important than the direction of near-term PV system prices is the plethora of national and regional policies and regulations that can either set a solar boom in motion, or cause it to crumple. For instance, Japan's rampant small-scale PV sector attracted

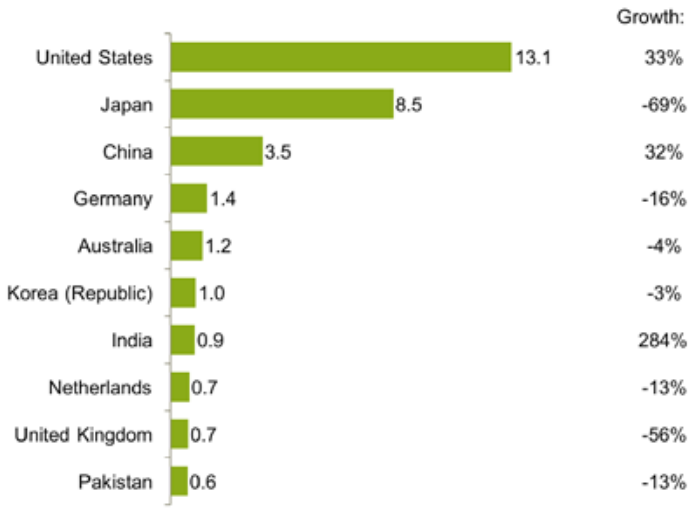
FIGURE 39. PUBLIC CAPEX BENCHMARKS FOR RESIDENTIAL PV SYSTEMS, $/W



Source: Bloomberg New Energy Finance

[38] This data is drawn from Bloomberg New Energy Finance research, December 2016 PV Supply Monthly Update, published on 9 January 2017.

FIGURE 40. SMALL DISTRIBUTED CAPACITY INVESTMENT BY COUNTRY, 2016, AND GROWTH ON 2015, $BN



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

a very substantial $27.1 billion of investment in 2015, but has since come off the boil as lower feed-in tariffs put the brakes on growth. Investment in new small-scale capacity in that country shrank to just $8.5 billion in 2016, behind the US on $13.1 billion, but well ahead of its nearest rival, China, on $3.5 billion.

Japan's decision to slow growth by cutting subsidies is clearly working and it now seems unlikely that the market will return to the peaks seen in 2015. The rate of installation fell to 5GW in 2016 from 6.9GW in 2015, while a further tariff reduction, due to take effect in fiscal 2017, is forecast to contain growth at between 3.2GW and 3.6GW in the current year. Between July 2012, when the solar feed-in tariff was introduced, and the end of September 2016, a total of 20.5GW of small-scale PV had been commissioned, almost half of which was between 10kW and 50kW in size.

As illustrated by Figure 40, the US toppled Japan from the top investment spot in 2016. A total of $13.1 billion was spent on small-scale PV, up from $9.8 billion the previous year. The US market had a much higher mix of relatively expensive residential solar in 2016 than in Japan, where commercial installations dominated. This is a key reason why America's investment total was higher than Japan's, even though the amount of capacity added was lower, at 3.4GW.

The US solar market faces uncertainty, not least because President Donald Trump has made it plain that he is sceptical about the science behind anthropogenic climate change and intends to withdraw the US from the Paris Climate Change Agreement. It is thought that his administration is unlikely to try to repeal the ITC, which is set to run at its current 30% rate until 2020 and then decline to 10% in 2022. There is also a possibility the new government will seek to erect additional trade barriers against Asian solar companies, or tighten the current trade barriers to exclude modules made in factories set up in south-east Asia to dodge them. If so, that might raise the cost of solar systems in the US.

Development was curtailed in the southwest of the country in 2016 as net metering programmes in the states of Arizona and Nevada were scrapped (although the latter reinstated its scheme for existing solar customers in early 2017). In addition, small-scale solar in California is being constrained by a 5% net metering cap on municipal utilities. Developers are therefore seeking out and expanding into new markets elsewhere – 18 states experienced greater than 100% growth in residential PV additions over the first nine months of 2016, with growth highest across the Eastern seaboard.

Falling prices are changing the face of the US residential solar market. Smaller, local installers offering new loan products are eroding the hegemony built up by a handful of established players over the last few years. The financing services these big companies offer, such as complex third-party power purchase agreements, are no longer the necessity they once were, while proliferation of the technology and greater standardisation has broadened the pool of capable solar engineers. In the final quarter of 2016, the market share of the country's three largest installers (SolarCity, Vivint and Sunun) fell to 32%, having been 45% during the same period the previous year.

China's solar market as a whole may stand head and shoulders above the rest of the world – 34.2GW of new capacity was added to the grid in 2016, almost three times the 12.4GW added in the US – but in terms of recent investment in small-scale projects, the $3.5 billion committed to sub-1MW plants in 2016 trailed behind volumes recorded in the US and Japan. Nevertheless, this total represented an improvement on the $2.7 billion seen in 2015, and is likely to be the first of many such increases thanks to the launch of the PV for Poverty Alleviation (PVPA) campaign in October 2016.

As part of China's goal to eliminate poverty by 2020 (the closing year of the 13th Five-Year-Plan), the PVPA has approved 2.18GW of small-scale user-owned capacity in 14 provinces. It also approved almost 3GW of larger developer-owned projects, which together with the user-owned capacity will

benefit 555,000 poor households. Over the next two to three years, a further 10GW are expected to be approved, a higher share of which will go to user-owned projects, according to statements from the National Energy Administration.

In another important development, the NEA said in 2016 that rooftop PV is no longer part of the quota system and can therefore qualify for subsidies once connected to the grid.

Neighbouring India's small-scale solar sector is about to take off. Investment in 2016 grew by almost 300% to $928 million, a trajectory that will need to be maintained if the country is to meet its ambitious target to install 40GW of rooftop solar by 2022. Given that sub-1MW solar capacity stood at just 500MW in April 2016, a compound annual growth rate of 108% is required over the next six years to meet the target.

Most of the growth so far has come from commercial and industrial customers, although some residential installations are also taking place. Several states have recently introduced net-metering regimes and are supporting the roll-out of projects. These measures are likely to carry the market forward in the immediate future, as will favourable economics due to high power tariffs and cash availability. However, the sector will need almost $50 billion of capital if it is to meet the 40GW goal.

India's market for small solar home systems (of less than 100W) and lanterns has also seen impressive growth. Over the last four years, sales of such items saw a compound annual growth rate of 47%, with some 2.3 million units sold in financial year 2016. Historically, this market has been supported by government subsidies and the efforts of non-government organisations. However, new business-driven distribution models are starting to look promising, and pay-as-you-go mechanisms, growth in the range of financing options and the penetration of retail banking should offer support for future growth.

Around the world in 2016, there were thousands of examples of sub-1MW PV projects going ahead that made an impression on their local communities. Here are just a very few, all well into three figures in terms of kilowatts of capacity. In December, Sacramento Kings' NBA basketball club completed the installation of a 700kW solar array on top of its Golden 1 Center arena. In the same month, Merino Panel Products installed a 550kW project in Jhajjar, India. In November, Expo Freight opened a 651kW system in Wellampitiya, Sri Lanka, that country's second largest rooftop solar plant. In October, St Scholasticas Academy-Markinia private school in the Philippines switched on a 204kW rooftop PV system.

NASCENT MARKETS

Declines in the cost of equipment, most notably solar panels, along with innovative business and financing models are transforming access to energy in some of the world's least developed nations. No less than 1.2 billion people lack sufficient access to energy, and several hundred million more are subject to frequent power outages.

Over the past five years, the market for basic solar-powered lights and small home systems with multiple lights, phone charging and basic appliances has grown rapidly, with more than 24 million units sold. This has seen the rise of pay-as-you-go solar companies such as M-Kopa, Off-Grid Electric, d.Light, Bboxx, Nova Lumos and Mobisol. Together they have raised more than $360 million in capital and serve about 700,000 customers, a small fraction of the addressable market in East and West Africa.

The world of small-scale clean energy project development in emerging economies is naturally opaque and therefore hard to quantify. However, analysis of Chinese customs data offers some useful insights. For instance, in the first nine months of 2016, PV modules and cells equivalent to 6.8GW were exported from China to emerging economies. But just 4.1GW of utility-scale capacity was installed in those same countries in 2016.

While this does not constitute evidence for the size of the small-scale market, it does allow for an indicative assessment. Bloomberg New Energy Finance estimates that the market for Chinese small-scale PV in emerging economies between January 2015 and the end of 2016 was approximately 1.4-2GW, after adjusting for anomalies such as shipments that may have transited through emerging countries or large-scale projects undergoing long construction cycles.

Countries such as Pakistan and Nigeria with their large populations and unreliable grid power supply are among the largest markets for small-scale solar in the developing world. Bangladesh, Myanmar, Ghana and the Dominican Republic imported significantly more PV modules than required by their known project pipeline. West Africa also appears to be particularly fertile ground for small-scale solar activity.

And there is activity in East Africa too. Off-grid solar start-up Bboxx sells about 200 small-scale systems per day. These come with a 50W roof-mounted solar panel and a lead-acid battery, phone chargers and LED lights. The company closed a $20 million Series C venture capital funding round in August 2016, led by French energy giant Engie. The company has 36 retail outlets in Kenya and Rwanda, but hopes to scale up to 400 retail shops in the next two years.

PUBLIC MARKETS

- A total of $6.3 billion was raised by clean energy companies on global public markets in 2016, a 53% decline compared with 2015 and 60% down on 2014.
- Funds raised via initial public offerings increased by 12% to $2.6 billion. However, this increase was entirely thanks to Innogy's $2.2 billion stock market debut.
- US yieldcos were much less active than in 2015 and no new funds were launched. Falls in yieldco share prices and the collapse of SunEdison sent shockwaves through the sector, but some US yieldcos and UK quoted project funds managed to raise new equity last year.
- Overall, solar companies and funds raised $1.7 billion, less than one-fifth of the previous year's total, while those focused on wind garnered $4.2 billion.

Fundraising by renewable energy companies on the world's public markets fell sharply in 2016. Together they notched up sale proceeds of $6.3 billion last year, which was 53% less than the $13.3 billion raised in 2015 and 60% down on the peak of $15.9 billion achieved in 2014. This was lower than at any time since 2005, except for 2012 when only $4 billion was raised. Figure 41 shows the volume of investment raised on the public markets since 2004.

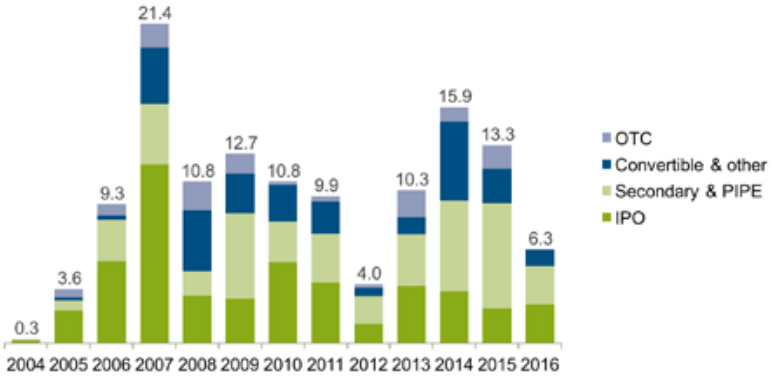
The recent decline in fundraising on the public markets chiefly reflects the bursting of the US 'yieldco' bubble in late summer 2015. In the preceding a year and a half, investors poured some $12 billion into these quoted renewable asset vehicles, and their closely related cousins, the European quoted project funds.

YIELDCO HANGOVER

Investor enthusiasm abated suddenly in the months after July 2015 when it became clear that US yieldcos' growth projections were unrealistic. Their shares fell by an average of 40% and it became almost impossible for them to issue fresh equity.

Yieldcos returned to the market in early 2016, but fundraising was more modest than previously. NextEra Energy Partners, 8Point3 Energy Partners and Pattern Energy Group raised a combined total of slightly more than $1 billion in new equity last year, while the six London-listed quoted project funds raised about $700 million. Although considerable, this level of fundraising pales in comparison with the total of $7 billion of new equity secured by these entities in 2015.

FIGURE 41. PUBLIC MARKET NEW INVESTMENT IN RENEWABLE ENERGY BY STAGE, 2004-2016, $BN



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

Overindulgence on yieldcos in 2015 may have given investors a hangover in 2016, but it did not completely extinguish investor appetite for the renewable energy sector. Funds raised via initial public offerings (IPOs) increased by 12% to $2.6 billion. However, this was thanks to a single very substantial debut offering – in early October, Innogy, the renewable energy arm of German utility RWE, raised $2.2 billion from the sale of a 10% stake on the Deutsche Börse. A further 15% was sold for $2.9 billion by existing investors, making it Europe's biggest IPO since Glencore in 2011.

The IPO is part of a major restructuring by RWE in response to an energy policy that favours renewables over fossil fuels and nuclear. Wind and solar are suppressing wholesale power prices and squeezing coal and natural gas out of the market. Utilities such as RWE and rival E.ON are adapting by separating traditional and renewable power generating operations – the former carved out its green business as Innogy, while E.ON placed its conventional generation assets into a new company, Uniper, which listed in Frankfurt in September last year.

Earlier in the year, investors proclaimed their enthusiasm for the sector when they snapped up shares in Dong Energy, the world's largest offshore wind farm operator. The Danish group, which also runs the country's largest utility and retains a small oil and gas business, has repositioned itself as a green energy company in recent years. The listing on the Copenhagen Stock Exchange enabled existing shareholders — including the Danish government and Goldman Sachs — to sell 20% of the company for slightly more than $3 billion. No fresh capital was raised.

The Innogy and Dong deals prove that there was investor appetite for certain blue chip clean energy companies in 2016. However, the wider picture reveals a more hesitant sector.

German wind turbine maker Senvion, for instance, dropped plans for a very substantial initial public offering early last year. The company's owners, New York-based private equity firm Centerbridge Partners, had intended to raise as much as $780 million from its listing in Frankfurt, but changed its mind, citing "a background of recent market volatility". Centerbridge bought the company from Indian wind turbine maker Suzlon Energy in 2015. Later, in March, it came back with a more modest plan, selling $278.1 million of shares in an IPO but not raising any fresh equity.

Other than Innogy, Dong and Senvion, just six companies went ahead with IPOs, raising a total of $271 million in new money between them. The next largest IPO was by China Jinjiang Environment Holding, a China-based waste-to-energy project developer, which raised $138 million on the Singapore Stock Exchange. Another Asian company, India-based Azure Power Global, raised $40.4 million when it floated on the New York Stock Exchange in October. The stock was priced below its marketed range and fell on the first day of trading.

US company TPI Composites, a manufacturer of composite wind turbine blades, also got off to a disappointing start. It raised $79.1 million in new equity on the Nasdaq Global market in July. However, immediately prior to its launch, the company lowered the price of its IPO to $11 per share from an expected range of $15 to $17, and cut the size of its offering by one million shares to 6.3 million. Despite such an inauspicious beginning, the company's shares have since risen – as of late January this year, they were up 38% on the IPO price.

FIGURE 42. NEX VS SELECTED INDICES, 2003 TO JANUARY 2017

Index values as of 10 January 2017; Nasdaq and S&P 500 rebased
Source: Bloomberg New Energy Finance

FIGURE 43. NEX VS SELECTED INDICES, JANUARY 2016 TO 10 JANUARY 2017

Index values as of 10 January 2017; NEX, MSCI ACWI World & Emerging and S&P 500 rebased
Source: Bloomberg New Energy Finance

CLEAN ENERGY SHARES

Uncertainty and volatility characterised the performance of clean energy share prices on global markets. The WilderHill New Energy Global Innovation Index, or NEX, which tracks around 95 quoted clean energy entities on markets across the globe, ended 2016 down 8.3%. Meanwhile, broad market indices advanced. The S&P 500 rose 9.5%, while the MSCI ACW added 5.6%. Another low-carbon energy gauge, the S&P Global Clean Energy Index ended the year 19% lower. Figures 42 and 43 show how the NEX has lagged the broader markets both in 2016 and over the longer term.

The NEX's top performer in 2016 was US smart meter manufacturer Itron – the company's shares climbed 74% over the course of the year thanks to higher-than-expected income. Next, US grid technology vendor EnerNOC rose 56% on the back of a Supreme Court decision to uphold a Federal Energy Regulatory Commission rule that puts 'demand response' on an equal footing with generation in grid procurement. Shares in Brazilian sugar and ethanol producer Sao Martinho increased by a similar percentage as domestic sugar prices hit a record high.

The index's worst performer was solar giant SunEdison (down 99%), which filed for bankruptcy protection in April 2016. The two yieldcos associated with it, TerraForm Power and TerraForm Global, were not part of the bankruptcy. Not far behind, UK fuel cell manufacturer Intelligent Energy Holdings lost 92% of its value in 2016 after failing to raise funds for a deal that would have seen it install its technology on more than 27,000 telecommunications towers in India. Shares in US solar giant SunPower lost 78% over concerns that demand for utility-scale solar

projects is slowing and competition is dragging panel prices lower.

Figure 44 shows the top 20 companies in the NEX by market capitalisation in early February 2017. They include companies that are not in renewable energy but are in energy smart technologies such as electric vehicles and lighting. One feature of the list is that, whereas wind developers and manufacturers are fairly well represented, there are no solar companies at all until First Solar at number 17. If the list was extended further, the next solar company would be polysilicon maker GCL-Poly at number 27. This shows that, in the biggest single sector of renewable energy, competition is fierce, making profits is hard, and investors are valuing accordingly.

FIGURE 44. LARGEST COMPANIES IN THE NEX INDEX, BY MARKET CAPITALISATION ON 7 FEBRUARY 2017

	Domicile	Sector	$m
Tesla Motors	US	Electric vehicles	41,524
BYD	China	Electric vehicles	17,888
Vestas Wind Systems	Denmark	Wind turbine maker	15,880
Dong Energy	Denmark	Offshore wind developer	15,379
Novozymes	Denmark	Biofuel enzyme maker	12,421
Acuity Brands	US	Lighting	9,120
China Longyuan	China	Wind developer	6,734
Goldwind	China	Wind turbine maker	6,287
Osram Lighting	Germany	Lighting	6,082
Gamesa Corporacion	Spain	Wind turbine maker	5,959
EDP Renovaveis	Portugal	Wind developer	5,582
Verbund	Austria	Hydro, wind operator	5,508
China Everbright Intl	Hong Kong	Environmental consultancy	5,426
Kingspan	Ireland	Energy efficiency	5,103
Nibe Industrier	Sweden	Sustainable heating	4,015
Philips Lighting	Netherlands	Lighting	3,799
First Solar	US	Thin-film PV maker	3,339
Huaneng Renewables	China	Wind developer	3,135
Mercury NZ	New Zealand	Hydro operator	3,104
NRG Yield	US	Wind, solar yieldco	3,060

NEX = WilderHill New Energy Global Innovation Index. Some of the companies in the list are in energy smart technologies rather than renewable energy

Source: Bloomberg

SECONDARY ISSUES

In line with the overall downward trend, secondary fundraising also fell in 2016 – the volume of funds accruing from follow-on sales dropped 74% to $2.6 billion. The largest offering was by Sungrow Power Supply, which raised $396 million on the Shanghai Stock Exchange. The China-based solar inverter manufacturer, together with compatriot Huawei Technologies, knocked Germany's SMA Solar Technology off the number one spot in 2015. It has begun to focus its attention on US residential rooftop solar.

The Sungrow deal stood out not simply because of its size but also because, remarkably, the remaining nine of the top 10 largest secondary offerings in 2016 were all by US yieldcos or UK quoted project funds. NYSE-listed NextEra Energy Partners, the yieldco created by power producer NextEra Energy, was the first to break the ice following the fundraising hiatus that had prevailed since August 2015. It raised $290 million in February 2016 and six months later, in September last year, it once again tapped the markets, this time raising $353 million.

Two more US yieldcos, 8Point3 Energy Partners and Pattern Energy Group, raised $118 million and $270 million, respectively. However, not all were successful: NRG Yield and TerraForm Power, funds that individually raised the largest amount of new equity in 2015, did not tap the public equity markets in 2016. The latter had hoped to conduct a follow-on offering in January 2016, but its failing parent company SunEdison put paid to those hopes. When the solar giant finally collapsed in April 2016, it was the renewable energy sector's biggest ever bankruptcy.

Quoted project funds and yieldcos raised new equity in small instalments in 2016, including by the use of at-the-market offerings. Like NextEra, some of the London-listed project funds – The Renewables Infrastructure Group, Greencoat UK Wind and NextEnergy Solar Fund – tapped the markets more than once last year. The last of these three had five separate offerings to its name by the end of 2016, raising a total of $166 million.

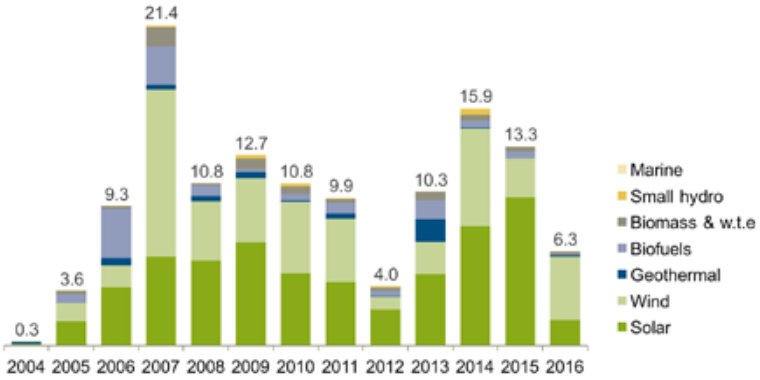
BY SECTOR AND LOCATION

A breakdown of 2016 deals shows that solar companies and funds raised $1.7 billion, less than one-fifth of the $9.9 billion they took home in 2015, and well below the solar sector's 10-year average of $5.4 billion per annum (see Figures 45 and 46). Not since 2005 has the sector reaped such meagre rewards on the public markets – back then, solar modules cost almost $4 per Watt, compared with around $0.5 per Watt for Chinese polysilicon modules in mid-2016. The largest deal in 2016 was Sungrow Power Supply's $396 million follow-on offering on the Shenzhen Stock Exchange.

It is significant that two Chinese giants of the solar sector, NYSE-listed Trina Solar and JA Solar Holdings, which is listed on Nasdaq, said they wanted to take their companies private. Their decision reflects a view that they have been undervalued by stock market investors. However, since these plans were announced, the outlook for the solar industry has darkened – PV production capacity grew faster than installations in 2016, despite surging to a record 75GW, and the cost of solar modules has fallen 30%.

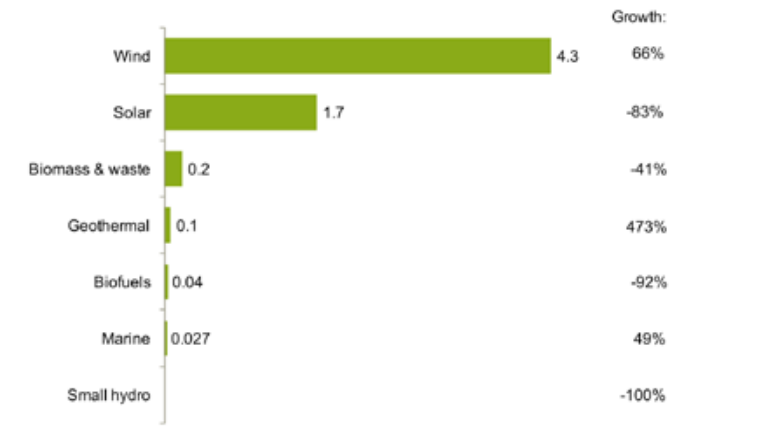
Wind companies and funds, in contrast to solar, raised more money than the previous year. Some $4.3 billion of new equity raisings were recorded, an increase of 66%, led by Innogy's issue of $2.2 billion worth of new shares in its IPO in October.

FIGURE 45. PUBLIC MARKETS INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2004-2016, $BN



Source: Bloomberg New Energy Finance, UN Environment

FIGURE 46. PUBLIC MARKETS INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2016, AND GROWTH ON 2015, $BN



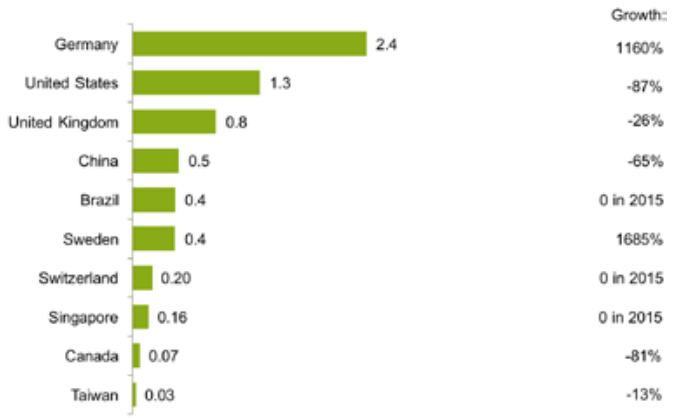
Source: Bloomberg New Energy Finance, UN Environment

Several wind-focused yieldcos and quoted project funds – namely, NextEra, Pattern Energy, Greencoat and Renewables Infrastructure Group – concluded follow-on offerings, raising a combined total of $1.4 billion. Other notable deals included TPI Composites' IPO, and Renova's $350 million from three exercise-of-rights transactions.

All other renewable sectors saw declines. In biomass and waste-to-energy, $192 million of new money was recorded, representing a 41% decline on the previous year. China Jinjiang Environment Holding's $137.6 million IPO on the Singapore Stock Exchange was the stand-out deal. Biofuel fundraising went from $437 million in 2015 to just $36 million in 2016, with only two companies raising funds on the public markets. One of these was Gevo, a US-based developer of advanced biofuel, which tapped investors for $24.4 million in three separate secondary offerings.

Figure 47 shows the breakdown of public markets investment in 2016 by the nationality of the company concerned. Germany was by far the largest country, at $2.4 billion, mostly thanks to Innogy's IPO, while the US came in second at $1.3 billion and the UK third at $839 million – both of the latter totals boosted by share issues from yieldcos and quoted project funds.

FIGURE 47. PUBLIC MARKETS INVESTMENT IN RENEWABLE ENERGY BY COMPANY NATIONALITY, 2016, AND GROWTH ON 2015, $BN



Top 10 countries
Source: Bloomberg New Energy Finance

VENTURE CAPITAL AND PRIVATE EQUITY

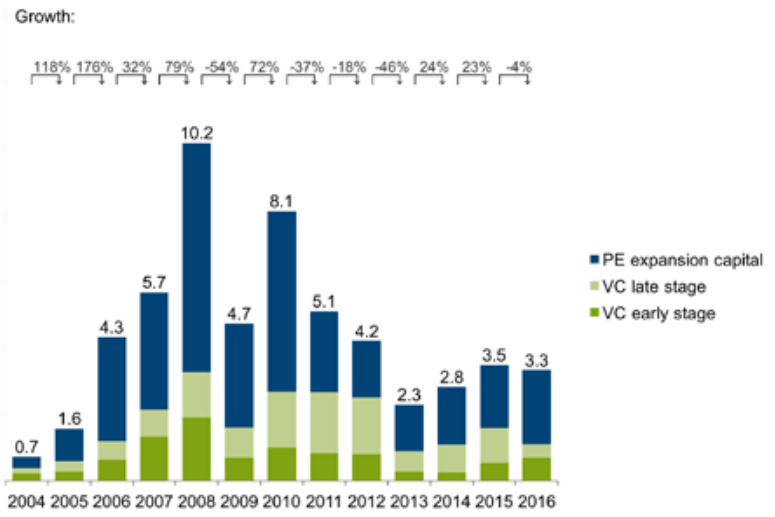
- Venture capital and private equity investment in renewable energy in 2016 fell by 4% to $3.3 billion, less than a third of its peak in 2008, but 46% above the recent low, in 2013.
- Investment in most venture capital investment stages fell sharply, but there were healthy gains in Series B and Series C, which grew 238% and 29% respectively. Private equity expansion capital gained 17% to $2.2 billion.
- As usual, solar attracted the largest investment. It captured more than two thirds of the total, although funding slipped 2% to $2.3 billion. Wind jumped 41% to $539 million, and small hydro almost quintupled to $165 million, but in each case the gain was due to a single deal. Biofuels slumped 60% to $254 million.
- The US remained the centre of worldwide VC/PE investment in renewables, at $2.3 billion, representing a fall of 2% but still more than two-thirds of the total investment. Investment in Europe doubled to $516 million, and that in the Other Asia-Pacific region jumped almost 28-fold to $55 million from a low base.

Venture capital and private equity investment in renewable energy held up well in a difficult year. Investors in the asset class confronted several challenges, including a slowdown in renewable energy investment more generally, especially in China and Japan; continuing turmoil in the solar sector; oil prices at low levels compared to recent standards; and a presidential election that has thrown the future direction of US energy policy into doubt.

In fact, global VC/PE investment in renewables fared better than total investment in renewable energy, and roughly in line with total VC/PE investment in all sectors. Renewable energy VC/PE investment fell 4% to$3.3 billion in 2016, while total renewable energy investment dropped 23% to $241.6 billion.Total VC/PE investment in all sectors of the global economy fell by around 5% to $158 billion, according to figures from Preqin, an alternative investment assets data provider.

VC/PE investment in renewable energy performed worse than equivalent investment in 'energy smart technologies', however. The latter heading

FIGURE 48. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY STAGE, 2004-2016, $BN

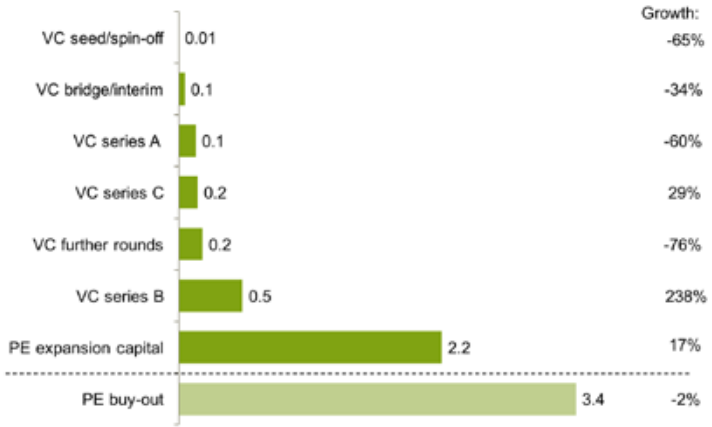


Buy-outs are not included as new investment. Total values include estimates for undisclosed deals

Source: Bloomberg New Energy Finance, UN Environment

includes electric vehicles, energy storage and smart grid technologies, areas that are discussed in a box at the end of Chapter 2 of this report. The money raised by specialist energy smart technology, or EST, companies from venture capital and private equity funds jumped 50% in 2016 to $7.5 billion, thanks in large part to two big investments in Chinese electric vehicle companies, worth $1 billion each.

FIGURE 49. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY STAGE, 2016, AND GROWTH ON 2015, $BN



Buy-outs are not included as new investment. Total values include estimates for undisclosed deals

Source: Bloomberg New Energy Finance, UN Environment

Taken together these figures may suggest a shift in VC/PE investment from renewable energy to EST, reflecting both the huge interest in electric vehicles and the increasing maturity of wind and solar. It may be that renewable energy VC/PE will never reclaim its 2008 peak of more than $10 billion.

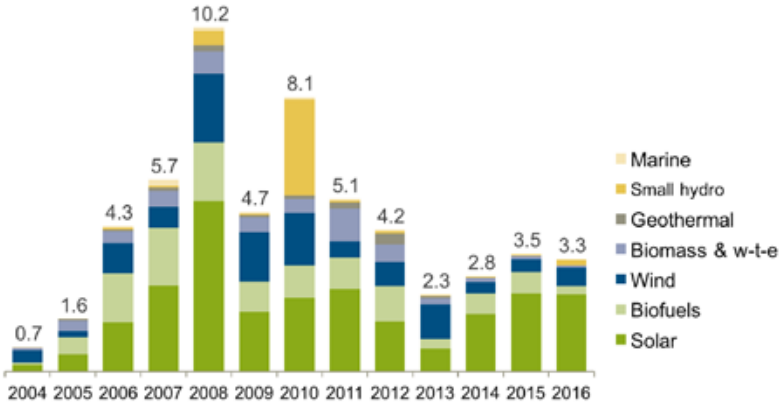
EARLY-STAGE AND LATE-STAGE

Figure 48 shows that there was a mixed picture in 2016 in terms of the amount of funding for young renewable energy companies at different stages. Within the overall $3.3 billion total, the early-stage venture capital element rose 28% to $691 million, and

there was a 17% increase in private equity expansion capital to $2.2 billion. However, late-stage venture capital slumped 60% to $413 million.

A more detailed breakdown, as presented in Figure 49, reveals that there were actually several weak spots in the VC/PE financing chain last year, with falls ranging from 34% for bridging funding to 65% for early spin-off and 76% for VC further rounds. The three risers were private equity expansion capital, which grew 17% to $2.2 billion; Series C venture capital, up 29% to $160 million; and Series B, which more than tripled to $539 million. Each of these apparent bright spots, however, was largely the result of just one or two deals. Had it not been for the funds raised by a single company, Sunnova Energy, for example, total investment in private equity would have shrunk.

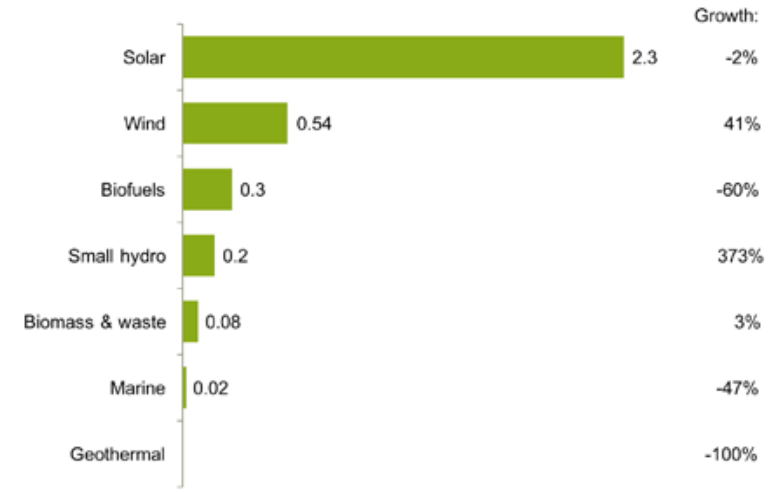
FIGURE 50. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2004-2016, $BN



Buy-outs are not included as new investment. Total values include estimates for undisclosed deals

Source: Bloomberg New Energy Finance, UN Environment

FIGURE 51. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2016, AND GROWTH ON 2015, $BN



Buy-outs are not included as new investment. Total values include estimates for undisclosed deals

Source: Bloomberg New Energy Finance, UN Environment

SOLAR

In every investment stage that achieved growth, the decisive deals were all in solar. This should come as no surprise since the sector remains by far the largest at this stage of the financing continuum, claiming 68% of all VC/PE investment in renewable energy, as shown in Figures 50 and 51. But the type of solar company financed by VC/PE is changing. Now that solar R&D is largely carried out by global PV manufacturers, and as the price of solar panels continues to plunge, the companies that attracted VC/PE investment were in the main not technology developers, but rather those whose business models are designed to cope with changing conditions of the solar market in developed countries such as the US, or to bring off-grid power to the 1.2 billion people in developing countries who have no access to electricity.

Sunnova was the biggest fundraiser by far. The residential solar installer, which is headquartered in Texas and operates in more than 20 US states, raised $428 million through three private equity rounds, including a single investment of $300 million from Energy Capital Partners. These and other deals have taken Sunnova's cumulative equity and debt funding to $1.5 billion.

Sunnova continued to attract investment in spite of torrid market conditions in the US, where the big incumbent installers such as SunCity, Sunrun and Vivint are experiencing slower growth, and whose share price performance has been described as the 'solarcoaster'. These companies expanded quickly by leasing solar panels to homeowners, protecting customers from high up-front costs. But because the price of panels has fallen by around 80% over the past five years – and continues to plunge – it may now be cheaper to borrow to buy the panels outright than to take on a lease. Sunnova is one of a number of companies that offer loans that allow customers to own their panels in as little as five years. The company's main investor last year, Energy Capital Partners, estimates that only 1% the US market for rooftop solar has been penetrated so far.

Solar Mosaic is another US company that was early to recognise the value of loans over leases. It secured $220 million in Series B funding organised by Warburg Pincus in August 2016. The company operates a peer-to-peer online platform that links individual and institutional investors with residential solar customers, and arranges the installations through a network of more than 20 independent dealers. Solar Mosaic offers only loan financing, and at the time of its fundraising, said it would write around $1 billion in solar loans over the following year.

Another large solar Series B deal, worth $90 million, was secured by Nova Lumos, a Dutch company operating in Nigeria, which provides pay-as-you go solar power to customers who live beyond the reach of the electricity grid. The company supplies a kit comprising a solar panel, control unit with several sockets, mobile phone charger and LED lights. The customer unlocks the system by making regular payments by SMS message. Taken together, the Solar Mosaic and Nova Lumos deals made up more than four-fifths of the growth in Series B funding in 2016.

Nova Lumos is one of many companies operating the same business model in developing countries, including M-Kopa, Off-Grid Electric, d.Light and Mobisol. By the autumn of 2016, the sector had raised more than $360 million in total and served about 700,000 customers. This is a tiny fraction of an addressable market of some 1.2 billion people

without access to electricity, and the companies will need to raise billions of dollars in debt to fund their expansion.[39]

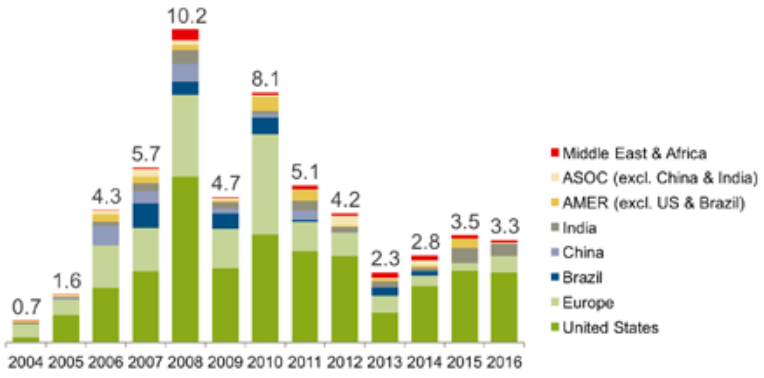
Bboxx was another pay-as-you-go off-grid solar provider to secure funding in 2016, through a Series C deal worth $20 million. The company is British and operates mostly in Kenya, Rwanda and Burundi, but plans to use the funds to expand into West Africa. The deal was noteworthy because the investor was Engie (formerly GDF Suez) through its stand-alone venture arm Rassembleur d'Energies, and was the utility's first move towards its goal of becoming a player in off-grid solar.

OTHER SECTORS

Wind secured the second largest tranche of investment, and here too there was evidence of innovative business models – or at least newly imported from the solar sector. Whereas wind development has so far been almost entirely at the utility scale, the American company United Wind installs small-scale turbines of 10kW-100kW and leases them to farms and rural businesses, which can consume the electricity or sell it back to the grid in states that allow net metering. The company secured $25 million in Series C venture capital, and then a further $142 million in private equity, and now counts both Tokyo Electric Power and oil giant Total among its investors. United Wind plans to use the new funds to expand from existing markets in New York, Colorado and Kansas to new markets in Minnesota, Iowa and Montana.

The largest wind deal was done by Greenko Energy of India, which secured $230 million in private equity from the sovereign wealth funds of Abu Dhabi and Singapore.[40] The independent power producer, based in Hyderabad, which has a generating portfolio of around 1GW of wind, small hydro and other renewables, aims to triple its capacity by 2020. The company also has around $800 million in debt.

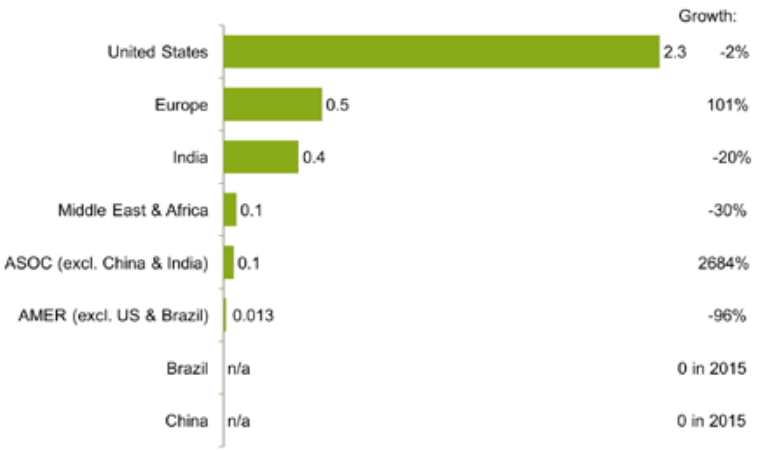
FIGURE 52. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY REGION, 2004-2016, $BN



Buy-outs are not included as new investment. Total values include estimates for undisclosed deals

Source: Bloomberg New Energy Finance, UN Environment

FIGURE 53. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY REGION, 2016, AND GROWTH ON 2015, $BN



Buy-outs are not included as new investment. Total values include estimates for undisclosed deals

Source: Bloomberg New Energy Finance, UN Environment

[39] Bloomberg New Energy Finance, Research Note, How can pay-as-you-go solar be financed?

[40] Bloomberg New Energy Finance, H2 2016 India Market Outlook.

Biofuels slumped 60% to $254 million, with only three deals of any significance, as the sector continued to struggle with low oil prices and the tribulations of the US RFS2 biofuel regulation and the "ethanol blend wall". The blend wall results from the refusal of some manufacturers to honour warranties if their vehicles have run on a blend of more than 10% ethanol, and as a result the US Environmental Protection Agency (EPA) has slashed its 2017 targets for cellulosic ethanol – the advanced biofuel made from non-food feedstocks.

Against this backdrop, Calysta Energy, which is developing an advanced biodiesel, raised $30 million in Series C funding; Fulcrum BioEnergy, the waste gasification company, secured the same amount in a late-stage VC, or 'pre-IPO' round; and Agrivida, the crop and enzyme developer, attracted $20 million. All three of these companies are US-based.

REGIONAL MIX

The geography of VC/PE investment remained broadly unchanged in 2016, as shown in Figures 52 and 53. If anything, US dominance has increased in recent years, even though investment there slipped by 2% last year. That country's share of total VC/PE investment edged up from less than 65% in 2014 to almost 69% in 2016, well above its long-term average of 52%. By contrast, although investment in Europe doubled year-on-year to $516 million, its share of 16% was well below its long-term average of 26%.

Among other regions, venture capital and private equity players played only an occasional role in 2016, as they have over the 13 years shown in Figure 52. India saw equity commitments slip 20% to $394 million, while both Asia outside China and India, and the Middle East and Africa, saw VC/PE investment of between $50 million and $100 million.

RESEARCH AND DEVELOPMENT

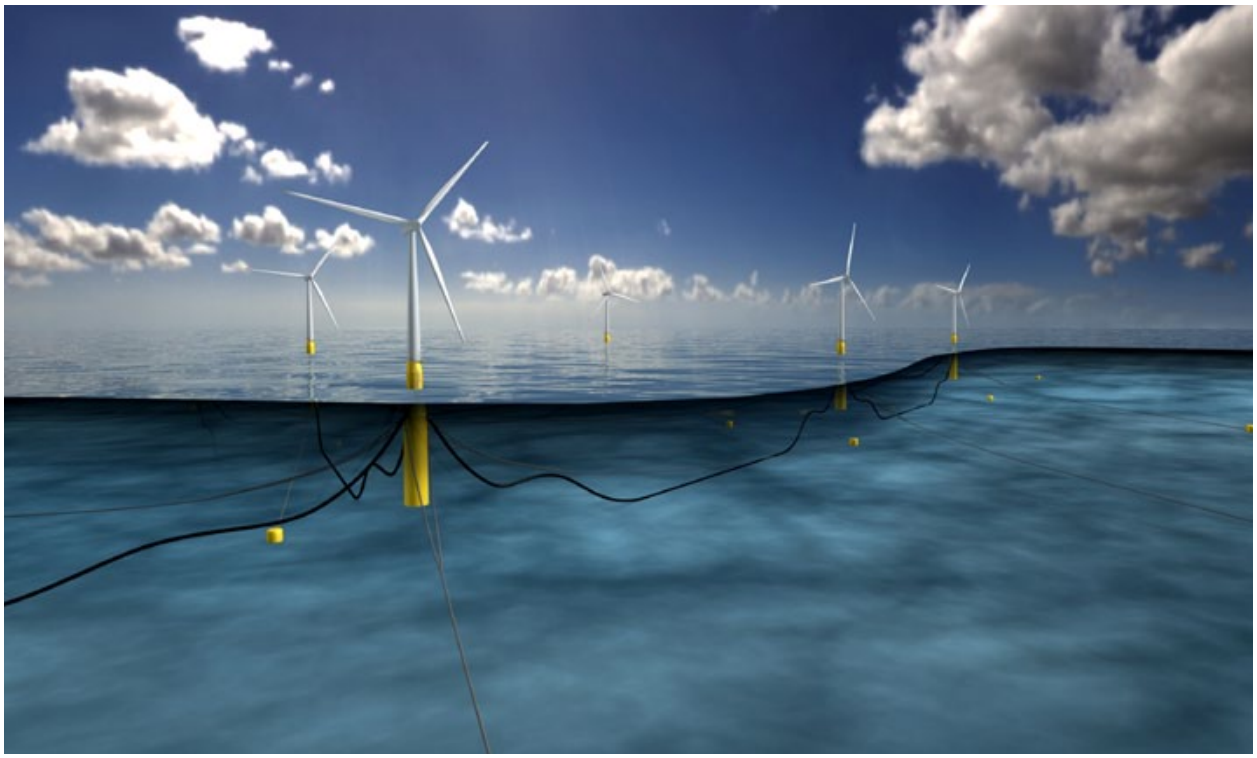
- Investment in research and development in renewable energy fell by 7% in 2016 to $8 billion, 14% below its peak in 2011.
- Corporate R&D slumped by almost 40% last year as wind and solar manufacturers retrenched. But estimated government spending on renewables research increased by 25% to a record $5.5 billion, breaking a three-year losing streak.
- Solar R&D investment fell by 20% to $3.6 billion and wind dropped 13% to $1.2 billion. Biofuels managed a gain of 11% to $1.7 billion in spite of low oil prices and a challenging regulatory environment.
- Europe remained the biggest regional investor in R&D, in spite of an 8% fall to $2.2 billion. China's investment slipped 2% to $2 billion but stayed well ahead of the US, where spending rose 13% to $1.5 billion.

At the start of 2016, the prospects for R&D investment in renewable energy could hardly have looked better. Almost 200 countries had just signed the Paris climate accord, widely seen as a historic turning point that should assure trillions of dollars of investment in renewable energy over the coming decades. President Barack Obama had launched Mission Innovate, in which 20 of the world's richest countries committed to double their investment in clean energy R&D within five years. And Bill Gates had founded the Energy Breakthrough Coalition, a group of high-profile investors backing early-stage innovation with reported initial funding of $2 billion. The US Congress had unexpectedly extended subsidies for wind and solar until 2020, and in India, Prime Minister Narendra Modi had committed his country to install 100GW of solar by 2022.

FIGURE 54. R&D INVESTMENT IN RENEWABLE ENERGY, 2004-2016, $BN

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

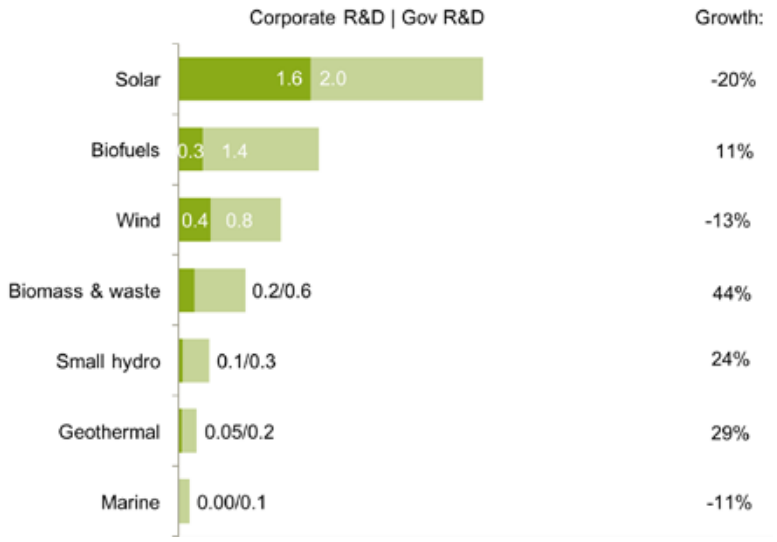
Yet in 2016, total investment in renewable energy R&D fell 7% to $8 billion, as shown in Figure 54, in what appears to be a continuing bumpy retreat from its peak of $9.3 billion in 2011. Last year's decline was caused by a 40% fall in corporate R&D spending, comprising big reductions in corporate R&D in solar (down 39%), wind (down 52%) and biomass and waste (down 50%), as shown in Figure 55.



Among the major regions, total R&D investment in the US rose 13% to $1.5 billion, while that in Europe fell 8% to $2.2 billion, and that in China slipped 2% to $2 billion, as shown in Figure 56.

The decline in renewable energy R&D would have been much larger but for a 25% increase in government spending, perhaps a sign that Mission Innovation signatories (Australia, Brazil, Canada, Chile, China, Denmark, France, Germany, India, Indonesia, Italy, Japan, Mexico, Norway, South Korea, Sweden, United Kingdom, United States, United Arab Emirates and, surprisingly, Saudi Arabia) are beginning to make good on their commitment. If they keep it up, R&D on renewable energy by governments alone could perhaps reach $10 billion by 2020. The future of US commitment to Mission Innovation is unclear, following the change of administration in Washington in January 2017.

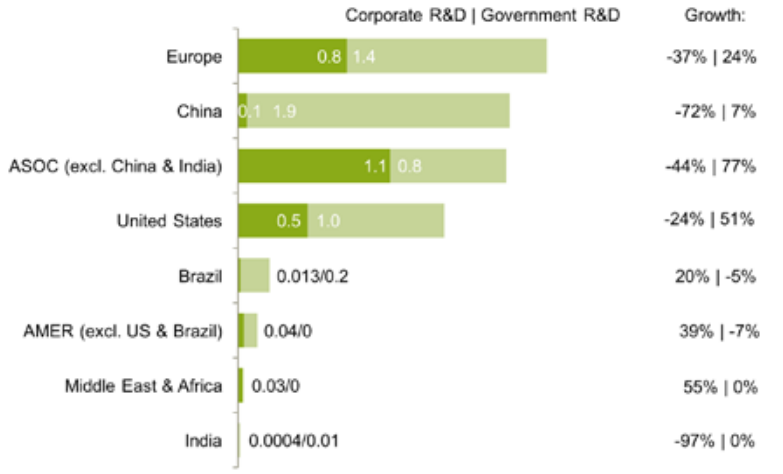
FIGURE 55. CORPORATE AND GOVERNMENT RENEWABLE ENERGY R&D BY TECHNOLOGY, 2016, AND GROWTH ON 2015, $BN



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

The slump in corporate investment came in spite of ample evidence that R&D works. In solar, this took the form of plunging power prices for new projects around the world. Records tumbled in quick succession from 64 US cents per kWh in Rajasthan, India, through Peru, Mexico, UAE, Morocco and finally Chile, where the agreed price was an astonishing 29 cents per kWh.

FIGURE 56. CORPORATE AND GOVERNMENT RENEWABLE ENERGY R&D BY REGION, 2016, AND GROWTH ON 2015, $BN



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

At these prices – and wind power was not far behind – renewable energy has started not simply to compete with fossil fuels but to undercut them without subsidy in much of the world.

This milestone has been achieved partly by years of investment to reduce the cost of renewable generation, and partly by fierce competition among developers for power deals and among manufacturers for module deals – the latter recently intensified by overcapacity. This has squeezed companies' margins, which no doubt explains much of the reduction in R&D spending in 2016. But many of the recent bids assume a couple of years' future efficiency improvements before the project gets built, so manufacturers will soon have to redouble their R&D spending to stay competitive.

SOLAR

In solar, some significant advances continue to work their way through the industry. For example, the introduction of diamond wire saws to slice multicrystalline silicon ingots into wafers can reduce the amount of silicon required for each wafer by as much as 17%. Only 2% of multicrystalline wafer production used this method in 2016, but analysts at Bloomberg New Energy Finance (BNEF) expect that by 2020 all production will have been converted. Manufacturers will also continue to shave costs by reducing the amount of silver used in electrical components, and investing in fluidised bed reactors to produce silicon more cheaply.

Manufacturers can increase the efficiency of crystalline solar cells by adopting a newer design known as passivated emitter rear contact (PERC), which increases energy output by 4% but adds only two steps to the production process. Other novel designs increase efficiency even more, but at greater expense. BNEF analysts expect PERC's share of production to rise from 6% in 2015 to more than 60% in 2018, helping to raise average crystalline silicon cell efficiency from 18.4% in 2015 to over 22% in 2025.[41]

These kinds of measures reduced the cost of an entire solar panel, or module, by 30% in 2016, and BNEF forecasts prices will fall further this year, perhaps to as little as $0.32 per Watt for standard multicrystalline silicon modules. Indeed, so successful has the industry been in reducing the cost of crystalline silicon modules that other technologies are struggling to compete. Thin-film modules, for example, once vied for dominance on the basis of lower production costs, but have now been undercut and reduced to niche applications and projects where the manufacturer is also the engineering contractor and developer. Of total photovoltaic production of 73GW in 2016, crystalline silicon captured 69GW and thin film just 4GW.

That is not to say that crystalline silicon will always have everything its own way, or that the days of fundamental breakthroughs in solar are over. Many researchers are convinced that the next major development will come from perovskites – a class of materials with the same crystal structure as calcium titanium oxide – which they believe could deliver major improvements in efficiency and cost. Named after the Nineteenth century Russian count who discovered the original mineral, perovskites can be manufactured using simple chemistry, unlike silicon, which can only

[41] https://www.bnef.com/core/insight/12330/view

be produced at extremely high temperatures in a vacuum. Experimental cells made from perovskites have increased in efficiency from less than 4% in 2010 to more than 20% in 2016, which makes this the fastest developing solar technology ever. "The rate of progress in the lab has been astounding," according to Jenny Chase, BNEF's head of solar research.

Perovskites also capture part of the light spectrum missed by crystalline silicon, raising the possibility of super-efficient hybrid cells. In May 2016, IMEC and Solliance reported they had produced a hybrid comprising a transparent perovskite cell stacked on top of a crystalline silicon cell, with a conversion efficiency of over 20%, and claimed this approach could eventually achieve 30% efficiency – compared to 24% for the most efficient silicon cells today. Other researchers have claimed hybrid cells might ultimately deliver 40% efficiency.

The industry is now racing to commercialise perovskite cells, pitting industry giants such as Trina Solar against thin-film producers First Solar and Solar Frontier, the Korea Research Institute of Chemical Technology, and start-ups such as Oxford Photovoltaics, which in October 2016 raised $11 million to develop perovskite cells. Though interest in the technology is intense, experts suggest that it will be commercialised in "in five years at the earliest." It must also catch up with crystalline silicon technology, which has a 'learning rate' of more than 24%, or in other words, whose costs fall by almost a quarter with every doubling of capacity.

WIND

The wind sector also produced dramatic cost reductions in 2016, with a series of new record low bids for offshore projects during the year. First, Dong Energy set a new benchmark of EUR 72.7 per MWh in the Netherlands' 700MW Borssele I & II auction. Vattenfall won the next two auctions, Denmark's 350MW near-shore and 600MW Krieger's Flak, with bids of EUR 63.8/MWh and EUR 49.9/MWh respectively. Finally, in December, a consortium of Shell, Eneco and Mitsubishi won the Dutch 700MW Borssele III & IV auction with a bid of EUR 54.5/MWh.

These records were set by Danish and Dutch projects in shallow waters near to shore, but huge progress was also made in the UK, the world's largest offshore market. Here the cost of offshore wind power has fallen 32% since 2012, declining to an average levelised cost of electricity of GBP 97/MWh for projects approved in 2015-16, and beating an industry-government target of GBP 100/MWh four years early. A report published by the Offshore Wind Programme Board found most of the reduction had been achieved by technological advances, particularly the installation of larger turbines of 7-8MW, and that there is scope to make further progress through measures such as enhanced control systems. Several projects would incorporate 66kV array cables and distributed lightweight transformers, for improved performance and lower cost.

One important area of development is offshore foundations. So far most turbines have been mounted on monopiles or jacket structures adopted from the oil industry, but the industry is now experimenting with newer designs such as suction buckets. These are like an upturned bucket that sticks to the sea floor when the water inside it is pumped out, and are easier and quicker to install and remove, do less damage to wildlife and the environment, and require less steel, so reducing cost.

The industry is also developing floating turbines to push into deeper waters further out. These have so far typically been mounted on spar, semi-submerged or tension leg platforms, also adopted from the oil industry. The technology has been given a boost by a recent French tender, which awarded contracts to two consortia comprising Eolfi and CGN, and Engie, GE and Principle Power. Each consortium will build 24MW of floating capacity made up of four 6MW turbines. BNEF analysts expect that by 2020, the total capacity of floating wind turbine projects in progress will reach 96MW.

Most wind R&D is carried out by big industrial players, but there are still some smaller companies pursuing interesting alternative approaches. One such is Spinetic Energy, a British start-up founded in 2013 to commercialise a radical concept in community-scale wind generation, intended to make wind as modular and cheap as solar PV. The problem, says Spinetic, is that while solar has achieved economies of scale through mass production, wind has done so by massively increasing the size of individual turbines – the world's biggest now measure more than 700 feet from blade tip to sea level. Conventional horizontal axis turbines cannot be both small and cost-effective, and this excludes them from some potential markets.

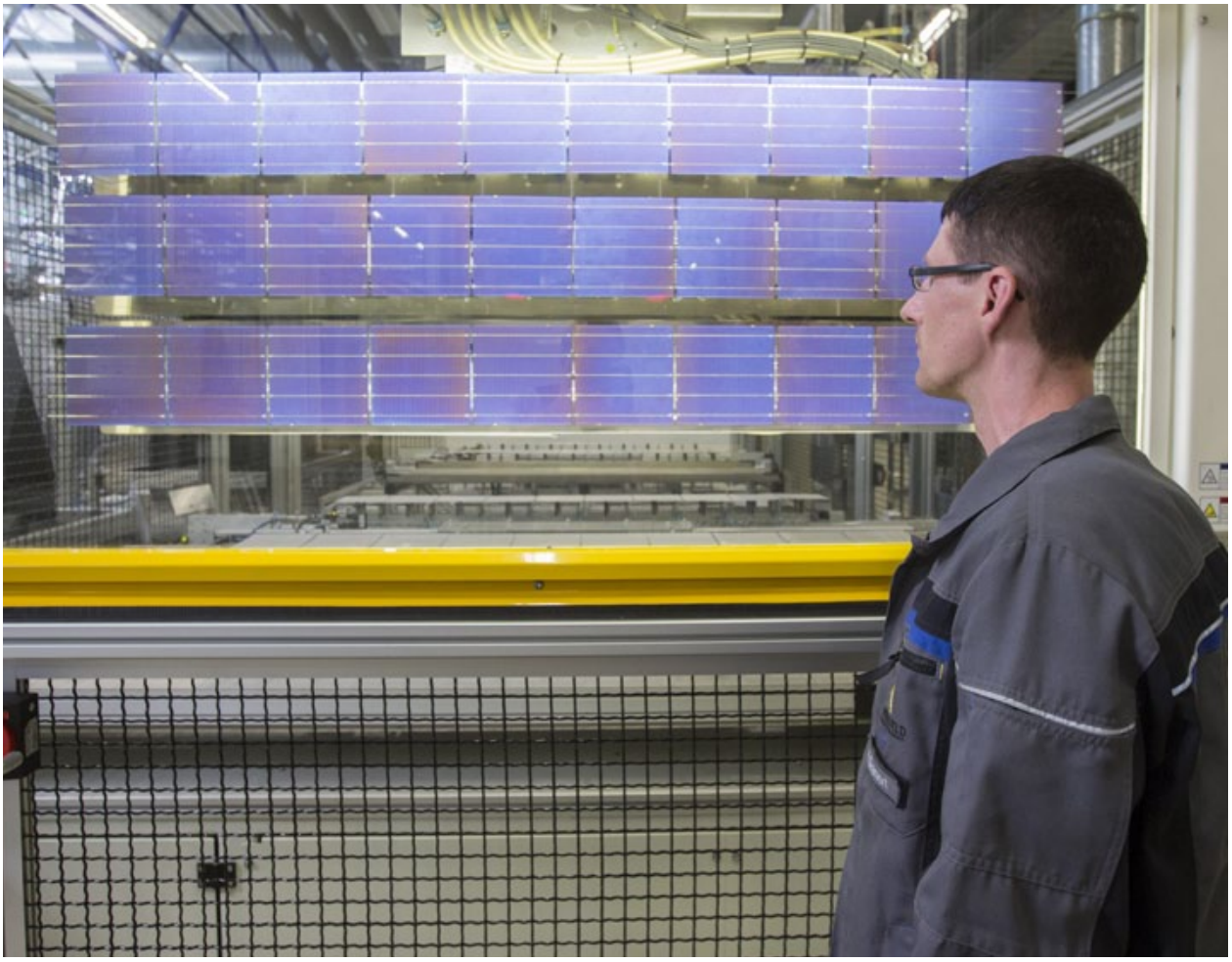
Spinetic's approach has been to develop a 'wind panel' of five 2-metre-high vertical wind turbines mounted in a lightweight aluminium frame, itself raised 5-10 metres above ground level. This is high enough to be out of reach of people and animals, and to ensure exposure to reasonable wind speeds, yet low enough to be far less obtrusive than conventional turbines. Each blade drives its own small generator, and each panel would be capable of generating 500W-1kW. The panels would be easy and quick to install and could be linked to form a long fence of generators. Spinetic says this arrangement could be incorporated into community-scale hybrid micro-grids in both developed and developing countries, meaning the world's 1.2 billion people without access to electricity could be served by wind as well as solar.

SMALLER SECTORS

Biofuels was the only large sector to increase R&D spending, up 11% to $1.7 billion, in spite of low oil prices and a dispiriting regulatory backdrop. In Europe, the EU scrapped its mandate to achieve 10% renewable energy in transport after 2020 and replaced it with a weaker set of targets. BNEF analysts believe this will lead to 28% of EU ethanol plants and 50% of biodiesel plants being decommissioned – "effectively giving up on first-generation biofuels". To fulfill the new target of 3.6% renewable energy in transport would require the construction of 170 next-generation cellulosic ethanol and diesel plants, if the necessary investment can be found.[42]

In the US, biofuels continued to struggle with the contradictions between the RFS2 biofuel mandate, with its volumetric production targets, and the "ethanol blend wall" resulting from manufacturers' refusal to honour warranties if their vehicles have run on a blend of more than

[42] Bloomberg New Energy Finance, Research Note, EU winter package: renewables, biofuels & transport.



10% ethanol. As a result, the US Environmental Protection Agency (EPA) was forced to slash its 2017 targets for cellulosic ethanol – the advanced biofuel made from non-food feedstocks.

One brighter spot was jet fuel, as FedEx, Jetblue, Alaska Airlines and Air BP signed (non-binding) agreements to buy aviation biofuels, and Air BP bought a $30 million stake in Fulcrum BioEnergy.

In marine energy, recent years have seen a series of upsets, particularly for wave technology developers. Several leading players went out of business in 2013-15, and the remaining, depleted field has found it hard to raise fresh venture capital funding. Nevertheless, in 2016 Finnish company AW-Energy raised EUR 10 million in loans from the European Investment Bank to develop further its WaveRoller technology, currently being demonstrated off the coast of Portugal. Australian companies Carnegie Wave Energy and BioPower Systems have been awarded government grants to develop demonstration projects off Western Australia and Victoria respectively.

The other fledgling, marine energy technology, tidal stream, has progressed further, with the first multi-MW demonstration projects being installed at MeyGen, off the north coast of Scotland, and at Paimpol-Brehat, off the French Brittany coast.

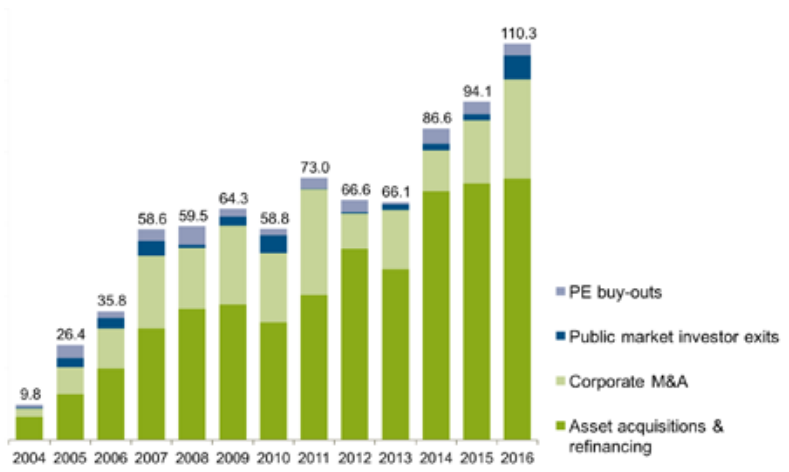
During 2016, Atlantis Resources, the company behind MeyGen, raised GBP 6.5 million via a share issue on London's Alternative Investment Market, while OpenHydro, involved at Paimpol-Brehat, raised EUR 47 million from its shareholders, led by French engineering group DCNS. Another turbine maker, Scotrenewables, was awarded a EUR 10 million grant from the European Commission's Horizon 2000 programme, in February 2016.

ACQUISITION ACTIVITY

- Acquisition transactions in renewable energy set a new record high for the third consecutive year, rising 17% to more than $110 billion.
- Growth was driven mainly by corporate mergers and acquisitions (M&A), which jumped 58% to $27.6 billion, and public market investor exits, which almost quadrupled to $6.7 billion – both new record highs.
- Asset acquisitions and refinancing remained the largest single category of acquisition activity, with deals worth $72.7 billion equating to 66% of the total, although the value of those grew by just 2% in 2016. Private equity buy-outs were also almost unchanged, down 2% at $3.4 billion.
- Wind retained its top spot in overall acquisition activity, with deals worth $62.3 billion, up 10% on 2015, but it is increasingly challenged by solar, which jumped 43% to $43.8 billion.
- In asset acquisitions and refinancings, the established regional giants were neck and neck again in 2016: US activity rose 14% to $29.2 billion, while that in Europe rose 8% to $28.6 billion. China grew 7% to $4.4 billion, but all other regions contracted.

While new investment in renewable energy shrank in 2016, acquisition activity enjoyed another bumper year. Total acquisition activity set a record high for the third year in a row, rising 17% in 2016 to $110.3 billion. The increase was driven by an upsurge in corporate M&A, which jumped 58% to $27.6 billion, as shown in Figure 57, and activity in the solar sector, which gained 43% to $43.8 billion (Figure 58). Public market investor exits were another significant feature, leaping 269% to $6.7 billion.

FIGURE 57. ACQUISITION TRANSACTIONS IN RENEWABLE ENERGY BY TYPE, 2004-2016, $BN

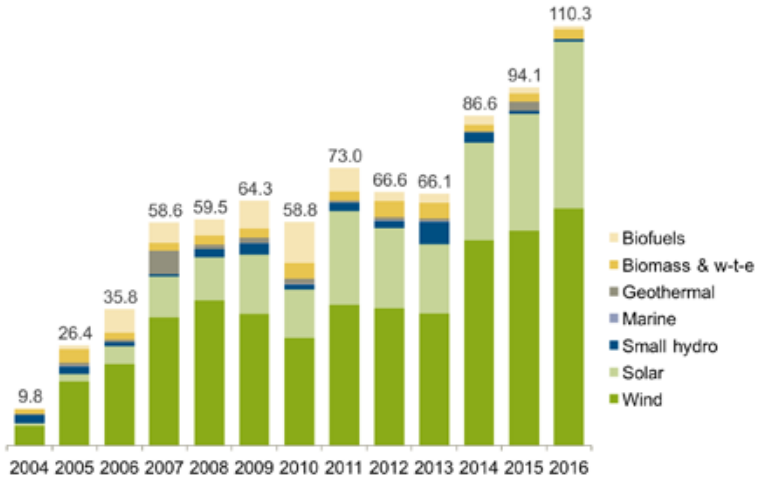


Total values include estimates for undisclosed deals
Source: Bloomberg New Energy Finance

There is logic to the strength of acquisitions activity despite weaker new investment levels. As the renewable energy sector gets larger, there is simply a bigger deck of assets to shuffle. As it matures, and grapples in places with overcapacity, there is a natural tendency to consolidate. And as the rate at which new wind and solar farms are built begins to slow, but demand to own assets persists, the deal rate should rise.

Demand from investors was indeed buoyant in 2016, as they sought refuge from chronically low bond yields in the stable, long-term returns offered by renewable generating assets, and appeared

FIGURE 58. ACQUISITION TRANSACTIONS IN RENEWABLE ENERGY BY SECTOR, 2004-2016, $BN



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

increasingly comfortable with technology risk. There was growing interest in mature portfolios, as utilities restructured and sold out to financial investors. And it is a sign of the strength of this corner of the renewable energy markets that activity grew in spite of the almost complete withdrawal of yieldcos from the fray for much of the year.

CORPORATE M&A

The year's most prominent feature was the surge in corporate M&A, which included two major deals that could have a profound impact on the corporate architecture of renewable energy. See Figure 59.

The highest-profile transaction was Tesla's controversial acquisition of SolarCity for an enterprise value of $4.9 billion, which accounted for almost half the growth in corporate M&A in 2016.[43]

Analysts panned Elon Musk's plan to combine two companies he controlled – being both chief executive and the largest shareholder of each. But in the end investors backed Musk's vision of a 'one-stop-shop' for clean energy, with a single company to supply customers with solar panels, battery storage and an electric car. Now all he has to do is deliver it – along with his other ambitious plans. Between launching the bid in June and sealing it in November, Tesla lost almost $5 billion in market capitalisation, more than the value of the bid, though by the end of the year it had recovered all of it.

The next largest deal was done by the Italian utility Enel, which bought out the 31% minority shareholders of its subsidiary Enel Green Power for $3.5 billion. Enel said the deal was necessary because the subsidiary was expanding more quickly than it could finance itself. But it might be truer to describe the move as a reverse takeover of the utility – at least in spirit. That is certainly how Enel's chief executive Franco Starace, who led the subsidiary from 2008 to 2014, saw it – describing the deal as "effectively…turning Enel into Green Power".[44] Starace also committed Enel to increase its planned investment in renewables by 29%,

FIGURE 59. LARGEST CORPORATE M&A DEALS IN RENEWABLE ENERGY IN 2016, $BN

Acquirer	Target	Country of target	Sector	Business model	$bn
Tesla Motors	SolarCity	United States	Solar	Service Company	4.9
Enel	Enel Green Power	Italy	Wind	Developer	3.5
State Power	Pacific Hydro	Australia	Wind	Developer	2.1
Five Seasons	China High Speed Transmission	Hong Kong	Wind	Equipment Manufacturer	2.1
Beijing Enterprises	EEW Energy from Waste	Germany	Biomass & Waste	Power Generator	1.6
Tata Power	Welspun Renewables Energy	India	Solar	Developer	1.4
Endesa Generacion	Enel Green Power Espana	Spain	Wind	Developer	1.3
Nordex	Acciona Windpower	Spain	Wind	Equipment Manufacturer	0.9
Tongwei	Tongwei Solar Hefei	China	Solar	Equipment Manufacturer	0.8
China Three Gorges	BCP Meerwind Luxembourg	Luxembourg	Wind	Service Company	0.7

Source: Bloomberg New Energy Finance

[43] Where companies buy a majority stake or an entire company, as Tesla did, Bloomberg New Energy Finance values the deal by its enterprise value, which includes the target company's debt. Where a company buys a minority stake, the deal is valued on the basis of the equity stake alone.

[44] Bloomberg New Energy Finance, 7 December 2015.

and phase out its thermal generation, including 23 coal-fired power stations that will be closed or converted to biomass. "We could become a very large integrated renewable energy company – something that today does not exist."

Wind dominated the rest of the top 10 largest M&A deals. These included the acquisition of Pacific Hydro, which despite the name has marginally more wind than hydro capacity in projects across Australia, Chile and Brazil, by the State Power Investment Corporation of China, for $2.1 billion; the takeover of Spanish turbine manufacturer Acciona Windpower by its German competitor Nordex for $864 million; and Endesa Generacion's $1.3 billion purchase of a 60% stake in Enel Green Power Espana. A British Virgin Islands-registered company called Five Seasons XVI took a 65% stake in gearbox maker China High Speed Transmission for $2.1 billion. The only solar deal among the top 10 other than SolarCity was the acquisition by Tata Power Renewable Energy of Welspun Renewables for $1.4 billion.

PUBLIC MARKET EXITS

The other main change to acquisition activity in 2016, the near quadrupling of public market investor exits to $6.7 billion, was also dominated by wind, and again featured two major deals that illustrate the increasing maturity of the sector. 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.

The biggest deal was Dong Energy's long-awaited IPO, in which its joint owners, the Danish government and Goldman Sachs, sold a 17% stake in an IPO on the Copenhagen Stock Exchange for just over $3 billion. The success of the flotation, which had been proposed and pulled repeatedly since 2004, shows investors are now comfortable backing a utility that is fundamentally committed to renewable energy. Dong has transformed itself from one of the most coal-intensive utilities in Europe to the world's biggest offshore wind operator. It plans to complete a further six offshore

wind farms by 2020, more than doubling its capacity to 6.7GW, according to the company's chief executive. About 80% of its investment will go to offshore wind, and all cash generated by its oil and gas business – which it has been trying to sell – will be invested in renewables. Within days of its IPO, Dong took its final decision to invest some $2 billion in a 450MW offshore wind farm in German waters, Borkum Riffgrund 2, using the latest MHI Vestas 8MW turbines.

The other significant deal was the flotation of Innogy, a company hived off by Germany's RWE to house its cleaner energy assets, as the success of renewables upended the conventional utility business model in Europe. A similar split was performed by E.ON. Innogy's IPO raised $5.2 billion, comprising $2.9 billion for its previous owners and $2.2 billion in new equity for a company that has around 3.6GW of renewable capacity, overwhelmingly wind and hydro, along with grid and gas assets. Again, the success of the flotation showed the willingness of investors to back a major reorganisation to reflect the new reality of European markets increasingly ruled by renewables.

Senvion's launch on Germany's Xetra Stock Exchange was not quite so happy. The turbine manufacturer's owners, the private equity firms Centerbridge Partners and Arpwood Capital, raised $287 million by selling shares through a private placement, less than half the value of a planned IPO they had been forced to pull, blaming market volatility.

PRIVATE EQUITY BUY-OUTS

A total of $3.4 billion changed hands as a result of private equity buy-outs in 2016, down 2% from the 2015 figure and more or less in line with the average seen over the last 10 years.

The largest deal in this category was Cerberus Capital Management's acquisition of Spanish solar, hydro and wind developer Renovalia Energy for an estimated $1.1 billion. Far behind was the second largest, Zhongshan Ruisheng Antai Investment's purchase of 67% of turbine maker China Ming Yang Wind Power for $258 million.

ASSET TRANSACTIONS

Asset acquisition and refinancing remained the largest category of acquisition activity, with deals worth $72.7 billion or two-thirds of the total, although growth was a modest 2%. Wind dominated here too, taking 13 of the top 20 deals, and almost 60% of their total value, at $41.6 billion. Analysts at Bloomberg New Energy Finance say that since the rate of onshore wind farm construction is slowing, but demand increasing, investors are scouting for older projects to buy. So between 2009 and the middle of 2016, more than a third of Europe's onshore wind capacity, around 50GW of 136GW, had changed hands. And tight competition among buyers means that new projects are increasingly being bought during the construction phase, another sign that institutional investors are now comfortable shouldering technology risk.

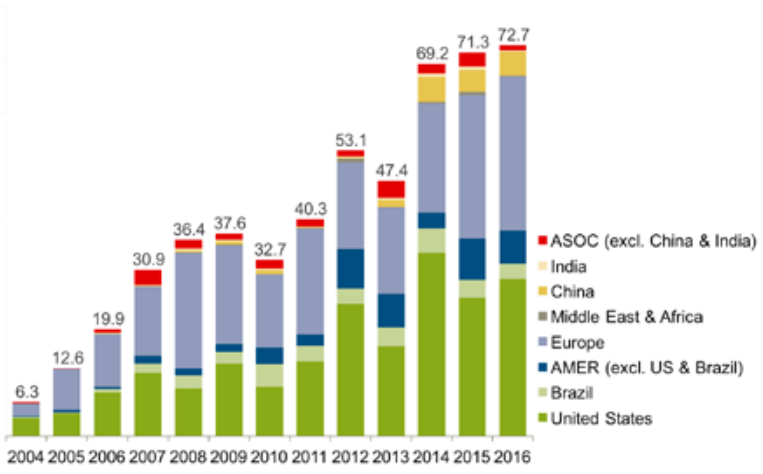
The biggest wind deal was the $2.2 billion refinancing of the Dudgeon East Offshore Wind Farm project in the UK. Owners Masdar, Statoil and Statkraft supplied $237 million in equity and secured $1.8 billion in senior debt. The 402MW wind farm was the first to secure financing under the UK's new Contracts for Difference scheme, and is due to start generating in late 2017.

The next largest deal was clinched by Macquarie Capital and Macquarie Infrastructure Fund 5, which bought a 50% stake in Dong Energy's 573MW Race Bank Offshore Wind Farm, also in UK waters, for $2 billion. Under the terms of the deal, Macquarie took on half the project's remaining construction costs, including cables connecting it to the shore.

The largest deal overall, however, was the refinancing of what was briefly the world's largest solar farm for $2.7 billion. The 586MW Sun Star project in California was developed by SunPower but is now owned by BHE Solar, a subsidiary of Warren Buffett's Berkshire Hathaway Energy. Sun Star has since been overtaken in size by a 648MW plant owned by Adani Green Energy in Tamil Nadu in southern India. See Chapter 5 for discussion of this project.

Four US solar deals were funded through 'tax equity', the system by which investors with large tax liabilities can reduce them by investing in solar projects. On this basis, First Solar raised $1.2 billion from General Electric and Goldman Sachs to refinance its 294MW Moapa solar farm; sPower secured $764 million from US Bancorp and PNC Financial Services Group to refinance its 191MW Beacon PV portfolio; SolarReserve won the agreement of a banking consortium to provide $750 million to refinance its Crescent Dunes solar thermal plant; and SunEdison raised $624 million from Bank of America to refinance its 156MW Comanche PV Plant, in a deal that was arranged before SunEdison's insolvency but which closed after it.

FIGURE 60. ASSET ACQUISITIONS AND REFINANCINGS BY REGION, 2004-2016, $BN



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

Among the larger of the outright acquisitions registered in 2016, the Copenhagen Infrastructure Fund bought the Tri Global Texas Copenhagen Wind Portfolio, comprising two projects with a total capacity of 510MW, for just over $1 billion, and in Mexico the gas pipeline company Infraestructura Energetica Nova paid Fisterra Energy and Cemex $852 million for their 252MW Ventika wind farm project.

Figure 60 shows the breakdown of asset acquisitions and refinancings by region. Of the $72.7 billion global total in 2016, some $29.2 billion took place in the US (up 14% on the year), and $28.6 billion happened in Europe (up 8%). The only other significant centres for activity were the Americas excluding the US and Brazil, at $6.1 billion (down 21%), and China, at $4.4 billion (up 7%).

GLOSSARY [45]

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.

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

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