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

GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2017

KEY FINDINGS

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JOINT FOREWORD FROM ERIK SOLHEIM, PATRICIA ESPINOSA AND UDO STEFFENS

ERIK SOLHEIM

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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

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"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."

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

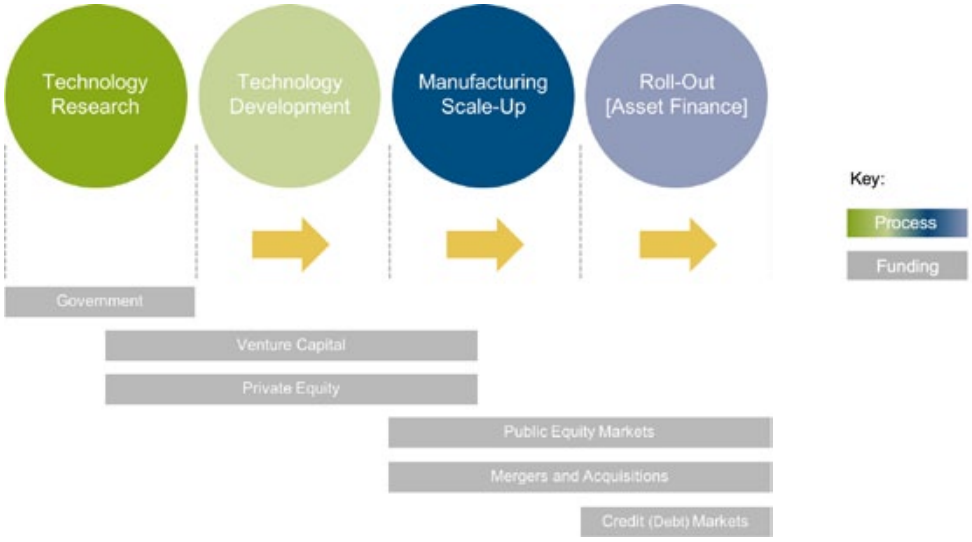
Bloomberg New Energy Finance tracks deals across the financing continuum, from R&D funding and venture capital for technology and early-stage companies, through to asset finance of utility-scale generation projects. Investment categories are defined as follows:

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.

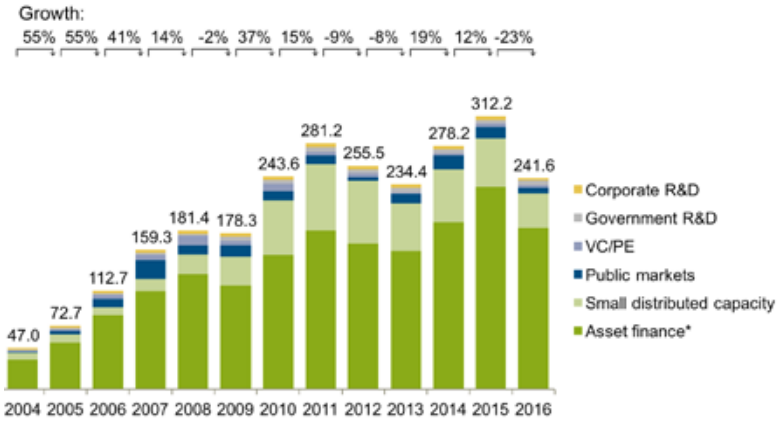
[1] Investment in large hydro-electric dams is not included in the headline figures in this report. Final investment decisions in this technology are estimated to have been worth $23.2 billion in 2016, down 48%.

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.

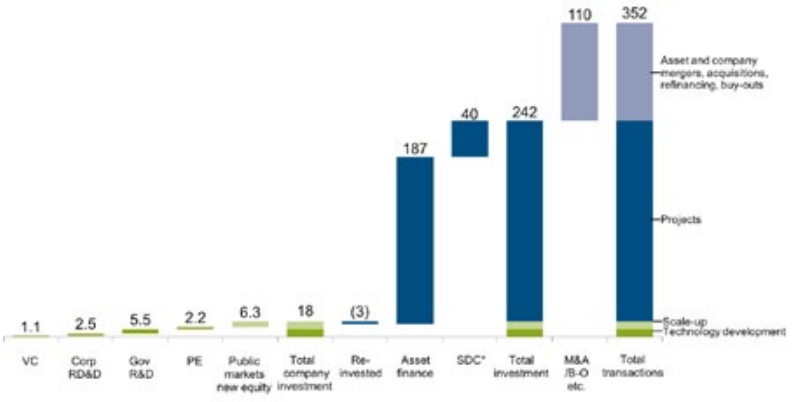
Finally, several up-and-coming renewable energy markets in the developing world produced record investment figures in 2015 but then saw sharp falls in 2016 in response to scheduled pauses, or delays, in their auction schedules. As Chapter 1 explains, South Africa, Mexico, Morocco and Chile – all $2 billion-plus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

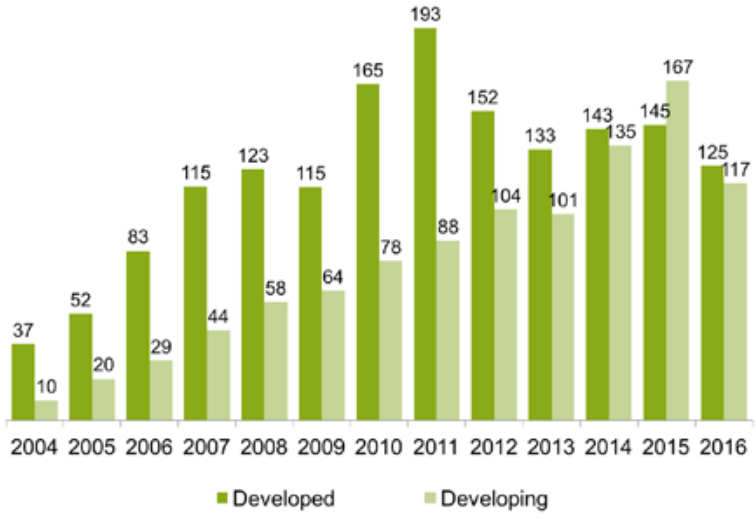
New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals
Source: UN Environment, Bloomberg New Energy Finance

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.

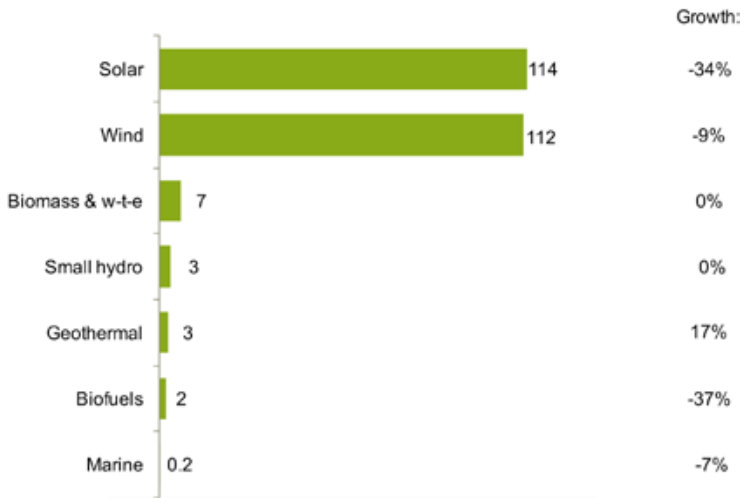
FIGURE 4. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY: DEVELOPED V DEVELOPING COUNTRIES, 2004-2016, $BN



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.

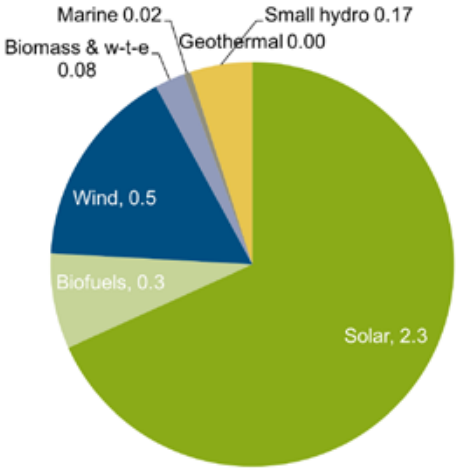
Figure 7 splits out public markets investment by sector in 2016. Overall, this fell 53% to $6.3 billion, partly due to a downturn in equity raising by 'yieldcos', or quoted funds set up to own renewable energy projects. Wind accounted for $4.3 billion of the public market activity, up 66%, while solar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

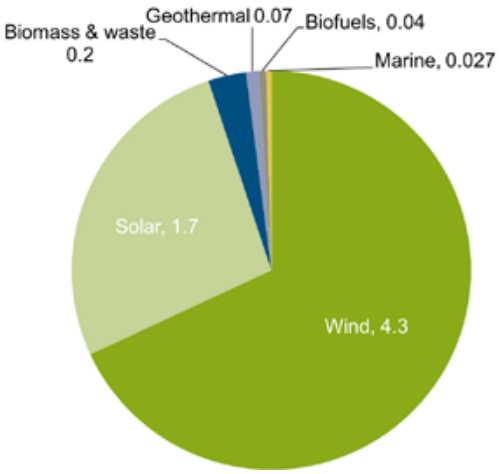
FIGURE 6. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2016, $BN



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

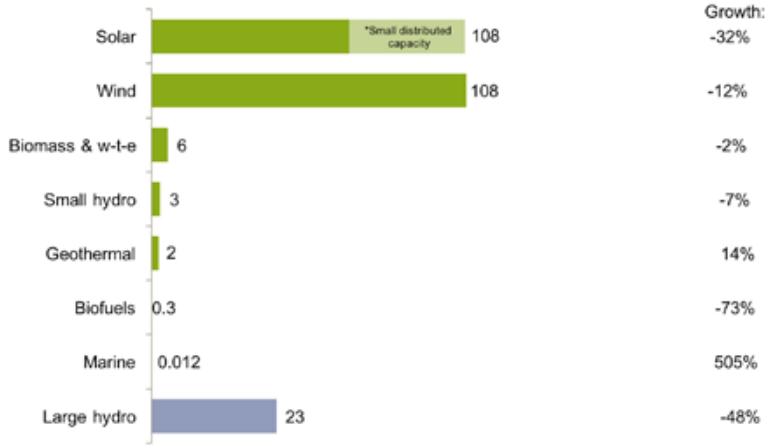


Source: UN Environment, Bloomberg New Energy Finance

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

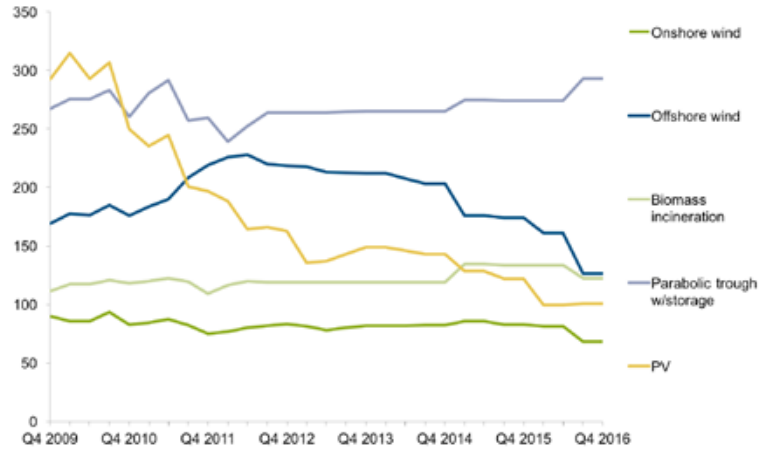
$101 per MWh, down 17% in just one year. Onshore wind's central levelised cost estimate was $68 per MWh in H2 2016, down 18% in a year, while that for offshore wind was $126, down 28%. Figure 9 shows that while electricity from PV and onshore wind have been getting cheaper and cheaper since 2009, biomass 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



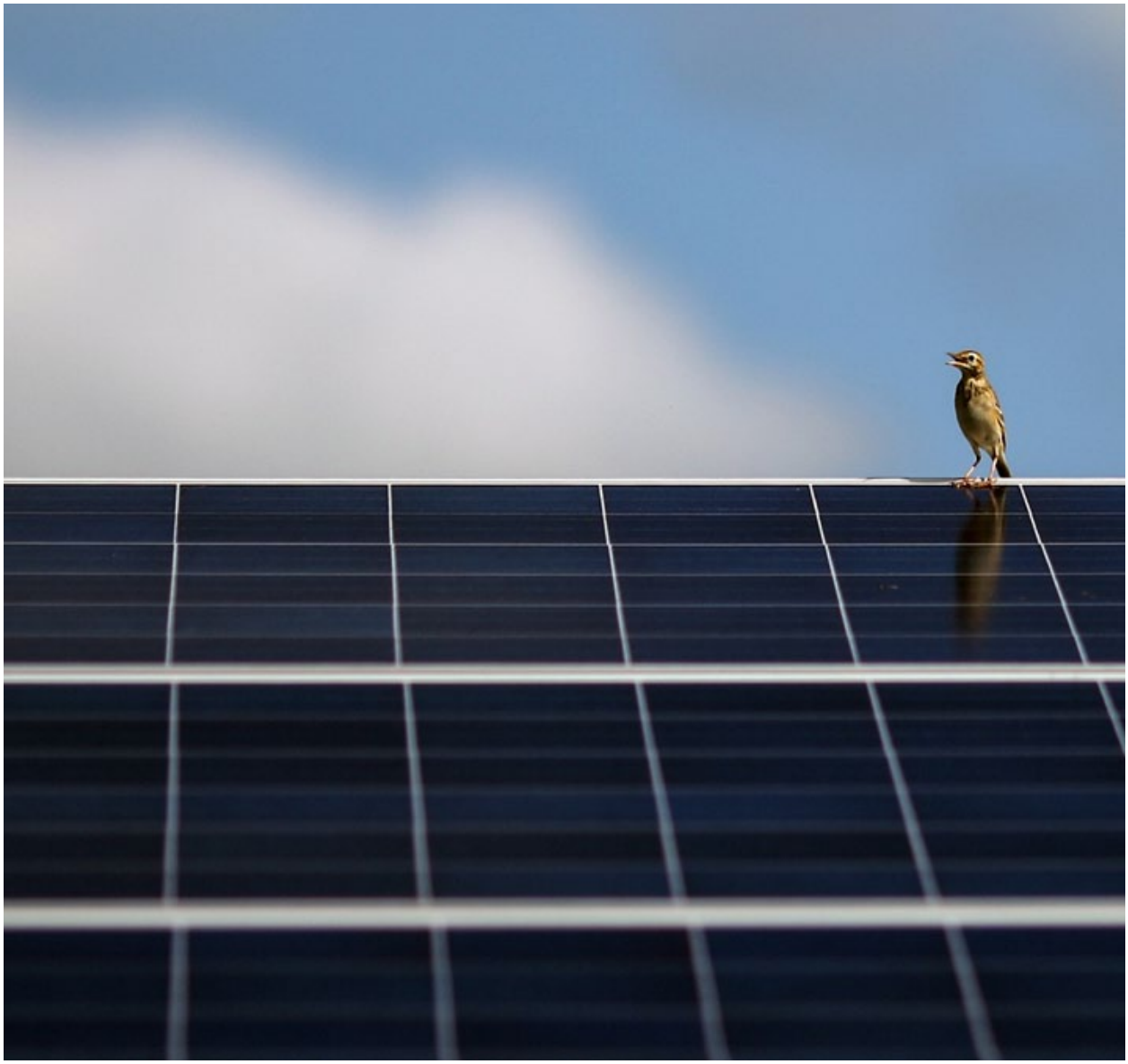
Solar thermal is parabolic trough with storage, PV is crystalline silicon with no tracking
Source: Bloomberg New Energy financea

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.

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