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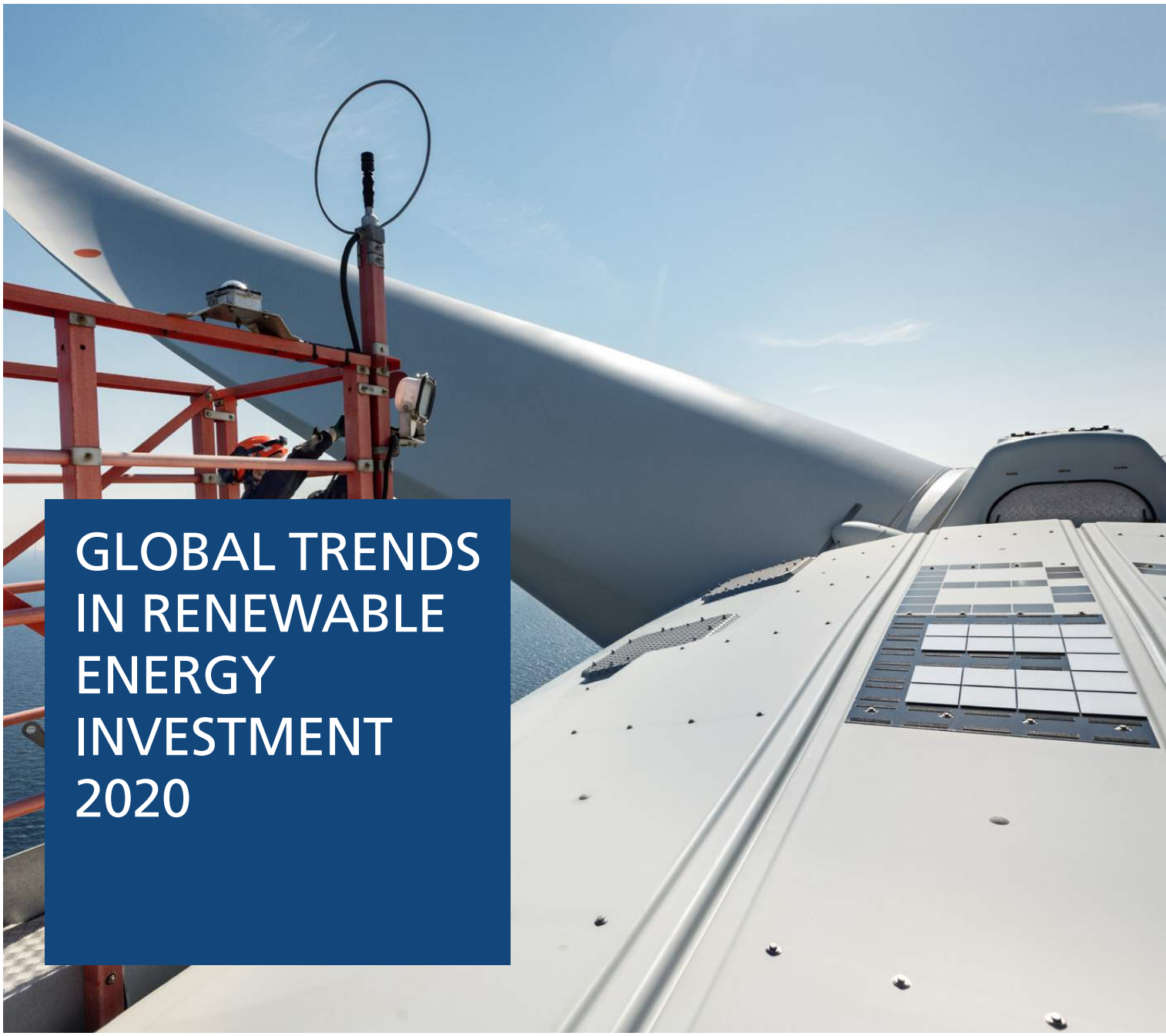

GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2020

UN environment programme

BloombergNEF

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CONCEPT AND EDITORIAL OVERSIGHT
Angus McCrone (BloombergNEF) (Lead Author, Chief Editor)
Ulf Moslener (Frankfurt School) (Lead Editor)
Francoise d'Estais (UNEP) (Lead Editor)
Christine Grüning (Frankfurt School)
Malin Emmerich (Frankfurt School)

CONTRIBUTORS
Tayo Ajadi (BloombergNEF)
Victoria Cuming (BloombergNEF)
Rohan Boyle
David Strahan
Matthias Kimmel (BloombergNEF)
Michael Logan

COORDINATION
Angus McCrone (BloombergNEF)

DESIGN AND LAYOUT
The Bubblegate Company Limited

MEDIA OUTREACH
Sophie Loran (UNEP)
Terry Collins
Veronika Henze (BloombergNEF)
Robert Leonhardt (Frankfurt School)
Vera Klopprogge (Frankfurt School)

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and Nuclear Safety

FOREWORD FROM INGER ANDERSEN, NILS STIEGLITZ AND JON MOORE

INGER ANDERSEN

Executive Director

UN Environment Programme

NILS STIEGLITZ

President

Frankfurt School of Finance and Management

JON MOORE

Chief Executive

BloombergNEF

It is nothing new to say that clean energy is better for the planet, and humanity, than energy derived from fossil fuels. Its benefits in avoiding greenhouse gas emissions, delivering cleaner air and bringing energy to marginalized communities are essential to a better future for all. What is new is that the world has a unique opportunity to accelerate clean development by putting renewable energy at the heart of Covid-19 economic recovery plans.

Governments will inject huge amounts of money into their economies as they look to bounce back from Covid-19 lockdowns, which have saved lives but stopped growth and cost jobs. This new report, *Global Trends in Renewable Energy Investment 2020*, shows that putting these dollars into renewables will buy more generation capacity than ever before, and help governments deliver stronger climate action under the Paris Agreement.

The report shows that renewable energy capacity, excluding large hydro, grew by a record 184 gigawatts (GW) in 2019. This was 20GW, or 12%, more than new capacity added in 2018. Yet the 2019 dollar investment was only 1% higher, at $282.2 billion. Meanwhile, the all-in cost of electricity continues to fall for wind and solar, thanks to technology improvements, economies of scale and fierce competition in auctions. Costs for electricity from new solar photovoltaic plants in the second half of 2019 were 83% lower than a decade earlier.

This is great progress, but there is room to do much more. Nations and corporations have made clean energy commitments over the next decade. Analyzing them in its focus chapter, the report finds commitments for 826GW of new non-hydro renewable power capacity by 2030, at a likely cost of around $1 trillion. However, these commitments fall far short of what is needed to limit the rise in global temperatures to less than 2 degrees Celsius under the Paris Agreement. It also falls short of last decade's achievements, which brought around 1,200GW of new capacity for $2.7 trillion.

This lack of ambition can be rectified in economic recovery packages. Simply repeating the investment of the last decade over the next would buy far more clean energy than it did before. The slump in the fossil fuel sector due to Covid-19, combined with the resilience clean energy has shown during this period, made it clear that clean energy is a smart investment.

If governments take advantage of the ever-falling price tag of renewables to put clean energy at the heart of Covid-19 economic recovery, instead of subsidizing the recovery of fossil-fuel industries, they can take a big step towards clean energy and a healthy natural world – which ultimately is the best insurance policy against global pandemics.

"The chorus of voices calling on governments to use their Covid-19 recovery packages to create sustainable economies is growing. This research shows that renewable energy is one of the smartest, most cost-effective investments they can make in these packages.

"If governments take advantage of the ever-falling price tag of renewables to put clean energy at the heart of Covid-19 economic recovery, they can take a big step towards a healthy natural world, which is the best insurance policy against global pandemics."

Inger Andersen, Executive Director of the UN Environment Programme

"Renewables such as wind and solar power already account for almost 80% of newly built capacity for electricity generation. Investors and markets are convinced of their reliability and competitiveness.

"The promotion of renewables can be a powerful engine for the recovery of the economy after the Coronavirus crisis, creating new and secure jobs. At the same time, renewables improve air quality thus protecting public health. By promoting renewable energies within the framework of Coronavirus economic stimulus packages, we have the opportunity to invest in future prosperity, health and climate protection."

Svenja Schulze, Minister of the Environment,
Nature Conservation and Nuclear Safety, Germany

"We see the energy transition is in full swing, with the highest capacity of renewables financed ever. Meanwhile, the fossil fuel sector has been hit hard by the Covid-19 crisis – with demand for coal- and gas-fired electricity down in many countries, and oil prices slumping.

"The climate and Covid-19 crises – despite their different natures – are both disruptions that command attention from policy makers and managers alike. Both crises demonstrate the need to increase climate ambition and shift the world's energy supply towards renewables."

Nils Stieglitz, President of Frankfurt School of Finance & Management

"Clean energy finds itself at a crossroads in 2020. The last decade produced huge progress, but official targets for 2030 are far short of what is required to address climate change. When the current crisis eases, governments will need to strengthen their ambitions not just on renewable power, but also on the decarbonization of transport, buildings and industry."

Jon Moore, Chief Executive of BloombergNEF

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METHODOLOGY AND DEFINITIONS

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

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

METHODOLOGY

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

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

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

This report does not cover larger hydro-electric dams of more than 50MW, except for brief mentions in Chapters 1 and 2.

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

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

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

This 2020 report contains revisions to a number of investment figures published in the 2019 edition of Global Trends in Renewable Energy Investment. Revisions reflect improvements made by BloombergNEF to its data during the course of the last 12 months, and also new transactions in 2018 and before that have since come to light.

DEFINITIONS

Investment categories in this report are defined as follows:

Capacity investment: all money invested in renewable energy generation projects, large or small. It covers both **asset finance** of utility-scale projects, whether from internal company balance sheets, from loans, or from equity capital, and the financing of **small-scale solar systems** of less than 1MW. The Focus Chapter and Chapters 1 to 4 of this report concentrate entirely on capacity investment.

Total renewable energy investment: this brings together capacity investment with the R&D, VC/PE and public markets categories listed below. It also incorporates an adjustment for **re-invested equity** (generally when money raised from VC/PE or public markets is then re-invested in renewable energy assets). The adjustment prevents double-counting. Total renewable energy investment is discussed in Chapter 5.

Research and development (R&D): all money invested in early-stage renewable energy technologies and techniques, whether financed out of government budgets or from the balance sheets of specialist renewables companies. This is discussed in Chapter 6.

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. This is discussed in Chapter 6.

Public markets: all money invested in the equity of specialist publicly quoted companies developing renewable energy technology and clean power generation. This is discussed in Chapter 6.

Acquisition activity: the value of existing equity and debt purchased by new corporate buyers, in companies developing renewable energy technology, or setting up or operating renewable power and fuel projects. It includes refinancing. Acquisitions are not included in total renewable energy investment because they represent money changing hands, rather than new money coming into the sector. They are discussed in Chapter 7.

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

REN21's annual Renewables Global Status Report (GSR) was first released in 2005. The Global Status Report is the sister publication to UNEP Global Trends in Renewable Energy Investment, and its latest edition will be released June 2020. The GSR grew out of an effort to capture comprehensively, for the first time, the full status of renewable energy worldwide. Over the years, the report has expanded in scope and depth, in parallel with tremendous advances in renewable energy markets and industries. The GSR is the industry standard on the status of renewables. The report is based on thousands of data points, hundreds of reports and other documents, and personal communications with experts from around the world.

KEY FINDINGS

- Governments and companies around the world have committed to adding some 826 gigawatts of new non-hydro renewable power capacity in the decade to 2030, at a likely cost of around $1 trillion. Those commitments fall far short of what would be needed to limit world temperature increases to less than 2 degrees Celsius. They also look modest compared to the $2.7 trillion invested during the 2010-2019 decade, as recorded by this Global Trends report.

- The Covid-19 crisis has slowed down deal-making in renewables in recent months, along with that in other sectors, and this will affect investment levels in 2020. However, governments now have the chance to tailor their economic recovery programs to accelerate the phase-out of polluting processes and the adoption of cost-competitive sustainable technologies.

- The stakes are high. If this chance is missed, it may be even more difficult to find the funding to decarbonize the energy system in a post-Covid-19 global economy characterized by elevated government debt and squeezed private sector finances.

- In 2019, the amount of new renewable power capacity added (excluding large hydro) was the highest ever, at 184 gigawatts, 20GW more than in 2018. This included 118GW of new solar systems, and 61GW of wind turbines.

- Falling costs meant that this record commissioning of green gigawatts could happen in a year when dollar investment in renewable energy capacity stayed almost flat. In 2019, renewable energy capacity investment was $282.2 billion, just 1% higher than the previous year.

- Capacity investment in solar slipped 3% to $131.1 billion in 2019, while that in wind climbed 6% to $138.2 billion – the first time that wind has outweighed solar in terms of dollars committed since 2010. Falling capital costs, and a further slowdown in China's PV market, held back the solar total.

- Investment in offshore wind hit its highest ever, at $29.9 billion, up 19% year-on-year thanks to a fourth-quarter surge, most notably in China but also in France – the first financial close in its offshore program – and the U.K. The year saw Taiwan secure its first three financings for sea-based arrays.

- The U.S. edged ahead of Europe in terms of renewables investment last year. The U.S. invested $55.5 billion, up 28%, helped by a record rush of onshore wind financings to take advantage of tax credits before their expected expiry, while Europe committed $54.6 billion, down 7%.

- Developing countries continued to outpace developed economies in renewables investment. In 2019, they committed $152.2 billion, compared to $130 billion for developed countries. But there was a shift in the mix, with China and India both slipping back, while 'other developing countries' jumped 17% to a record $59.5 billion. Included in the latter figure was the largest financing ever in the solar sector: $4.3 billion for the Al Maktoum IV solar thermal and photovoltaic complex in Dubai.

- Once again, renewables dwarfed conventional generation sources in terms of both capacity additions and investment. Nearly 78% of the net gigawatts of generating capacity added globally in 2019 were in wind, solar, biomass and waste, geothermal and small hydro. Investment in renewables excluding large hydro was more than three times that in new fossil fuel plants.

- Renewable technologies (excluding large hydro) raised their share of global generation to 13.4% in 2019, from 12.4% in 2018 and just 5.9% in 2009. That share is increasing slowly because of the large, established fossil fuel fleet. However, that amount of renewable electricity production last year was enough to prevent the emission of an estimated 2.1 gigatonnes of CO2.

- The all-in, or levelized, cost of electricity continued to fall for wind and solar, thanks to technology improvements, economies of scale and fierce competition in auctions. For solar PV, it stood in the second half of 2019 some 83% lower than a decade earlier, while the equivalent reductions for onshore and offshore wind were 49% and 51% respectively.

THE IMPACT OF 2030 TARGETS

- This Focus Chapter of the Global Trends report looks ahead to the new decade, and the additions in renewable energy capacity that are implied by official government targets and company voluntary targets. It compares those extra gigawatts with what would be required to bring global power system emissions into line with the need to limit climate change. It also looks at some specific targets to bring low-carbon alternatives into other parts of the energy system, such as heat and transport.
- Renewable energy 2030 targets already written into official policy by 87 governments around the world would mean the construction of an estimated 721 gigawatts of new capacity in wind, solar and other non-hydro renewable power technologies over the next decade, according to analysis by BloombergNEF.
- Meanwhile, those private sector companies that have joined the RE100 group, pledging to source 100% of their power from renewables, will need to buy an estimated 210 terawatt-hours of green electricity by 2030, on top of what they consume now, in order to be on track. This could prompt the construction of an estimated 105 gigawatts of new wind and solar plants.
- Taken together, these commitments by governments and companies would imply 826GW of new capacity. This could entail around $1 trillion of investment globally during the next 10 years, or an average of $100 billion per year.
- However, the targets above – and the implied investment – are only a fraction of what would be required to put the world on a path to reduce carbon dioxide emissions sufficiently to limit temperature increases to "well below" 2 degrees Celsius, as stated in the Paris Agreement. This message of a shortfall in ambition is in tune with the message of the latest UNEP Emission Gap report.[1]
- The 2030 targets are also modest compared to what has already been done. As shown in Chapter 1 of this report, in the decade 2010-2019, the world added 1,213 gigawatts of renewable power capacity (excluding large hydro-electric dams), investing nearly $2.7 trillion.

The beginning of a new decade provides an opportunity for the Global Trends report to feature this forward-looking chapter. True to the report's established role, the usual analysis of renewable energy investment in the year just past is contained in the subsequent Chapters 1 to 7.

This chapter looks at the amount of new renewable power capacity that will need to be built in the years up to 2030 to meet the official targets of governments around the world, and then at the additional amount implied by targets set by private sector companies. It then compares those numbers with what would be necessary to meet international climate goals.

[1] https://www.unenvironment.org/resources/emissions-gap-report-2019

The Focus Chapter takes a full 10-year view. It is written at a time when the coronavirus is hitting countries around the world, one after the other. The pandemic's direct economic effects will be severe in the short term, but are likely to fade as the decade unfolds.

Health imperatives have understandably diverted the attention of governments away from climate and decarbonization priorities, and COP26 due to be held in Glasgow in November 2020 has now been postponed to 2021. In the private sector, many investment deals in clean energy will take longer to complete this year than usual because of the difficulties of bringing participants together. And some company boards will be concentrating during 2020 on financial survival rather than longer-term sustainability.

However, the coronavirus outbreak may also have a more lasting influence on the energy transition. For instance, the focus on health and respiratory problems, and citizens' experience of cleaner air in world cities during 'lockdown' periods, could lead to stronger pressure on governments to phase out polluting power stations and modes of transport.

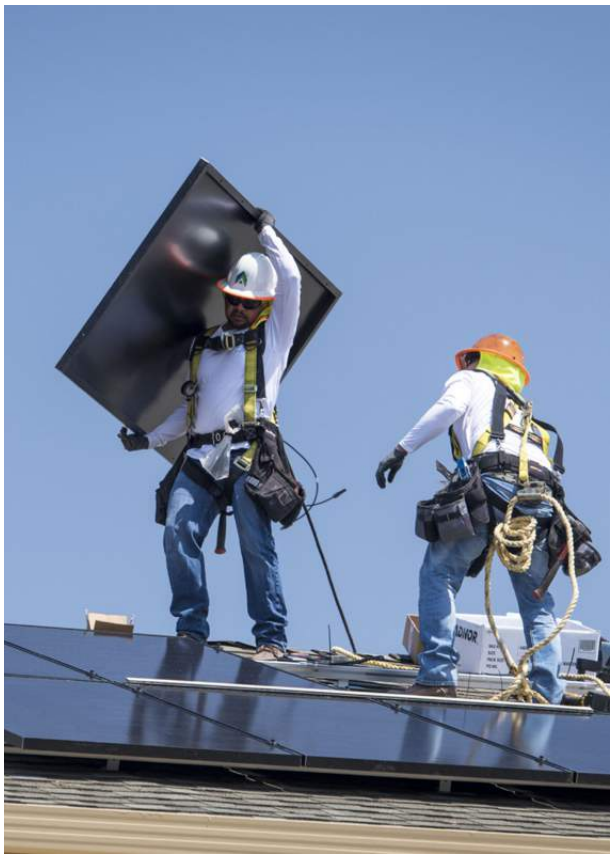
In addition, governments are likely to use stimulus programs to try to accelerate economic recovery, as they did in 2009 after the financial crisis. These programs could prioritize work that would "kill two birds with one stone" – boosting both economic activity and decarbonization, for instance by building electricity transmission lines to link renewables to the grid, or expanding charging networks for electric vehicles. Another option might be to include 'green conditionality' on the provision of support funds.

However, there is a risk of the opportunity being missed. Some governments could end up spending heavily on 'traditional', carbon-intense infrastructure, in so doing cramping their fiscal room to fund more climate-friendly investments later in the decade.

GOVERNMENT 2030 RENEWABLE ENERGY TARGETS

Governments around the world have written into official policy, or put into law, targets that would raise the amount of renewable power capacity installed by 2030. The figures, drawn from analysis by BloombergNEF,[2] indicate that some 721 gigawatts of wind, solar, biomass and waste-to-energy, geothermal and marine power plants would need to be built over the coming decade to meet those targets. How this compares to what was achieved in the 2010-2019 period, and to what is needed to curb emissions, is discussed later in this chapter, starting on page 17.

Note that this analysis of targets is not based on the Nationally Determined Contributions, or NDCs, as prepared by countries in the context of the Paris Climate Agreement of December 2015. Some of those aspirations have been translated into government policy statements or laws, but others have not. This chapter concentrates on what is written into official policy so far, and therefore has the clearest momentum behind it.



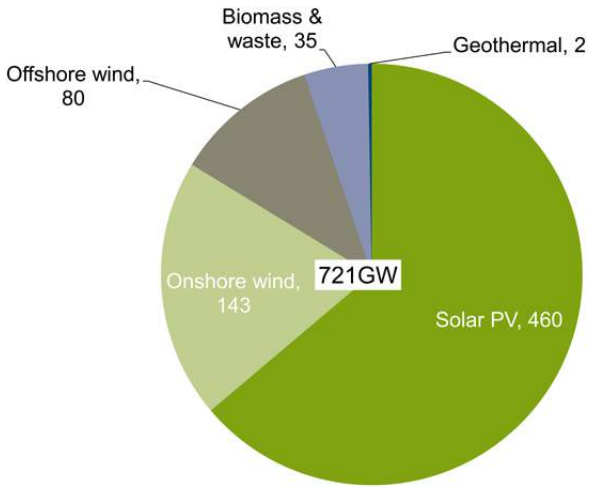
[2] The analysis covers 87 countries that have targets relating to 2030, or to earlier years. It does not seek to guess progress toward longer-term targets for years after 2030.

One clear message from Figure 1 is that governments as a whole have been more ambitious about setting targets for solar than they have for any other non-hydro renewable energy technology. This reflects the fact that three countries (China, India and Germany) would need to build a further 70GW, 68GW and 48GW respectively by 2030 or earlier, in order to meet their ambitious solar targets. The U.K., India and Germany would need to build 32GW, 30GW and 17GW respectively, to meet their offshore wind targets.

In addition, governments have official targets to install 488 gigawatts of hydro-electric capacity, large and small, by 2030. Large hydro-electric dams of more than 50 megawatts are outside the main scope of this report, although they are discussed briefly in Chapters 1 and 2. Smaller hydro projects are included in the report, but official government targets do not usually split out small from large hydro.

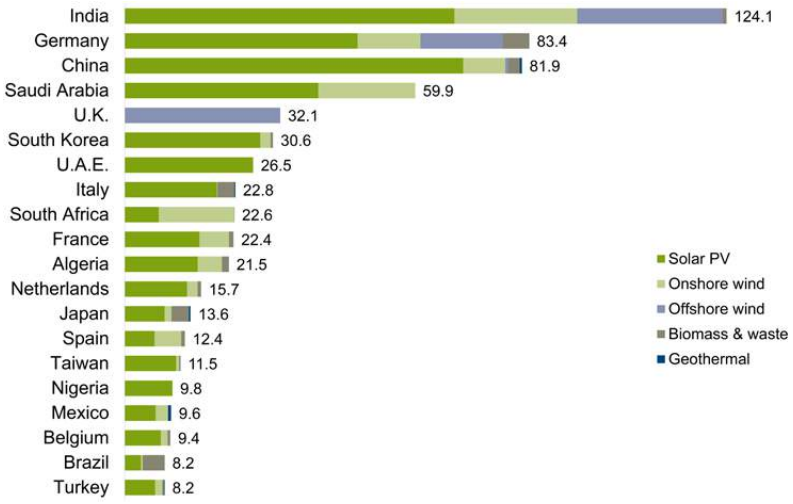
These targets for low-carbon power generation come from no fewer than 87 governments, representing both high-income countries that were early movers in green energy 10-20 years ago, and developing economies. Some of the latter are established backers of renewable power. Others have come to it more recently as a result of improved cost-competitiveness, and the climate change emergency.

FIGURE 1. RENEWABLE POWER ADDITIONS REQUIRED TO MEET GOVERNMENT TARGETS WITH DEADLINES BETWEEN 2020 AND 2030, GW



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 2. RENEWABLE POWER ADDITIONS REQUIRED TO MEET GOVERNMENT TARGETS WITH DEADLINES BETWEEN 2020 AND 2030, BY COUNTRY, GW



For targets based on electricity consumption or generation, the equivalent volume of capacity was devised, based on BloombergNEF's New Energy Outlook 2019 estimates for future demand and capacity factors for the relevant technologies.
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

Developed economies[3] account for just over two-fifths (297GW) of the new non-hydro renewables capacity implied by 2030 government targets around the world,[4] with the two most populous developing economies of China and India accounting for 206GW and 'other developing countries' for the remaining 219GW.

The latter category includes relatively modest targets for non-hydro capacity in 2030 in some economies that have invested significantly already, such as Brazil and Mexico, but also ambitious ones for relative newcomers to wind and solar, such as Saudi Arabia, the United Arab Emirates and Algeria. Figure 2 shows

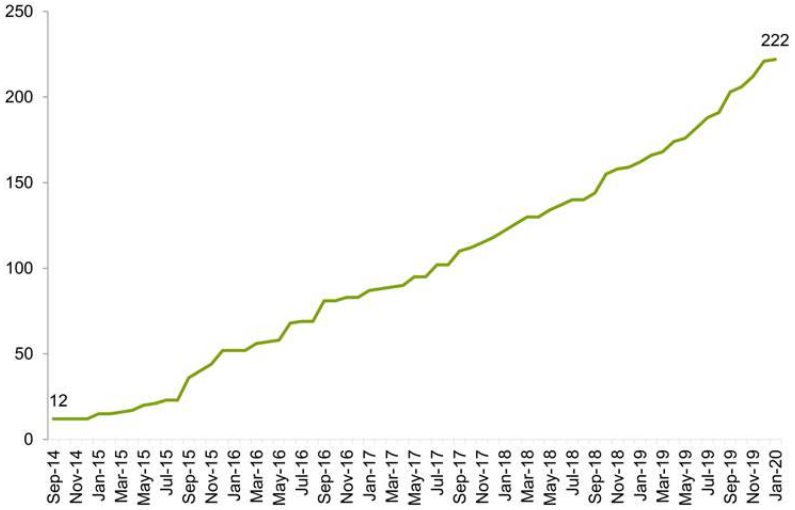
[3] On the definition used in this report (all OECD countries, except for Mexico, Chile and Turkey).
[4] Actual investment in 2019 by developed countries was close to this proportion, at 46% of the world total.

the top 20 countries by the size of their targeted non-hydro renewable power additions between 2020 and 2030. Note that the U.S. is not covered in Figure 2, because it has no national renewables deployment targets. Sub-national targets, such as the Renewable Portfolio Standards of certain U.S. states, are not included in the analysis in this Focus Chapter.

Many countries that built significant green power capacity in the 2010-2019 decade (see Figure 20 in Chapter 1) feature only modestly in the 2030 official targets. They may well end up adding far more renewables than the targets imply.

Equally, some of the countries that have set official policy targets for renewable energy in 2030 may not meet them. Or they may decide in the interim to amend policies in order to have different targets. However, legislated targets do provide an indication of intent as far as adding renewable energy over the decade is concerned.

FIGURE 3. GROWTH OF CORPORATE MEMBERS OF RE100



Data to end of January 2020
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

PRIVATE SECTOR RENEWABLE ENERGY TARGETS

It is not only governments that set targets for the decarbonization of the electricity system. Private sector entities can too, and more and more companies have been doing exactly that. Figure 3 shows the sharply rising trend in the number of corporations joining the RE100 group, which brings together organizations that have set a target to source 100% of their power from renewables by a particular date in the future.

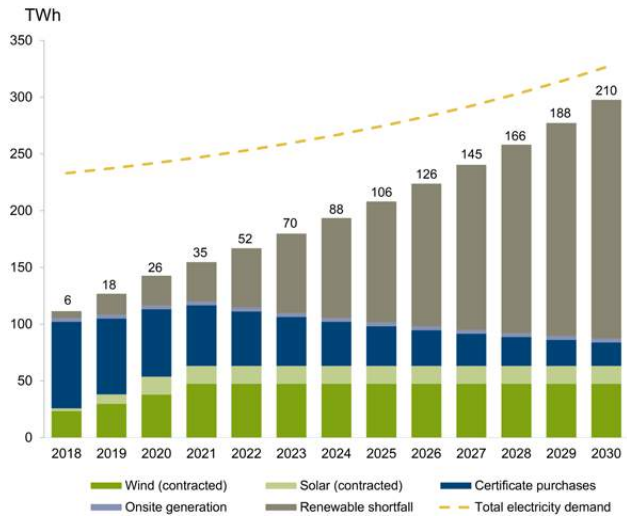
Prominent members of RE100 include Apple, Facebook and Microsoft, all of which have been prolific signatories of renewable energy power

purchase agreements,[5] but also a wide range of companies from countries as diverse as Japan, the U.K. and India. The list includes 19 of the 100 largest companies in the world by revenue.[6]

RE100 is just the tip of the iceberg, because many other companies have set targets for a lower proportion than 100% or have set no actual target but are actively seeking to raise the share of renewables in their energy mix.

Corporations are making these efforts in order to help demonstrate the sustainability of their business models, as well as for economic reasons.[7] One audience is customers, since many of these, particularly the young, may want to choose brands that are perceived as environmentally friendly. Another is investors, many of whom now have sustainability mandates or are putting pressure on corporate boards to improve their performance on ESG (environmental, social and governance) issues. A third is staff and potential recruits – many people prefer to work for a company that takes sustainability seriously.

FIGURE 4. PROJECTED RENEWABLE ELECTRICITY SHORTFALL FOR THE RE100, TWH



Certificate purchases are assumed to step down 10% each year. Onsite generation and contracted wind and solar purchases remain flat through 2030. Electricity demand and renewable electricity demand don't intersect in 2030, as some companies have targets extending out past 2030

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

Figure 4 looks at what is implied between now and 2030 by the commitments of existing RE100 members. BloombergNEF estimates that these RE100 members would need to source an additional 210 terawatt-hours (TWh) of green electricity by 2030. Meeting this 210TWh shortfall by 2030 could underpin 105GW of new solar and wind plant construction globally by 2030, if the current members relied solely on offsite solar and wind power purchase agreements (PPAs).[8] For context, this is more than the U.K.'s 101GW power fleet, and comes on top of 16.4GW of existing PPAs already signed by RE100 members.

It may be that the total new renewable energy capacity built as a result of RE100 commitments turns out to be even greater than this. For one thing, the number of companies signing up to RE100 has increased rapidly year-on-year, and could well continue to do so – raising the required gigawatts of extra wind and solar capacity. For another, RE100 members also have supply chains, with other companies selling them components, materials and services. Members are increasingly looking at moves to encourage, or even oblige, suppliers to 'go green' with their own electricity consumption.

There are inevitably a number of assumptions behind Figure 4. One is that the electricity consumption of these companies continues to increase at the same rate as in recent years, despite continuing efforts to improve energy efficiency; another is that they raise the renewable share of their electricity consumption in line to hit their 100% targets by their chosen end-date; a third assumption is that their method of doing so is by signing PPAs with renewable power providers, rather than by buying 'green certificates' on the market.[9] It is harder to argue that a company is causing new green power capacity to be built if they are merely buying green certificates, than if they are signing PPAs with to-be-constructed wind farms, solar parks or other green power plants.

[5] See Chapter 2, Figure 26 for aggregate statistics on corporate PPA activity.

[6] According to the Fortune Global 500 list.

[7] In many cases, also locking in long-term electricity prices that are lower than would have been the case a few years ago, because of the falls in the costs of wind and solar.

[8] Onsite renewables could also play a role but, for simplicity, they are not included in the estimate.

[9] Including Renewable Energy Certificates in certain U.S. states, 'el-certs' in Sweden and Norway, and Guarantees of Origin in other European countries.

INVESTMENT IMPLIED BY TARGETS

The estimates above, based on actual commitments by governments and companies, imply a total of 826GW of new non-hydro renewable energy capacity would need to be built between now and 2030.[10] The actual investment involved in building these gigawatts would depend on the mix of renewable energy technologies chosen (for example, offshore wind has a much higher average capital cost per megawatt than solar photovoltaics), on where the new capacity is located, and also on how the costs of those technologies evolve during the 2020s.

At 2019 global benchmark capital costs per megawatt, 826GW of new capacity might have an upfront capital cost of some $900 billion – if the technology split was 75:25 between utility-scale PV and onshore wind. Or $1.1 trillion if it was 70:20:10 between utility-scale PV, onshore wind and offshore wind.[11]

However, the consensus expectation is for the costs for all three of those technologies to continue to fall during the 2020s – not necessarily as spectacularly as they did in the decade just ended, but still appreciably, as manufacturing techniques improve further and (in offshore wind) even larger and more powerful machines are introduced.

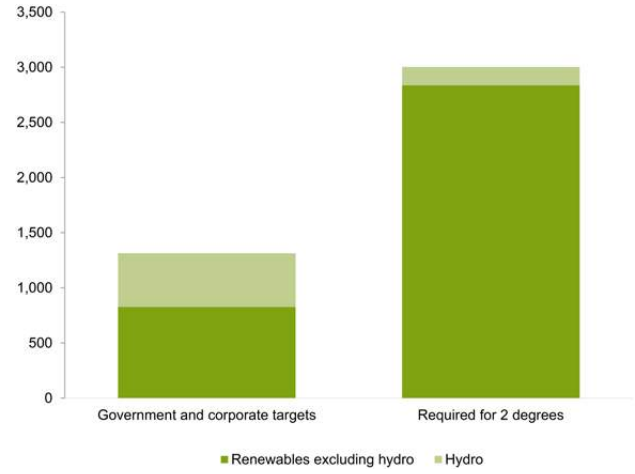
Both the amount of new capacity projected as a result of these commitments and the amount of investment (even at today's costs) look modest compared to what the world achieved in the 2010-2019 period. During that decade, as shown in Figures 14 and 19 in Chapter 1, some 1,213 gigawatts of renewable power capacity (excluding large hydro) were commissioned globally, and nearly $2.7 trillion invested.

The above estimates for additional renewables capacity resulting from public and private sector targets provide reassurance that the world will continue to invest in low-carbon generation (assuming that those organizations do not decide to abandon their targets). However, the implied 826GW of additional non-hydro renewable power capacity, plus the 488GW of extra hydro dams in government plans, would be far below estimates of what would be needed for the electricity system to contribute its share to achieving global climate goals (see Figure 5).

As part of the Paris Agreement in 2015 countries agreed to a common goal of limiting the rise in global temperatures this century to "well below" 2 degrees Celsius, with an aim of keeping the increase at 1.5 degrees. Even limiting the increase to 2 degrees would require the gross addition of some 2,836GW of new non-hydro renewable energy capacity by 2030, according to the base-case scenario in BloombergNEF's New Energy Outlook 2019. The latter's projection of the technology mix, based on the evolution of relative costs, is for this to consist of 1,646GW of solar, 1,156GW of wind, and 34GW of other non-hydro renewables, at an estimated cost of $3.1 trillion over the decade.[12]

This section supports the message of the latest UNEP Emission Gap Report that there is a big gulf between countries' current ambitions, even those as expressed in their Nationally Determined Contributions for the Paris Agreement, and what the science tells us needs to be done about global emissions by 2030.

FIGURE 5. CAPACITY ADDITIONS TO 2030 IMPLIED BY TARGETS, VERSUS REQUIRED FOR 2 DEGREES, GW



Required for 2 degrees is the additional capacity shown in BNEF's New Energy Outlook 2019 base case. This includes specific assumptions on efficiency, electrification of transport, etc.
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

[10] The assumption made here is that none of the 105GW in corporate targets end up counting toward the government-targeted 721GW.
[11] Capex estimates per megawatt are from BloombergNEF New Energy Outlook 2019 https://www.bnef.com/core/insights/20917
[12] BNEF's estimate also sees the addition of 167GW of hydro capacity, and 130GW of nuclear, plus large amounts of battery storage to balance the system. See https://about.bnef.com/blog/solar-wind-batteries-attract-10-trillion-2050-curbing-emissions-long-term-will-require-technologies/

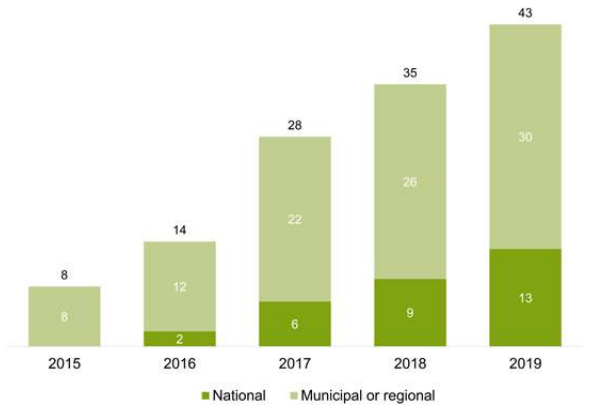
Electricity is a vital part of the overall energy system, and for that system's CO2 emissions, but it is far from the only part. In 2016, it was responsible for 42% of global energy-related emissions, with transport contributing 24% and buildings and industry a further 32%.

In the boxes below, we look at two areas that, like electricity, are becoming subject to specific government targets, and are attracting rising interest among companies and investors. One is transport, and the other is heat.

TARGETS FOR LOW-EMISSION TRANSPORT

In transport, many of the targets that countries have put in place have concerned the phase-out of internal combustion engine (ICE) vehicles, rather than the share of electric vehicles per se. For instance, Norway's government has a target to end sales of new internal combustion engine cars within five years, while Denmark, Iceland, Ireland, Israel, Netherlands, Slovenia and Sweden have targets to do the same within 10 years. See Figure 6 for the rising trend in target setting around the world.

FIGURE 6. NUMBER OF GOVERNMENTS THAT HAVE ANNOUNCED PLANS TO PHASE OUT COMBUSTION VEHICLE SALES, 2015-2019



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

Major economies, meanwhile, have regulations restricting the pollution from both passenger and commercial vehicles. The U.S., for instance, has Corporate Average Fuel Economy, or CAFE, standards that govern the fuel economy of cars and light trucks sold there. These pertain to the entire fleet of vehicles sold by each manufacturer, and have had the effect of pushing many of them to introduce electric models to reduce the average fuel consumption of their annual sales in the U.S. The Trump administration recently announced its new targets for 2021-26. These will require only limited improvements in fuel economy, effectively reducing the requirement for automakers to sell more electric vehicles. States and NGOs will try to disallow this change, via the courts.

In the European Union, there is a target for emissions from passenger vehicles requiring average CO2 emissions per kilometer to be reduced to half of their current levels by 2030. Nearly half of this could be achieved through greater fuel efficiency in combustion-engine vehicles, according to BloombergNEF analysis, but the majority would need to come from plug-in models achieving a 35-50% share of new car sales by that date.

A third approach is direct incentivizing of electric vehicle sales. China in 2020 has subsidies available for electric vehicles (EVs) with more than 250km range, starting at $1,400 and going up to $3,600 for those with a range of more than 400km. The same country also has a target for 'New Energy Vehicles' – encompassing both electric and fuel-cell models – to account for 25% of total sales of passenger and commercial vehicles by 2025.

Nevertheless, EVs still make up only 2-5% of total passenger car sales in the large markets around the world, and the rate of growth of their sales globally has been slowing. The coronavirus crisis is likely to make a dent in electric vehicle sales growth in 2020, and the collapse in oil prices in the early part of this year may also prompt some consumers to stick with gasoline and diesel cars. The penetration of electric drivetrains in commercial vehicle fleets has been even slower so far, but they have made more progress in buses, particularly in China.

Faster uptake of EVs is likely to depend on the timing of further reductions in battery costs. Lithium-ion battery prices per kilowatt-hour have already fallen by 85% since 2010, but will have to drop by a further 30-40% to bring upfront and lifetime costs of electric cars into line, or below, those of combustion-engine equivalents.

There continue to be mandates for the use of biofuel in road transport in economies such as the U.S., Brazil and the European Union, but those mandates have grown only slowly, at best, in recent years and are not expected to become significantly more ambitious in the 2020s.

In 2018, renewable energy (mainly biofuels) made up 8% of the fuel used in road transport in the European Union, up from 5.2% in 2010 and short of a 2020 target of 10%. In 2018, the EU adopted a target for 2030 of 14% renewable energy in transport, including a 3.5% carve-out for 'advanced biofuels' and biogas. It put a cap of 7% on the use of first-generation biofuels.[13]

The limited role of biofuels suggests that electric vehicles are likely to be the main low-carbon option between now and 2030, at least for passenger cars, buses and light commercial vehicles. However, exactly how sustainable EVs are depends hugely on what is used to generate the electricity they consume – coal, gas, nuclear, hydro, wind or solar.

[13] https://www.europarl.europa.eu/factsheets/en/sheet/70/renewable-energy

TARGETS FOR RENEWABLE HEAT

Heat is arguably the most difficult nut to crack when it comes to the decarbonization of the energy system. In electricity, renewable technologies such as wind and solar are more and more cost-effective against fossil fuel alternatives, and batteries are becoming an increasingly viable option for balancing supply and demand over periods of seconds to a few hours. In transport, electric models are forecast to be cost-competitive with combustion engine rivals by the mid or late 2020s.

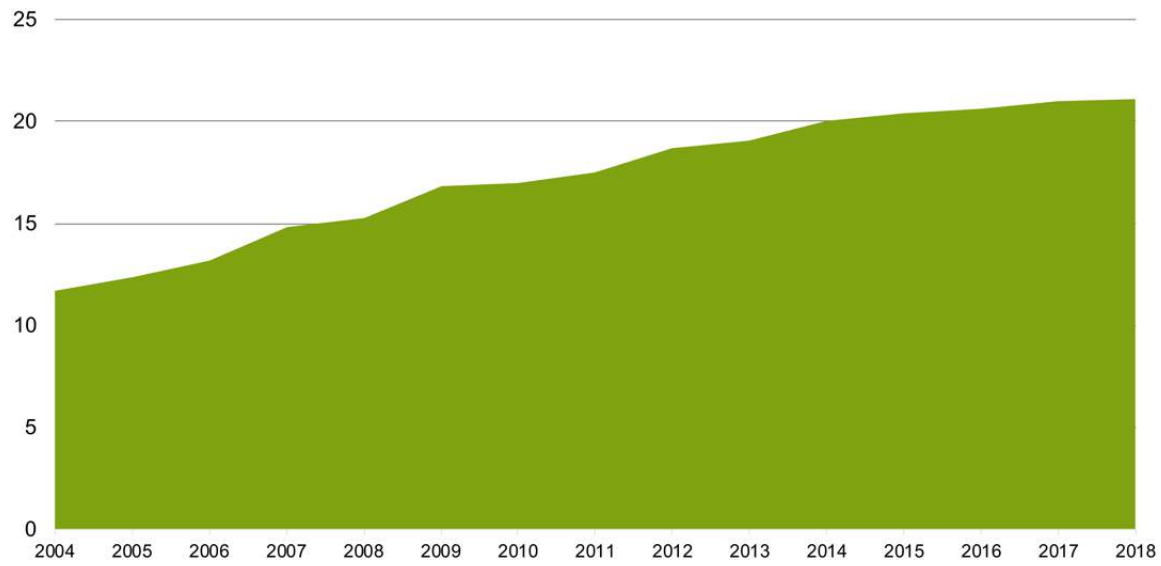
Heat – for residential or business buildings – has no one low-carbon answer. District heating linked to biomass or waste-to-energy plants may be a cost-effective option for the residential areas of some Northern Hemisphere cities, and biogas for others, particularly close to agricultural land. Biomass stoves may be economic, particularly if the building is close to sources of waste wood. Heat pumps are another contender, but they struggle to compete without subsidy against gas-fired heating where natural gas prices are low, and their low-carbon credentials depend in any case on the mix in the local electricity grid.

All these options would have more chance of economic competitiveness, with the imposition of carbon prices or carbon taxes – or sharp increases in those that already exist. Forcing CO2 emitters to pay for their pollution in this way would leave it up to the market to decide which heat technologies should prevail.

European Union countries have been the most active in specifically targeting the use of renewable heat. The EU as a whole raised the proportion of residential, commercial and industrial heating and cooling coming from green sources from 17% in 2010 to 21.1% in 2018. However, the trend flattened off noticeably toward the end of this period (see Figure 7). In addition, the overall average masked sharp differences between member states, with Sweden as high as 65% in 2018, and the Netherlands down at 6%.[14]

The EU has set an indicative (non-binding) target to increase the share of renewable heat by 1.3 percentage points per year from 2021 onwards.

FIGURE 7. SHARE OF RENEWABLE ENERGY FOR HEATING AND COOLING IN THE EU 27, 2004-2018, %



Source: Eurostat

[14] https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics#Share_of_renewable_energy_almost_doubled_between_2004_and_2018

That could be done entirely from increasing the use of biomass, waste and biogas in industrial processes and in district heating and home heating. Since the EU27 used some 467 million tonnes of oil equivalent for heating and cooling in 2018,[15] that could mean increasing the renewable element by 6 million tonnes of oil equivalent each year. The cost would depend on the type of technology used to produce the renewable heat, and whether most of the new capacity was utility-scale plants or small-scale systems and stoves.

The amount of investment required could be reduced if the EU continued to require less heat year-on-year. Between 2010 and 2018, the fuel consumed for heating and cooling in the EU27 fell by 9% in tonnes of oil equivalent. This reflected greater energy efficiency, and perhaps also the shift of some heavy industrial processes overseas. If this total continued to fall in the 2020s, then increasing the share of renewables by 1.3 percentage points per year could be achieved without building so much new capacity.

[15] https://ec.europa.eu/eurostat/web/energy/data/shares

RENEWABLE CAPACITY GROWTH IN 2019

- The world invested $282.2 billion in new renewable energy capacity (excluding large hydro) in 2019. This was a mere 1% higher than the total for the previous year, and it was 10% below the record figure of $315.1 billion set in 2017.
- However, the amount of new renewable power added in 2019 was the highest ever, at 184 gigawatts, a full 20GW more than in 2018. Steep falls in capital costs have meant that more capacity in wind and solar can now be added than ever before, for the same number of dollars.
- Investment trends in renewables in 2019 varied sharply between sectors and regions. Wind attracted a record $138.2 billion, up 6%, helped by a boom in offshore project financings. Solar saw a 3% fall to $131.1 billion, while biomass and waste grew 9% to $9.7 billion.
- China suffered an 8% fall in investment to $83.4 billion, its lowest since 2013, on a continuing government cutback in support for solar. However, financings in the U.S. leapt 28% to $55.5 billion, as developers rushed to qualify for tax credits before they expire.
- Renewables excluding large hydro dams accounted for a record 77.6% of the net new capacity added in all generation technologies in 2019. They produced 13.4% of global electricity, up from 12.4% in 2018.
- Over the 2010-2019 decade as a whole, nearly $2.7 trillion went into building out new renewables capacity around the world, with $1.4 trillion of this going into solar and $1.1 trillion into wind.

2019 saw a continuation of several of the trends in renewable energy investment that had been underway in the second half of the decade just ended. The overall level of investment, at $282.2 billion, up 1% on 2018, was only $10 billion or so below the five-year average – despite another trend (the continuing fall in costs for wind, and particularly, solar power).

Also consistent with earlier years were the growth of offshore wind, and the spread of large project financings to new markets (in 2019, the United Arab Emirates and Taiwan saw particularly large deals). A final trend was the dominant share of renewables in the net new capacity added to the world power generation mix.

It is likely that 2020, with the coronavirus health crisis and resulting economic recession, will mark at least a temporary break in some of those trends. However, green energy costs look likely to continue to fall, and governments and private sector entities will still face the climate change emergency when economies start to unfreeze.

DOLLARS DEPLOYED

Figure 8 shows that the world invested $282.2 billion in renewable energy capacity in 2019, some $2 billion more than in the previous year. The total for last year was made up of $230.1 billion of financings for utility-scale renewable energy projects of more than 1MW, down 5% on the 2018

total; and $52.1 billion of spending on small-scale solar systems of less than 1MW – up 37%. The trends in these two types of investment are discussed in Chapter 2.

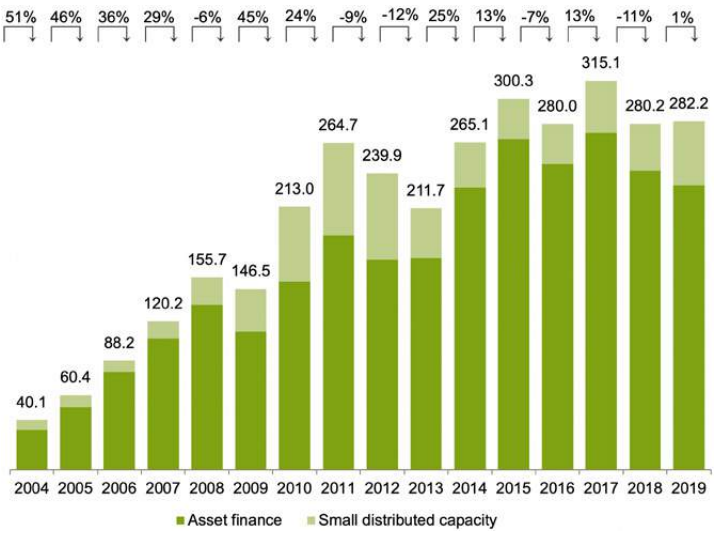
Global investment in renewables capacity has been relatively consistent since 2014, fluctuating in a $50 billion range between $265 billion and $315 billion. But beneath the headline figures, much has been changing on the unit costs of new additions, on the geographical split of investment, and on the mix between different technologies.

Looking at the sector dimension first, Figure 9 highlights again how wind and solar tower over the other renewable energy technologies in terms of investment. Last year, wind attracted a record $138.2 billion, up 6% on 2018, while solar got $131.1 billion, down 3% and its lowest since 2013.

The reasons for these changes are explored in detail in later chapters, but two of the key ones were the further rise in activity in offshore wind, both off the coasts of Europe and in the sea off mainland China and Taiwan; and the downward trend in costs per megawatt for solar photovoltaics.

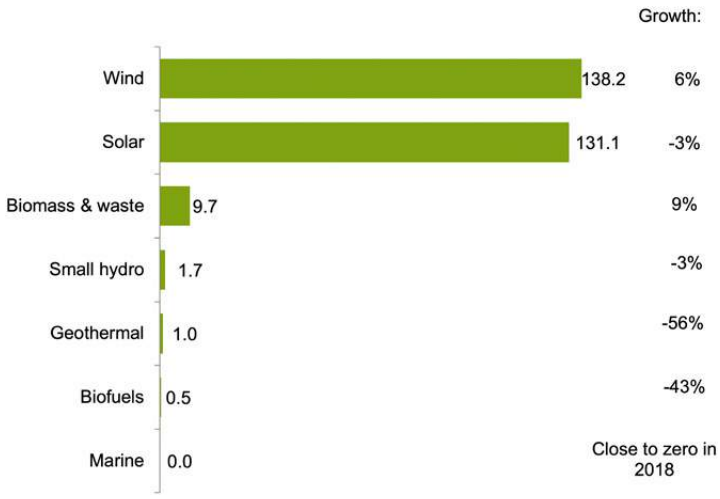
Biomass and waste-to-energy maintains a consistent third place among renewable energy sectors, with investment in 2019 up 9% at $9.7 billion. There were strong pockets of activity last year, notably in waste incineration plants in the U.K. and China.

FIGURE 8. GLOBAL RENEWABLE ENERGY CAPACITY INVESTMENT, 2004 TO 2019, $BN



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

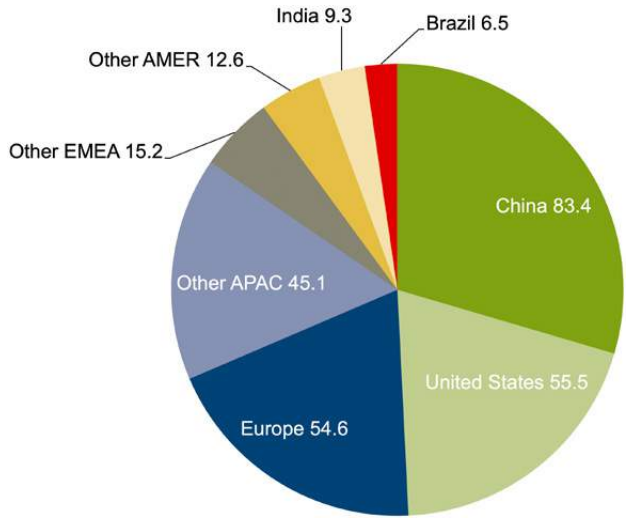
FIGURE 9. GLOBAL INVESTMENT IN RENEWABLE ENERGY CAPACITY BY SECTOR IN 2019, AND GROWTH ON 2018, $BN



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

The remaining sectors all languished in terms of dollars committed in 2019. Small hydro-electric projects of less than 50MW saw investment slip 3% to $1.7 billion, while geothermal had a 56% decline to $1 billion on a paucity of large new project financings. Biofuels took $500 million in new investment, down 43% and the lowest for three years, while marine (tidal and wave) energy saw no significant new financings at all.

FIGURE 10. INVESTMENT IN RENEWABLE ENERGY CAPACITY BY REGION, 2019, $BN



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

FIGURE 11. INVESTMENT IN RENEWABLES CAPACITY BY TOP 30 COUNTRY OR TERRITORY IN 2019, AND GROWTH ON 2018, $BN

		% growth on 2018
China	83.4	-8%
United States	55.5	28%
Japan	16.5	-10%
India	9.3	-14%
Taiwan	8.8	390%
Spain	8.4	25%
Brazil	6.5	74%
Australia	5.6	-40%
Netherlands	5.5	25%
United Kingdom	5.3	-40%
Chile	4.9	302%
United Arab Emirates	4.5	1223%
Germany	4.4	-30%
France	4.4	3%
Mexico	4.3	17%
Sweden	3.7	-19%
Ukraine	3.4	56%
Vietnam	2.6	-64%
Korea (Republic)	2.4	31%
Russian Federation	2.3	76%
Argentina	2.0	-18%
Turkey	1.9	-16%
Poland	1.8	349%
Finland	1.5	41%
Italy	1.3	-35%
Norway	1.0	-8%
South Africa	1.0	-76%
Kazakhstan	0.8	58%
Greece	0.7	11%
Israel	0.7	113%

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

The geographical split arguably offered more surprises in 2019 than the sectoral one. Figure 10 shows that the leading regions for investment were once again China, the U.S., Europe and Asia-Pacific excluding China and India. However, their relative contribution shifted, with China slipping back, and the U.S. overtaking Europe. The Other Americas (excluding the U.S. and Brazil) region was a strong feature, investment there rising 28% to $12.6 billion, while Brazil enjoyed a 74% rebound to $6.5 billion.

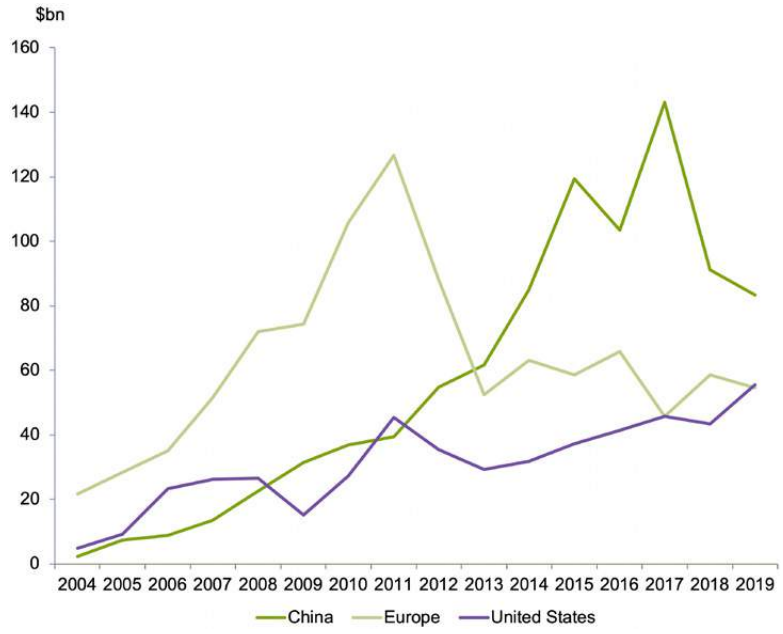
The ranking of the top 30 countries and markets is shown in Figure 11. The two most spectacular risers in the table were Taiwan, with a near-quintupling of its investment volume to $8.8 billion thanks mainly to a trio of offshore wind deals; and the United Arab Emirates, with a 13-fold increase to $4.5 billion on the back of the largest solar project financing anywhere in history.

One of the trends in recent years has been the widening geographical spread of investment in renewables. In 2018, this was manifest in the highest number ever of economies investing $1 billion or more. In 2019, the signal on this was a record number investing more than $2 billion, at 21 – up from 20 in 2018 and 16 in 2017.

Figure 12 reveals how the relative balance of investment has shifted between the three major markets during the 2004-2019 period. Europe started off as the dominant investor in renewables, and it remained the largest until it was overtaken by China in 2013 – as the solar booms in Germany and Italy cooled off dramatically and China raised its ambitions in both photovoltaics and wind.

China has been the dominant location for investment ever since, but its lead over the other two major markets peaked in 2017 – when it installed an unprecedented 53GW of solar, half of the world's total that year – and has since been shrinking. The U.S. lost its second place to China in 2009, won it back in 2011 as the Obama

FIGURE 12. RENEWABLE ENERGY CAPACITY INVESTMENT IN THE U.S., EUROPE AND CHINA, 2004-2019, $BN

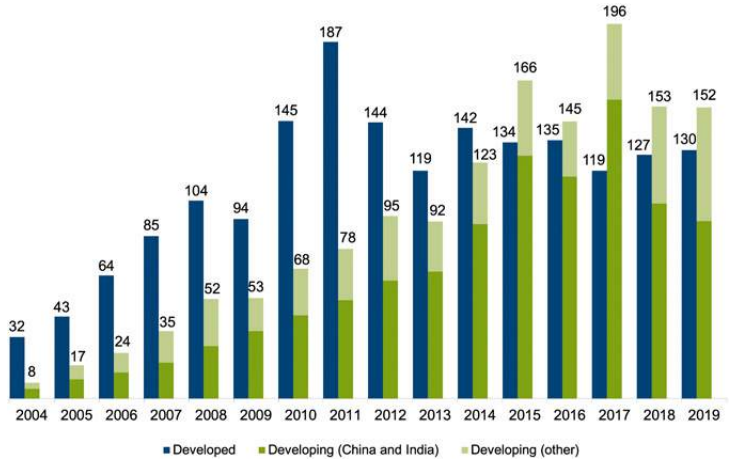


Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

administration's 'green stimulus' took effect, but then slipped back into third place until 2019, when it overtook Europe for the first time.

Developed economies tended to be the early adopters of renewable energy technologies such as wind, solar and biomass – although this was not the case with biofuels, where Brazil was one of the main centers of activity. Increasingly during the 2010s, however, and particularly once costs fell toward parity with fossil fuel alternatives, developing economies picked up the baton. They have usually been looking to build additional generating capacity to meet rising electricity demand, while for many developed countries it has been more about replacing existing coal, gas or nuclear generation.

FIGURE 13. INVESTMENT IN RENEWABLE ENERGY CAPACITY, DEVELOPED VS DEVELOPING COUNTRIES, 2004-2019, $BN



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

Figure 13 shows that developing economies accounted for the majority of global investment in renewables capacity for the first time in 2015, and have maintained that since. In 2019, they represented $152.2 billion out of the world total of $282.2 billion, a 54% share. This was the same proportion as in 2018, but down from 2017's share of 62%.

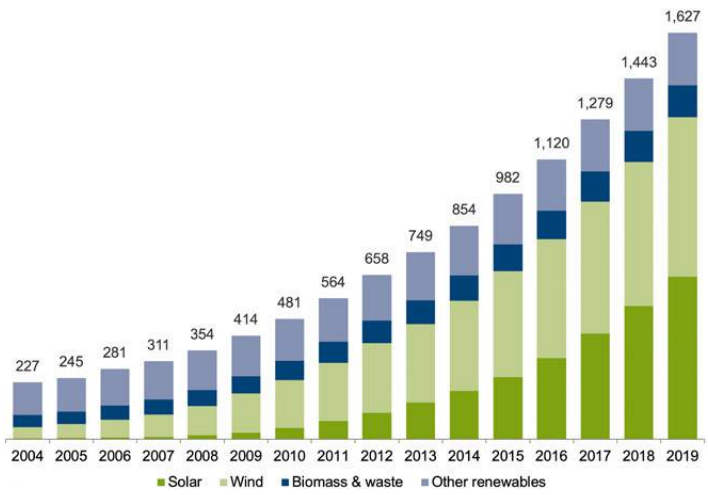
What 2019 did produce of note, however, was the highest ever figure for renewables capacity investment in 'other developing countries' – excluding China and India. This jumped 17% to $59.5 billion, and was double the equivalent total for 2016.

Chapter 3 of this report takes a detailed look at the investment trends in different developing economies, while Chapter 4 does the same for developed countries.

CAPACITY ADDED

Dollars spent on new green energy plants is one important perspective, but the other is the actual amount of capacity that results from this financial commitment. Figure 14 underlines how the cumulative number of gigawatts of renewable power nearly quadrupled over the decade of the 2010s. In 2019 alone, capacity jumped by an estimated 184GW to 1,627GW. This was the highest increment on record, and some 20GW more than 2018's addition of 164GW.

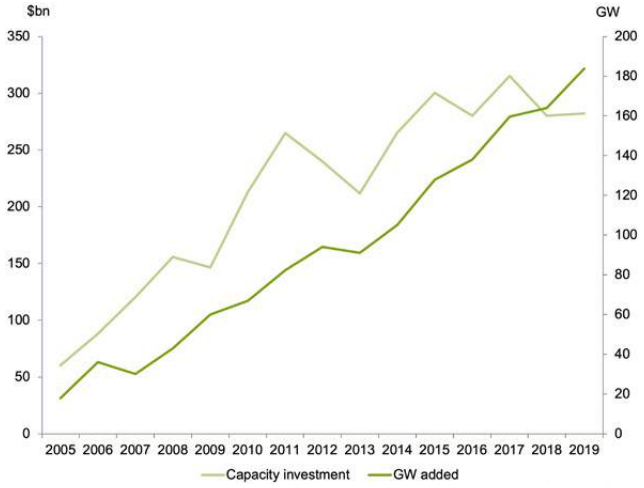
FIGURE 14. GLOBAL CAPACITY IN RENEWABLE POWER, 2004-2019, GW



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

Looking at the main technologies, the global solar power fleet expanded by an estimated 118GW in 2019, the biggest gain on record, while wind added 61GW. Over the decade, solar power multiplied 26-fold, while wind quadrupled. As predicted in last year's Global Trends report, solar added more new capacity worldwide, 625GW, during the decade than any other power generation source – coal, gas, hydro, nuclear or wind.

FIGURE 15. RENEWABLE ENERGY CAPACITY INVESTMENT IN $BN VS GW CAPACITY ADDED, 2005-2019



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

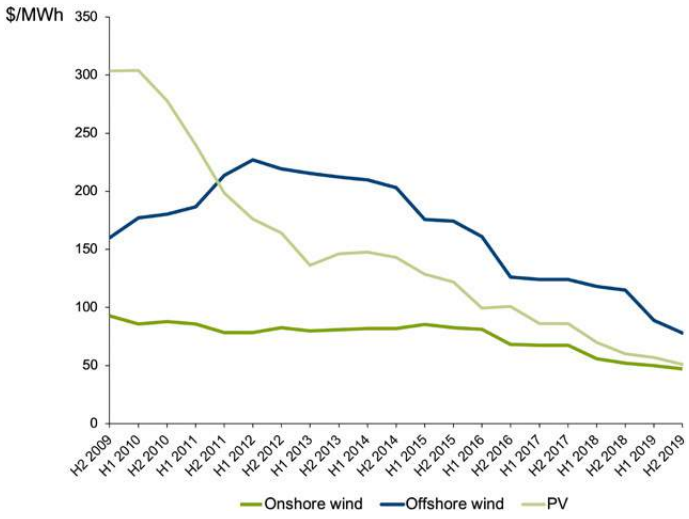
Figure 15 shows the comparison between billions of dollars invested and the renewable energy capacity added, during the whole 2004-2019 period. It comes with a caveat – dollars committed in one year often do not result in projects commissioned in the same year. The time from 'final investment decision' to full electricity production tends to be three to six months in the case of solar photovoltaics, but nine months or more for onshore wind, two to three years for offshore wind, and three years or so for biomass, waste-to-energy, solar thermal, geothermal and small hydro projects.

However, the lines in Figure 15 do give an indication of the way falling costs have enabled the world to get more bang for their buck. The gigawatts added line has continued to rise sharply, whereas the dollars committed line has oscillated around a flat trend since 2015.

THE COST REVOLUTION CONTINUES

The lifetime cost of generating electricity from wind and solar continued to decline in 2019. So-called levelized costs, which take into account not just the expense of buying the equipment

FIGURE 16. LEVELIZED COST OF ELECTRICITY, BY MAIN RENEWABLE ENERGY TECHNOLOGY, 2009 TO 2019, $/MWH



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

and constructing the plant but also developing it through the permitting stage, financing it and operating and maintaining it, have evolved as shown in Figure 16.

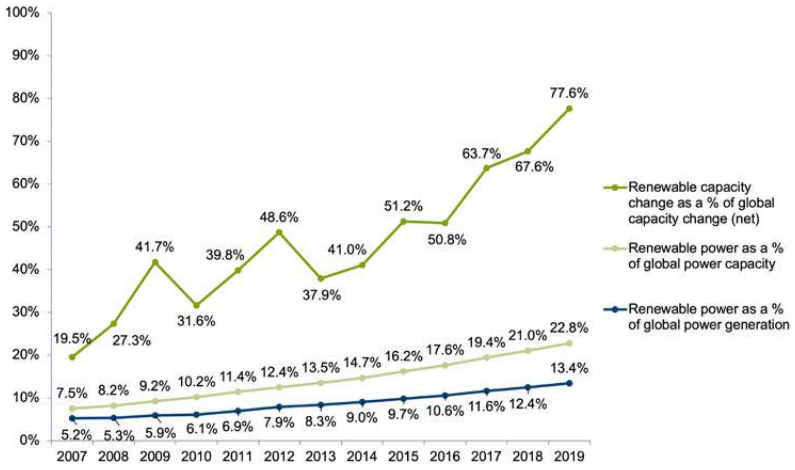
The global benchmark levelized cost of electricity, or LCOE, from onshore wind was $47 per megawatt-hour in the second half of last year, according to BloombergNEF analysis. This was down 10% on the same period in 2018, and 49% lower than in the second half of 2009. For offshore wind, the global benchmark LCOE in the second half of 2019 was $78 per MWh, down 32% on a year earlier, and 51% on the second half of 2009.

The biggest reductions in LCOE have come in solar photovoltaics. Their benchmark levelized cost stood at an average of $51 per MWh in the second half of 2019, down 15% on the year and a remarkable 83% lower than their figure of $304 in second half 2009, when solar generation was still an immature technology and heavily reliant on subsidy.

The latest reductions in LCOE have meant that an estimated two-thirds of the world's population now live in countries where either solar or wind, or both, is the cheapest option for new electricity capacity.[16] This leads on to the important point that LCOE estimates vary widely depending on the country's resources and local regulatory, labor and finance cost characteristics, and this is true for both renewable and conventional generation sources.

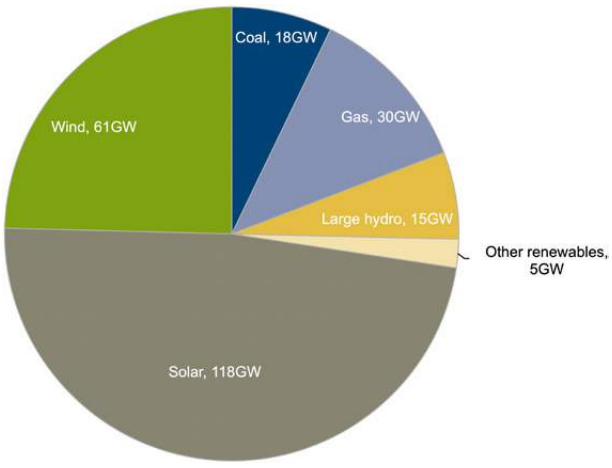
The big reductions in LCOE for wind and solar have come about as a result of a combination of lower capital costs, for instance as turbines have got bigger and more powerful and there have been further economies of scale in the manufacturing of solar panels; and improvements in the performance of equipment. The latter has seen the efficiency of PV monocrystalline modules increase from 17.5% in 2010 to 21.1% in 2019.[17] Wind turbine capacity factors (the amount of electricity produced per megawatt of power capacity) have also increased steadily – thanks to better siting, higher towers and improved operations and maintenance practices.

FIGURE 17. RENEWABLE POWER GENERATION AND CAPACITY AS A SHARE OF GLOBAL POWER, 2007-2019, %



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

FIGURE 18. NET POWER GENERATING CAPACITY ADDED IN 2019 BY MAIN TECHNOLOGY, GW



The chart does not show the negative figures from net closure of nuclear and oil-fired capacity in 2019
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

RENEWABLES VERSUS FOSSIL FUELS

Each year, the Global Trends report looks at renewables investment in the wider context of the whole electricity generation system. Figure 17 displays how the addition of green power capacity is gradually shifting the mix. The lower line shows that renewables excluding large hydro generated an estimated 13.4% of world electricity in 2019, up from 12.4% in 2018 and just 6.1% back in 2010.

The upper line is for the percentage of net new generating capacity added last year that consisted of wind, solar and other 'new renewable' technologies. This reached the highest ever in 2019, at just under 78%. Figure 18 shows

[16] BloombergNEF: *2H 2019 LCOE Update*. https://www.bnef.com/core/insights/21567
[17] ibid

that 184GW of renewable power plants (excluding large hydro) were added, together with a net 18GW of new coal-fired capacity, 30GW of gas-fired units and 15GW of large hydro dams. Not shown in the chart is that nuclear capacity globally is estimated to have shrunk by a net 5GW, and oil-fired plants by the same.

In the cases of coal, gas and nuclear, the net totals above result from a combination of new additions, and closures. In the case of coal, BloombergNEF estimates that 46GW came into service but 28GW 'retired', and for gas 50GW were added and 20GW taken out. For nuclear, some 5GW joined but 10GW retired.

Investment dollars went overwhelmingly to renewables, rather than to fossil fuel and nuclear technologies. Figure 8 in this chapter showed that renewables excluding large hydro attracted $282.2 billion of investment in 2019. If biofuels are also excluded, then the adjusted total would be $281.7 billion. Against that, new coal-fired generators are estimated to have taken $37 billion of investment, and new gas-fired plants $47 billion. Some $15 billion of investment is estimated to have gone into new nuclear reactors.

It is possible to estimate the impact on global carbon dioxide emissions of the renewable power capacity built by the end of 2019. As stated above, renewables excluding large hydro were responsible for 13.4% of world electricity last year. Global emissions from the power sector are estimated to have been 13.5 gigatonnes in 2019, as a result of electricity generation from coal, gas and oil-fired plants.[18] If the 13.4% of electricity had come from the same mix as the remaining 86.6%, then emissions would have been 2.1 gigatonnes more than they actually were.

Despite the significant difference that 'new renewables' are making, the challenge of curbing world emissions and limiting climate change remains daunting. Coal and gas-fired capacity is still being added, and that means that unless average running hours per plant falls significantly, the amount of electricity it generates will carry on increasing, and so will the emissions it produces. In 2019, fossil fuel technologies accounted for more than 60% of global electricity generation, and most of these power stations have years or decades to run before their scheduled closure.

Fossil fuel power stations, particularly open-cycle gas turbines, are an option (along with batteries and pumped hydro) for addressing peaks in electricity demand. However, much of the extra coal and gas capacity being added globally is not for peaking purposes, but designed to run as baseload generation.

Meanwhile, other parts of the energy complex, including transport fuels and heat, are also continuing to emit more CO2. These sectors were highlighted in brief in the Focus Chapter of this report, on pages 18-21.

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

INVESTMENT OVER THE DECADE 2010-2019

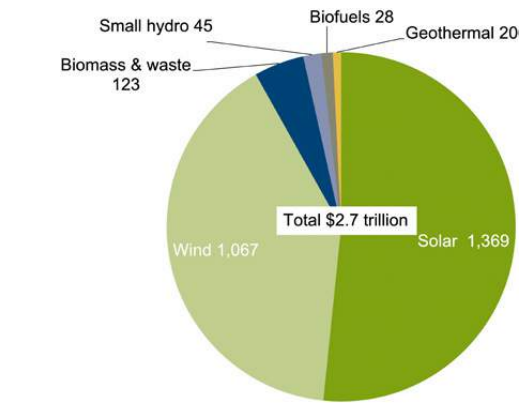
Last year's Global Trends report included a Focus Chapter looking at the likely outturn for investment in renewable energy capacity over the decade that was just ending. Here, we can revise those figures to take account of how 2019 finished up.

Figure 19 shows that nearly $2.7 trillion was invested globally in renewables excluding large hydro over the 2010-2019 period. This was more than three times, and possibly four times, the equivalent amount invested in 2000-2009 (data for the years 2004-2009 are available but not those for 2000-2003).

Solar was comfortably the largest recipient of finance for new projects in the decade just finished, attracting nearly $1.4 trillion, while wind took nearly $1.1 trillion. Biomass and waste-to-energy received $123 billion, small hydro $45 billion, biofuels $28 billion, geothermal $20 billion and marine less than $400 million.

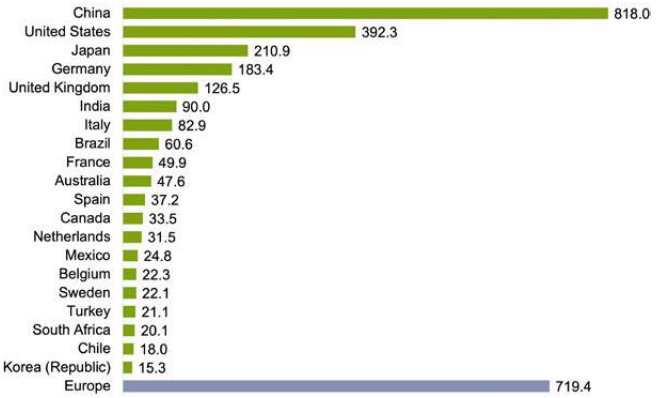
The decade saw no fewer than 72 countries each invest more than $1 billion in 'new renewables', and 26 of these invested more than $10 billion. Figure 20 shows the top 20 markets, ranging from China at a total of $818 billion to South Korea at $15.3 billion. Ironically, the top three countries – China, the U.S. and Japan – have all been criticized at times for not doing enough to decarbonize quickly. This table shows that they pumped $1.4 trillion between them into green energy over 2010-2019.

FIGURE 19. RENEWABLE ENERGY CAPACITY INVESTMENT OVER THE DECADE, 2010-2019, $BN



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 20. RENEWABLE ENERGY CAPACITY INVESTMENT FROM 2010 TO 2019, TOP 20 MARKETS, $BN



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

Europe invested $719.4 billion in renewables excluding large hydro during the decade, putting it about $100 billion behind China but more than $300 billion ahead of the U.S. Within Europe, Germany was by far the largest destination for investment dollars, at $183.4 billion, followed by the U.K. at $126.5 billion.

CAPACITY INVESTMENT – GLOBAL

- Global investment in new renewable energy capacity (excluding large hydro-electric projects) was $282.2 billion in 2019, up 1% on the previous year, thanks to a jump in spending on small-scale solar systems.
- Asset finance of utility-scale projects fell 5% to $230.1 billion, the lowest figure for any year since 2014. This was despite a late rush in offshore wind financings in the final quarter of the year.
- Investment in small-scale solar projects of less than 1MW leapt 37% to $52.1 billion, helped by the increasing cost-effectiveness of electricity from commercial and residential systems in key markets such as the U.S., China, Brazil, the Netherlands and Germany.
- Global offshore wind financings increased 19% to a record $29.9 billion last year. There was a rush of projects going ahead in Chinese waters to take advantage of a soon-to-expire feed-in tariff, together with the first financial close in France, and three large Taiwanese deals.
- Investment in onshore wind advanced 2% to $108.3 billion, the highest ever, with the U.S. one of the busiest markets as developers sought to qualify projects for the Production Tax Credit.
- However, investment in solar PV globally slipped 6% to $126.5 billion on a combination of slowdown in China and further reductions in unit costs.
- The biggest asset financing of the year came in solar thermal, in the shape of a $3.9 billion equity and debt package for the 700MW Al Maktoum IV trough and tower complex in Dubai. The project also has a 250MW photovoltaic component. Together, the two represented the largest ever non-hydro renewable energy project financing.
- Last year produced runaway records for the amount of green power capacity auctioned by governments around the world, at 78.5 gigawatts; and for the amount of capacity covered by corporate power purchase agreements, or PPAs, at 19.5GW.

Chapter 1 discussed the headline trends in the financing of renewable energy worldwide in 2019, and over the last decade. This chapter looks at the same subject in more detail, exploring the balance between utility-scale projects and small systems, the split between individual technologies, the modes of finance used, the role of government auctions in setting tariffs, and the importance of decisions made by private companies to buy green power.

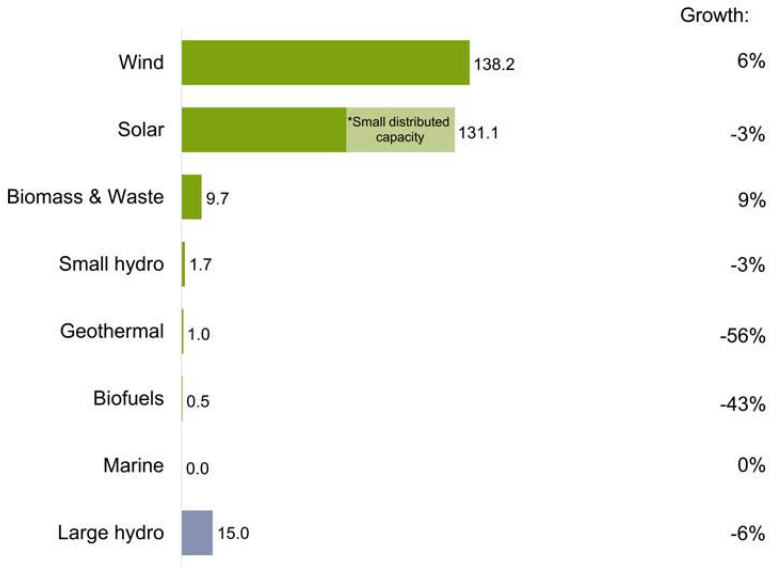
The following two chapters (3 and 4) look at the geographical profile of capacity investment, highlighting the particular issues affecting activity in all the different major markets.

TECHNOLOGY SPLIT

Figure 21 shows the year-on-year change in renewable energy capacity investment worldwide, with two additional elements. One is the split in solar between utility-scale projects of more than 1MW, at $79 billion, and spending on small distributed PV systems.

In 2019, overall solar capacity investment slipped 3% globally to $131.1 billion, but within this utility-scale asset finance dropped 19% – due in large part to a sharp slowdown in the financing of PV projects in China. However, money committed to small-scale solar systems around the world, including commercial and residential installations, jumped 37% to $52.1 billion, its highest

FIGURE 21. RENEWABLE ENERGY ASSET FINANCE AND SMALL DISTRIBUTED CAPACITY INVESTMENT BY TECHNOLOGY, 2019, AND GROWTH ON 2018, $BN



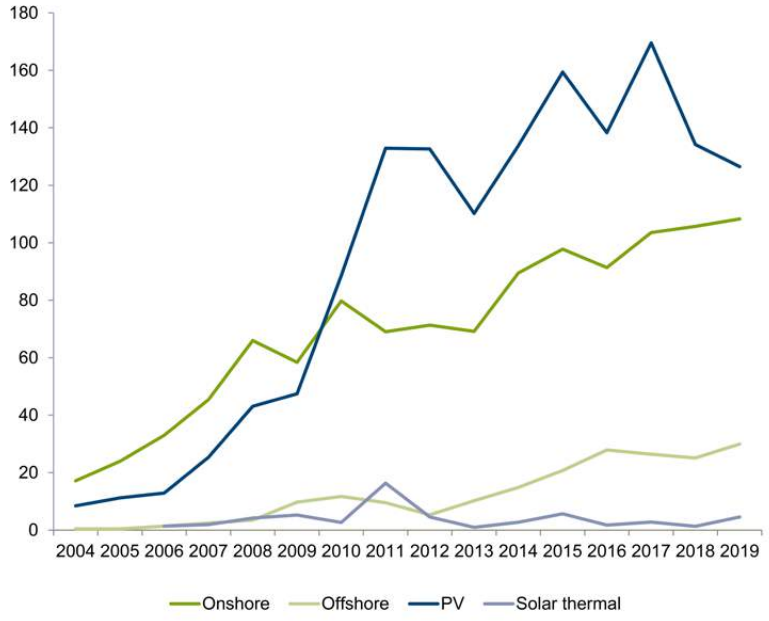
Total values include estimates for undisclosed deals. Small distributed capacity consists of solar systems of less than 1MW.

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

level since 2012. The latest declines in the cost per MW of small solar systems made them more cost-competitive, and are discussed later in this chapter.

Figure 21 also puts activity in "new" renewables such as wind and solar into perspective compared to that in the oldest low-carbon power generation option, large hydro-electric dams. These hydro projects (of more than 50MW) are outside the scope of this report, for reasons stated in the box at the end of this chapter. Nevertheless, the chart here illustrates that, even if they were included, their level of investment in 2019 would be dwarfed by that in wind and solar.

FIGURE 22. NEW INVESTMENT IN WIND AND SOLAR PROJECTS WORLDWIDE, BY SUB-SECTOR, 2004-2019, $BN



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

What is also clear from Figure 21, however, is that other sectors of renewable energy (apart from wind and solar) attracted few capital spending commitments in 2019. Small hydro projects of less than 50MW and geothermal plants saw investment of $1.7 billion and $969 million respectively, well down on historic peaks in 2011 ($7.3 billion for small hydro, $3.1 billion for geothermal). Marine energy continued to languish, with wave power still to solve technology challenges and megawatt-scale tidal stream projects blocked by lack of specific policy support in the key markets of the U.K. and France. Biofuels saw capacity investment of just $500 million, far below the peak of $22.9 billion way back in 2007, as the industry stagnated without fresh government purchasing mandates.

Only biomass and waste-to-energy of the smaller sectors enjoyed significant investment in 2019, at $9.7 billion, up 9% on 2018. This was in line with its five-year average, albeit well down on the 2011 peak of $16 billion. Waste-to-energy is the more dynamic part of this sector, with projects worth several hundred million dollars each reaching financial close in countries such as China and the U.K.

The split between onshore and offshore wind, and between photovoltaics and solar thermal (also known as concentrated solar power, or CSP) is shown in Figure 22. Offshore wind saw investment surging 19% to a record $29.9 billion in 2019. Behind this was a fourth-quarter rush of deals, including one in U.K. waters but also the first financial close in the French offshore program and a third transaction in Taiwan's, to add to two earlier in the year. But the biggest factor was a stampede of mainland China offshore wind projects, brought to financial close in order to qualify for a feed-in tariff soon to expire.

Onshore wind investment edged up 2% to $108.3 billion in 2019, also an all-time high. The two main reasons for this were a 7% advance in deal volume in China to $41 billion, and a 42% leap in U.S. financings to $31.5 billion – the latter to take advantage of the Production Tax Credit incentive, which was due to finish its qualifying period at the end of 2019. Further discussion of the dynamics in both countries is featured in Chapters 3 and 4.

PV continued to dominate solar investment, as the cheapest option by far, and also the simplest. Dollars committed to it worldwide slipped 6% to $126.5 billion, with the biggest factor being a 32% slump in investment in China as that country's government limited access to its feed-in tariff. On the other hand, investment in PV in Europe gained 25%, partly due to the spread of subsidy-free projects backed only by private sector power purchase agreements.

Solar thermal investment roared up by an eye-catching 256% to $4.6 billion, its highest since 2015. Most of this was thanks to the go-ahead on the $3.9 billion solar thermal portion of the Al Maktoum IV complex in Dubai – discussed further below, and in Chapter 3.

ASSET FINANCE

This section looks specifically at aspects of the $230.1 billion financing of utility-scale renewable energy projects. A later section in this chapter covers the $52.1 billion of investment in small distributed solar capacity.

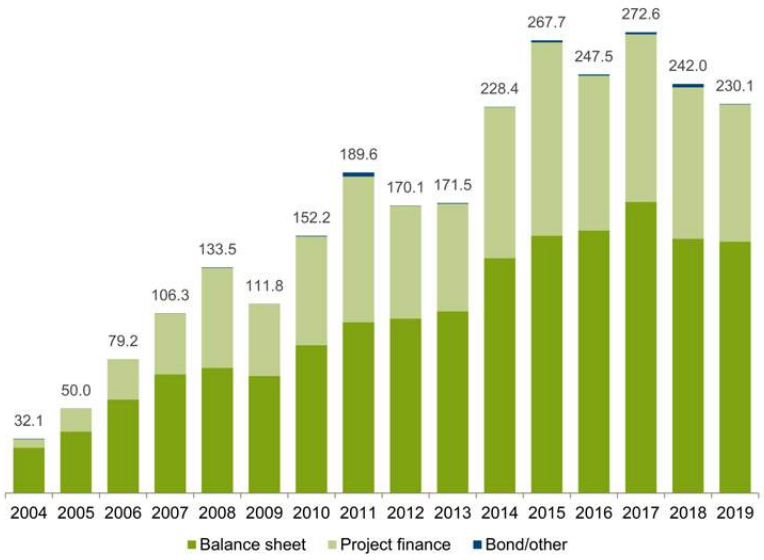
Figure 23 highlights the two main ways in which projects are financed – either on-balance-sheet by utilities, energy companies and developers, or on a non-recourse basis via a special purpose vehicle, or SPV, set up for that specific project (non-recourse project finance). In the first approach, the company or companies that own the project may raise bond or other debt finance to help pay for construction, but this will be done via their own corporate balance sheets. They will therefore bear the whole risk of project execution.

In the second approach, the developer is likely to own all or part of the equity in the SPV, but this will usually be supplemented by the raising of debt – so that only a proportion of the project risk will reside with the developer. In both cases, the project may well be refinanced once it is operational, since the financing terms available at this lower-risk stage of the life of a renewable energy plant are usually more advantageous than those available pre-construction. However, Figure 23 deals only with the financing mode used for construction, not the one used later in the operating phase.

In 2019, on-balance-sheet financing made up $148.6 billion, or 65%, of the renewable energy asset finance total of $230.1 billion, while non-recourse project finance accounted for $81.1 billion, or 35%. The bond/other category, which includes leasing, continued to be only a tiny proportion of the total, at $327 million last year significantly down on 2018's $2 billion.

The split between on-balance-sheet and non-recourse finance has always favored the former during the period since 2004. This is partly because many of the largest investors in renewables are utilities or independent power producers that prefer to take this approach for ease of execution, and then possibly refinance the project later. Also, the non-recourse structure that is very familiar in Europe, North America and China may be less easy to adopt in newer markets where risks are less well understood by domestic and international banks.

FIGURE 23. ASSET FINANCE INVESTMENT IN RENEWABLE ENERGY BY MODE OF FINANCE, 2004-2019, $BN



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

FIGURE 24. LARGEST ASSET FINANCE DEALS IN RENEWABLE ENERGY IN 2019

Project	Country/market	Technology	MW	Estimated cost ($bn)
Al Maktoum IV tower and parabolic trough plant	United Arab Emirates	Solar thermal	700	3.9
EDF and ESB Neart na Gaoithe	United Kingdom	Offshore wind	432	3.4
Wpd & Starwind Yunlin	Taiwan	Offshore wind	640	3.0
Orsted Greater Changhua Portfolio	Taiwan	Offshore wind	900	2.7
EDF Enbridge Saint Nazaire	France	Offshore wind	480	2.5
Swancor & Macquarie Formosa II Miaoli	Taiwan	Offshore wind	376	2.0
SPIC Zhanjiang Xuwen	China	Offshore wind	600	1.5
Fujian Funeng & Haixia Power Generation Fuzhou Changle C	China	Offshore wind	500	1.5
Enercon Markbygden Phase II	Sweden	Onshore wind	844	1.1
SPIC Zhejiang New Energy Investment Zhoushan Shengsi 2#	China	Offshore wind	402	1.0
Haixia Power Fuzhou Changle A	China	Offshore wind	301	1.0
NBT Zofia Phase II and Phase III	Ukraine	Onshore wind	750	1.0
Fryslan	Netherlands	Offshore wind	383	0.9
Huadian Fuqing Haitan Haixia	China	Offshore wind	300	0.9

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

Figure 24 shows the largest asset financings of 2019. Inevitably, the list does not give an accurate picture of the mix of investment overall, because it tends to favor those sub-sectors that typically have large investment volumes per project. Consequently, last year, there were 11 offshore wind arrays in the 14 top projects, due to the size of these investments, even though onshore wind and PV are both much larger than offshore in terms of global investment dollars allocated.

The biggest-ticket project reaching financial close in 2019 was the Al Maktoum IV solar thermal complex in Dubai, at $3.9 billion for 700MW, consisting of 100MW of tower technology and 600MW of the more established parabolic trough technology. Not shown in the list, because the BNEF database counts it as a separate project, is that Al Maktoum IV has a PV element – of 250MW and $400 million.

The overall package for Al Maktoum IV, at $4.3 billion, signed in March 2019, was the largest ever asset finance deal in solar, and the largest non-recourse project finance package in any renewable energy technology.

The list highlights the extent of the surge in offshore wind activity in East Asia. It includes the first three Taiwanese arrays to get financed, each of them involving a mix of local and European finance players. It also includes five projects from mainland China. Another 13 from there got the investment go-ahead in 2019, but were not big enough to get into Figure 24.

BECOMING 'BANKABLE'

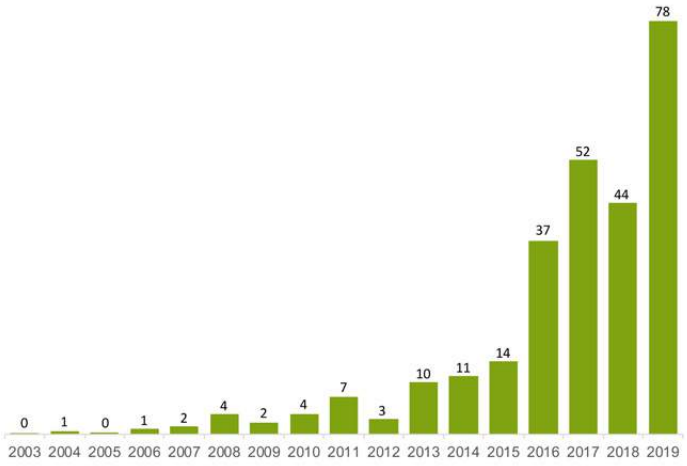
During the first half of the 2010-2019 decade, renewable power project developers relied almost exclusively on government-set incentives to secure their revenues, and become 'bankable' – in other words sufficiently predictable in their cash flows to convince lenders to provide debt.

These incentives came in three flavors: feed-in tariffs that locked in the price of electricity for projects for 10-20 years; green certificates that supplemented the income projects could get from selling electricity at market rates; and tax incentives that reduced the net capital costs of building new capacity.

As the costs of wind and solar power have fallen precipitously (see Chapter 1), the role played by these incentives has gradually faded. In 2019, they remained important in some markets – for instance, the feed-in tariff in China and the Production Tax Credit for wind in the U.S. In parallel, other ways of facilitating acceptable returns for renewable energy projects continued to grow in significance.

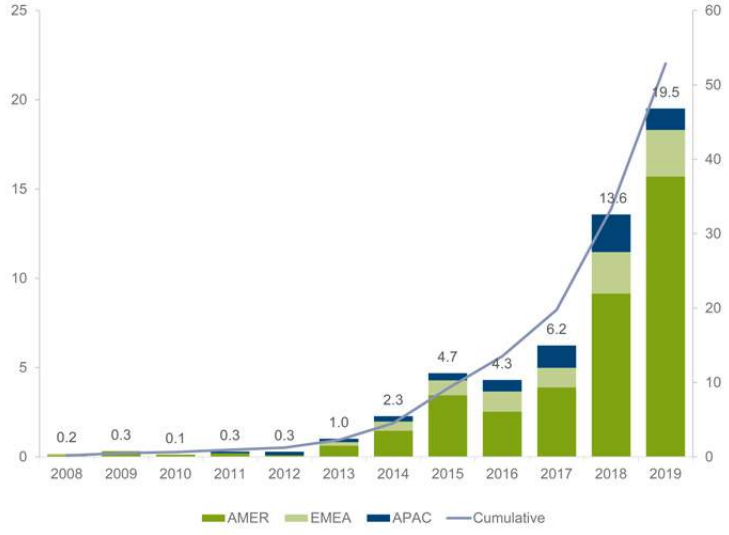
The first of these 'other ways' is the auction. As Figure 25 shows, the amount of renewable energy capacity winning fixed tariffs in government-run auctions has soared from just 2.8GW in 2012 (in early-adopter countries such as Brazil) to 44GW in 2018, and a runaway record of 78.5GW in 2019. The latter figure was equivalent to nearly half of the new renewable power capacity added worldwide last year.

FIGURE 25. GLOBAL AUCTIONED RENEWABLES CAPACITY, 2003-2019, GW



Excludes 60.8TWh of renewable electricity auctioned in Chile between 2006 and 2019, because it was not allocated on a GW basis.
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 26. GLOBAL VOLUME OF CORPORATE POWER PURCHASE AGREEMENTS SIGNED, BY REGION, 2008-2019, GW



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

The majority of last year's capacity awarded in auctions (50.7GW) was for solar, with onshore wind accounting for 14.7GW and offshore wind 11GW. The most important region for renewable energy auctions was Asia, with 53.6GW awarded, led by India, followed by Europe with 17.4GW.

Auctions have contributed to the rapid decline in renewable energy levelized costs (shown in Figure 16 in Chapter 1), by intensifying competition among developers for the available capacity. This in turn has pushed the whole supply chain, from landowners to equipment suppliers and financiers, to cut their costs.

A second way of securing electricity revenues for a significant part of the project life is to conclude a private sector power purchase agreement, or PPA. This can be with a utility, but the sharpest growth has been in corporate PPAs, as shown in Figure 26. These have snowballed from covering just 300MW of global capacity in the deals signed in 2012, to 4.7GW in 2015, to 13.6GW in 2018 and a record 19.5GW in 2019. By the end of last year, a cumulative 52.4GW of global renewables were subject to corporate PPAs signed at some point during the decade.

The U.S. made up by far the largest slice of this global PPA volume in 2019, at 13.6GW, up from 8.5GW in 2018. Europe also saw a record year, but at a more modest 2.6GW, up from 2.3GW. The largest corporate buyers of new renewable electricity contracts in 2019 were Google (2.7GW, consisting of 1.7GW of solar and 1GW of wind), Facebook (1.1GW) and Amazon (925MW).

There is starting to be a third option for new-build projects in locations with good resources for solar or wind and a low-cost supply chain, and that is to construct them without any long-term electricity price fixing at all – in other words, without a government-set incentive, a tariff set by a government-run auction, or a private sector PPA. That is to rely purely on short-term electricity prices.

Building on such a basis – "merchant" to use the industry term – means a high level of unpredictability in terms of revenues, and will not be to the taste of many debt providers. Developers adopting this approach are likely to construct entirely using equity, or else with only a small proportion of debt. Some 1.3GW of solar projects were built worldwide without subsidy or long-term contract in 2019, and this total is expected to increase rapidly as PV costs continue to decline and new financing models evolve.[19] New ways of financing may include shorter tenors on loans, much lower debt-equity ratios, 100% equity finance, and the use of debt-equity hybrid products.

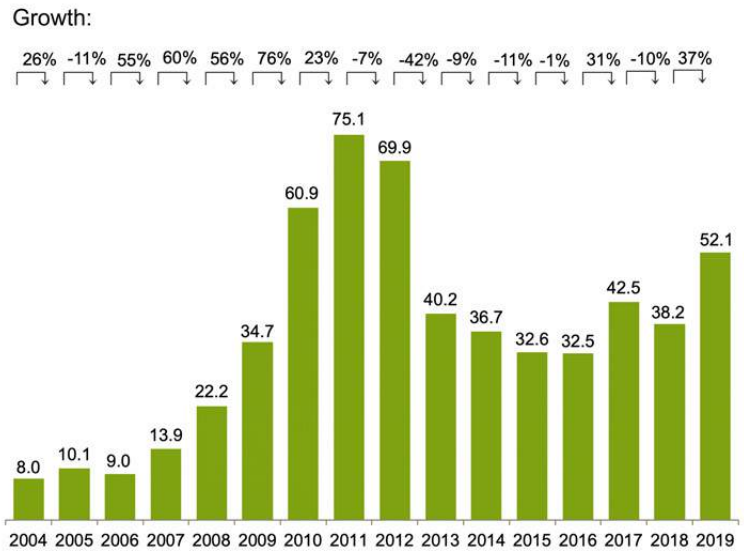
SMALL DISTRIBUTED CAPACITY

Figure 27 highlights the complex trend in investment in small-scale solar systems over the last decade. This category of capacity investment covers all PV installations of less than 1MW – in other words everything from residential rooftops with one, two or three panels to large warehouses and car park shelters with hundreds of panels, to commercial ground-mounted plants of several hundred kilowatts.

Small distributed capacity (SDC) investment hit its peak way back in 2011, at $75.1 billion, at a time of frenetic activity in Europe, especially Germany and Italy, as subsidies stimulated the purchasing of panels at what was then high costs per kW compared to what is available today. Investment then went into decline as solar costs fell and subsidies were either removed or cut sharply, reaching a low of $32.5 billion in 2016. However, last year saw a new upswing, with some $52.1 billion of new small-scale systems purchased globally, up 37% on 2018.

A geographical breakdown shows that the U.S. and China were the two biggest markets in 2019, with the former recording $9.6 billion of small-scale solar outlays, up 8% on 2018, and the latter $5.3 billion, up 176%. Other major markets were Brazil, 337% higher at $2.1 billion; India 40% higher at $1.5 billion; Germany, up 12% at $3.1 billion; the Netherlands, up 93% at $2.9 billion; and Australia, up 15% at $2.4 billion. There were also an estimated $5 billion deployed on small-scale solar in the Middle East and Africa, but details on exact location are yet to emerge.

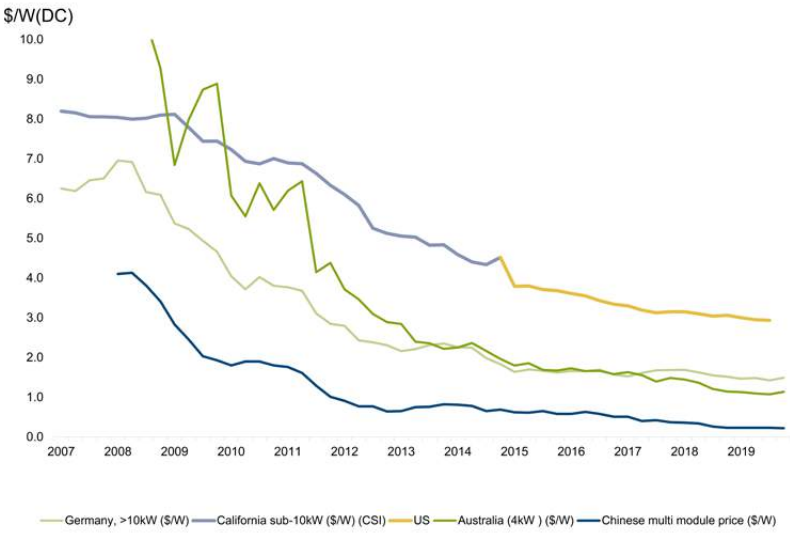
FIGURE 27. SMALL DISTRIBUTED CAPACITY INVESTMENT, 2004-2019, $BN



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

[19] https://about.bnef.com/blog/energy-vehicles-sustainability-10-predictions-for-2020/

FIGURE 28. SMALL PV SYSTEM COST IN GERMANY, THE U.S. AND AUSTRALIA, AND TREND IN CHINESE MODULE PRICES, $ PER WATT



$/W(DC) is cost per Watt in direct current terms.
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

The country-specific reasons for these increases will be explored in Chapters 3 and 4, which look at renewable energy investment by country. But the factor in common was the further fall in the capital costs of solar equipment, as displayed in Figure 28.

The chart shows the cost reductions respectively for a German small PV system of less than 10kW – down from $6.25 per Watt in early 2007, to $4.04 per Watt in early 2010, to an average of $1.59 per Watt during 2018, and $1.47 per Watt in 2019. In the U.S., the typical cost reduction has been from $7 per Watt in 2010 to $2.96 per Watt in 2019. Installation and balance-of-plant costs have fallen during the decade, but the most dramatic reduction has been in the modules themselves, with the Chinese multi-module price tumbling from $1.85 per Watt, to just 23 cents per Watt.

Among the many sub-1MW solar projects making the news in 2019 were an 852kW system on the roof of Autronic Plastics in Central Islip, New York State, U.S., a 540kW installation on the Carros Centre, Singapore, a 192kW rooftop system on the Indian Academy Dubai School in the United Arab Emirates, and a 531kW plant for Izumo Togo Electronics in Shimane Prefecture, Japan.

LARGE HYDRO PROJECTS

As shown in Figure 21, final investment decisions for large hydro-electric dams of more than 50MW are estimated to have been worth $15 billion in 2019, down 6% from the previous year. Investment in both 2018 and 2019 was far below the $40 billion-plus annual totals recorded several times during the preceding decade.

A major reason for the lower large hydro investment totals recently has been the absence of mega projects reaching financial close, or the start of full-scale construction. The most recent such project to reach that stage was the 16GW, $28 billion Baihetan dam in China in 2017. More fundamentally, some big projects in Africa and South East Asia have been delayed by environmental or political concerns.

Nevertheless, 2019 did see important milestones reached for a number of projects. Voith got a contract to supply four 250MW Francis turbines and generators for the 1GW Pakal Dul hydropower plant in Indian state of Jammu and Kashmir. The Asian Infrastructure Investment Bank approved a $90 million loan to Nepal for the construction of the 216MW Upper Trishuli 1 hydropower plant.

Tanzania's government said that it would pay in full for the 2.1GW Stiegler's Dam, otherwise known as the Rufiji project, which is expected to cost $3 billion and controversially is being built in a wildlife reserve. At the smaller end of the size range, Statkraft committed in 2019 to build the 52MW Los Lagos project in Chile.

In China, the government permitted the 2GW Lawa hydro project on the Jinsha river, between Sichuan and Tibet. This undertaking will involve investment of $4.6 billion, according to China Daily. Also getting the go-ahead for construction was the 392MW Chuosijia dam in Sichuan.

Meanwhile, new capacity entered operation in 2019 – relating to projects financed and started earlier in the decade. For instance, some 3.6GW of power were added to the giant Belo Monte installation in Brazil, and government figures showed that China commissioned some 3.8GW of new hydro capacity (large and small) in 2019.

RusHydro opened the 320MW Nizhne-Bureyskaya plant and also added 142MW to the Ust-Srednekanskaya installation, both of them in the Russian Far East. Uganda commissioned the 188GW Isimba dam on the White Nile, built by China International Water & Electric.

In Asia, the 1.3GW Xayaburi hydro plant in Laos began operations, selling power to the Electricity Generating Authority of Thailand. India commissioned the 111MW Sawra Kaddu plant in Himachal Pradesh, and Tajikistan put into operation 600MW of the multi-phase Rogun complex. Nepal launched the 60MW Upper Trishuli 3A installation, while leaders of both India and Bhutan attended the inauguration of the 720MW Mangdechhu run-of-the-river project in Bhutan. India is set to purchase the dam's surplus electricity.

In the Americas, the local subsidiary of Spanish energy group Iberdrola inaugurated the 350MW Baixo Iguacu hydropower project in the state of Parana, Brazil.

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

CAPACITY INVESTMENT – DEVELOPING COUNTRIES

- Renewable energy capacity investment in developing countries was $152.2 billion in 2019, down just a fraction from $152.7 billion in 2018. Dollars invested in the developing world made up 54% of the global total, outweighing developed economies for the fifth year running.
- The almost flat total for developing countries as a whole disguised big differences at the level of individual economies. Capacity investment in developing markets excluding mainland China and India gained 17% last year, reaching a record $59.5 billion.
- One of the highlights was Taiwan, where financial close for three large offshore wind projects drove a 390% jump in outlays to a record $8.8 billion. Another was United Arab Emirates, which boasted a 12-fold rise in investment, thanks to the largest solar financing ever – the Al Maktoum IV complex, with $3.9 billion for the solar thermal element, and $400 million for the PV component.
- However, investment fell back in both China and India. There was a steep drop in Chinese solar commitments, brought about by policy change in Beijing. Overall, investment in China slipped 8%, with increased wind activity offsetting some of the solar decline.
- India saw investment drop 14% to $9.3 billion, largely due to delays in financing projects brought about by the problems of their main electricity buyers, the distribution companies or 'discoms'. Lower capital costs per megawatt also contributed to the reduction in dollars invested in both India and China.
- Renewables capacity investment increased handsomely in Brazil and, in particular, Chile. But several formerly active developing country markets saw outlays decline in 2019 – notably South Africa, Vietnam and Morocco.

Global capacity investment in renewables excluding large hydro continues to be split relatively evenly between developed and developing countries, with the latter making up the small majority. In 2019, developing economies made up 54% of the global total against 46% for developed economies.[20] This ratio was also 54:46 in 2018, but it got as high as 62:38 in 2017 at the peak of China's solar boom. The last time developed economies invested more than developing countries was back in 2014.

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

Figure 29 splits the world into three groups. China and India between them invested $92.7 billion in new green energy capacity in 2019, down 9% on the previous year and the lowest since 2014. Other developing countries committed a record $59.5 billion, up 17% on the 2018 total. Developed economies (covered in Chapter 4) invested $130 billion, some 2% higher than the year before and their highest aggregate since 2016.

The upswing in investment in 'other developing countries', from just $24.3 billion in 2010 and $39.6 billion in 2015 to $59.5 billion in 2019, underlines the way wind and solar technology, in particular, have spread through more markets in recent years, thanks in large part to improved cost-effectiveness. One enabling mechanism has been auctions, discussed in Chapter 2, now the favoured tool for many countries for setting tariffs and allocating capacity.

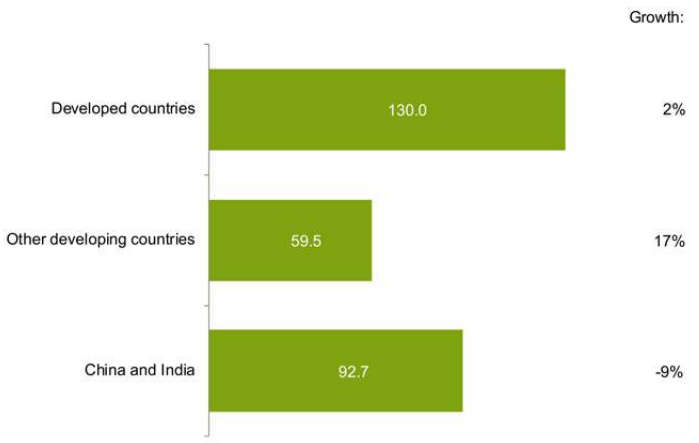
This chapter will look in turn at investment in China, India, the Middle East and Africa, Latin America and emerging Asia-Pacific.

CHINA

China has been the dominant investing country in renewables, excluding large hydro, since over-taking the U.S. in 2012, and the largest investing region on the definition used in this report since surpassing Europe in 2013. However, its investment volumes have not gone up in a straight line. They advanced every year up to 2015, before slipping back from $119.3 billion to $105.3 billion in 2016, jumping again to $143 billion in 2017 thanks to runaway solar project development, and then slipped back, first to $91.1 billion in 2018 and then to $83.4 billion in 2019.[21]

Figure 30 shows the split by technology for China's investment in renewables in 2019. The majority of the dollars committed – $55 billion – were to the wind sector, up 10% on 2018 and an all-time high. Within that, offshore wind attracted $14 billion, a 17% increase on the previous year, and onshore wind $41 billion, up 7%. Solar saw investment slide 33% to $25.7 billion, the lowest since 2012 and less than one third of the 2017 peak. Biomass and waste-to-energy secured $1.5 billion of investment, up 2%, while small hydro was unchanged at $1.2 billion.

FIGURE 29. CAPACITY INVESTMENT IN RENEWABLES: DEVELOPED COUNTRIES, CHINA AND INDIA, OTHER DEVELOPING ECONOMIES, 2019, AND CHANGE ON 2018, $BN



Total values include estimates for undisclosed deals. Developed countries are all OECD members, excluding Chile, Mexico and Turkey.
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 30. RENEWABLE ENERGY CAPACITY INVESTMENT IN CHINA BY SECTOR AND SUB-SECTOR, 2019, AND CHANGE ON 2018, $BN

	2019	% growth on 2018
Biofuels	**0.0**	**(0 in 2018)**
Biomass & waste	**1.5**	**2%**
Geothermal	**0.0**	**(0 in 2018)**
Marine	**0.0**	**(0 in 2018)**
Small hydro	**1.2**	**0%**
Solar	**25.7**	**-33%**
(of which PV)	25.7	-32%
(and solar thermal)	0.0	-100%
Wind	**55.0**	**10%**
(of which offshore)	14.0	17%
(and onshore)	41.0	7%
Total	**83.4**	**-8%**

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

[21] The full time series for China, the U.S. and Europe is shown in Figure 12 in Chapter 1.

Looking at those sector performances in turn, the central government's decision last year to end dedicated subsidies for onshore and offshore wind after 2020 has led developers to speed up project financing and commissioning times. Other changes are afoot in Chinese onshore wind that will encourage developers. For instance, building more ultra-high-voltage transmission lines is helping China to integrate renewables, and curtailment rates are falling. Subsidy-free wind farms are also starting to be financed, to take advantage of lower turbine prices and the best wind locations.

Among the largest onshore wind projects reaching financial close in 2019 were the Huolinhe Wulanchabu Siziwang number one installation, at 600MW and an estimated $780 million, and the Inner Mongolia Wudalai New Energy Xilinguole Xilinhaote plant, at 475MW and an estimated $481 million.

In offshore wind, the rush to finance in time to qualify for the expiring feed-in tariff was even more obvious than in onshore. No fewer than 17 sea-based wind projects of more than 100MW got the go-ahead in 2019, with 12 of them reaching that milestone in the fourth quarter of the year. The two largest were the 600MW SPIC Zhanjiang Xuwen array, at $1.5 billion, and the 500MW Fujian Funeng & Haixia Fuzhou Changle C project, also estimated at $1.5 billion.

In solar PV, the country's decision in May 2018 to suspend solar subsidies had a delayed impact on growth. The policy revamp and subsequent uncertainty stopped developers from originating new pipelines. The market freeze, together with the prolonged subsidy payment delays, forced many smaller developers to exit. There was an auction for new capacity in July 2019, but some developers ran into land permit problems or grid delays.

Two highlights in the otherwise sluggish market were distribution-grid-connected solar, which was over half the new build during the first three quarters, often built without subsidy; and residential solar, where the government allocated subsidies for 3.5GW of new projects.

Overall, the amount of new PV capacity commissioned in China in 2019 is estimated to have been just over 30GW, down from 44.3GW in 2018. Among the biggest projects financed last year were the China Power International Chaoyang plant, at 500MW and an estimated $424 million, and the Jiangsu Tianhe Heilongjiang Hegang site, at 500MW and $363 million. The sub-$1 million per MW capital cost figures for these plants underline that, along with slower capacity growth, the continuing fall in PV equipment costs contributed to the decrease in the dollar investment total for Chinese solar.

Waste-to-energy is going through a dynamic period in China, with a string of incineration plants being built, particularly near coastal cities, though their main objective is to take the pressure off landfill sites, with energy production a secondary benefit. Official figures show that the country added 7GW of biomass and waste capacity between 2015 and 2018. Capital costs per MW for waste-to-energy plants are significantly lower in China than in the West.

The solar sector in India is notable for the fierce competition for projects among developers, and for capital costs that are among the lowest in the world. India awarded 12.7GW of utility-scale projects in the second half of 2019 alone, led by the 8GW project capacity auctioned under the PV manufacturing-linked tender. This is 1.7 times the previous half-yearly record. The country's government has set an ambitious target of 100GW by December 2022, up from the 37GW it had installed by the end of 2019.

There were 9GW of solar projects installed in 2019, including utility-scale projects, grid-connected rooftop solar and off-grid solar. However, the growth of solar faces an obstacle, in the shape of the distribution companies, or "discoms", which buy the electricity. Many of the discoms are financially stressed. Some of them tried to re-set agreed tariffs in 2019, and others were slow to sign power purchase agreements.

The problem has been hard to solve so far because of a lack of agreement between federal government and the state governments about how to reduce, or eliminate, the liabilities of the discoms – which have been built up by providing subsidized power to consumers. Some privatization of distribution is taking place, but this has yet to make a big impact on the problem.

INDIA

Figure 31 shows the breakdown of India's renewable energy capacity investment in 2019. Solar PV, up 8% at $6.6 billion, and onshore wind, down 48% at $2.2 billion, continued to dominate the statistics, with trace contributions from biomass and waste, biofuels and small hydro. India also made its strongest noises yet in 2019 about starting an offshore wind program, although this is still probably several years away from resulting in actual financings.

FIGURE 31. RENEWABLE ENERGY CAPACITY INVESTMENT IN INDIA BY SECTOR AND SUB-SECTOR, 2019, AND CHANGE ON 2018, $BN

	2019	% growth on 2018
Biofuels	**0.2**	**(0 in 2018)**
Biomass & waste	**0.3**	**-32%**
Geothermal	**0.0**	**(0 in 2018)**
Marine	**0.0**	**(0 in 2018)**
Small hydro	**0.1**	**-14%**
Solar	**6.6**	**8%**
(of which PV)	6.6	8%
(and solar thermal)	0.0	-100%
Wind	**2.2**	**-48%**
(of which offshore)	0.0	(0 in 2018)
(and onshore)	2.2	-48%
Total	**9.3**	**-14%**

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

Among the larger PV parks financed last year were the Azure Power Rajasthan SECI plant, at 600MW and $432 million, and the ACME Maharashtra project, at 250MW and $193 million.

The Indian wind sector saw a severe slowdown in the second half of 2019 as financing activities, the awarding of new projects, and execution of under-construction plants all took a hit. Permitting and project execution challenges, and the financial difficulties of turbine manufacturers, also caused delays. The country added just 2.4GW of wind capacity in 2019.

The forward pipeline is, meanwhile, not nearly as healthy as it should be. A total of 8.7GW of projects could have been allocated through various tenders in 2019, but only 2.3GW were awarded due to under-subscription or cancellation of tenders.

Gujurat is likely to be the first Indian state to host offshore wind activity, and its administration was working on a tender during 2019. Key details are still to be ironed out. Firstly, it is unclear whether the state of Gujarat or the federal government will foot the subsidy bill. Secondly, India has relatively low wind speeds, so the turbines that are industry-standard may not be suitable for its wind resource. In addition, who will pay for the subsea cabling and offshore transformer is still to be determined.

MIDDLE EAST AND AFRICA

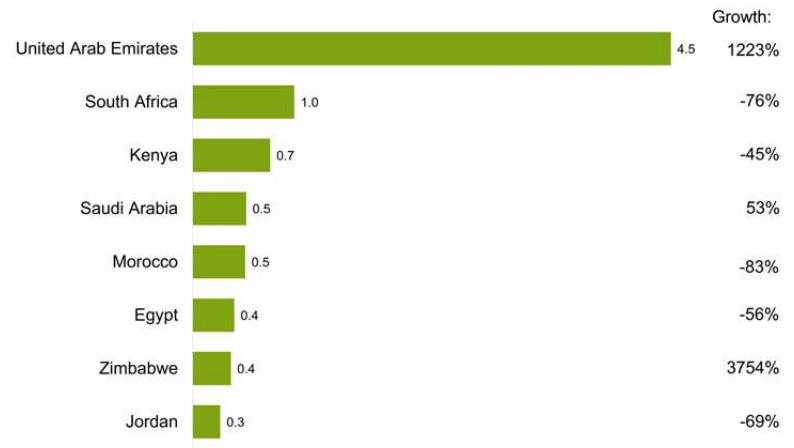
Renewable energy capacity investment in Middle East and Africa slipped 8% to $15.2 billion in 2019, from the record total of $16.5 billion reached in 2018. Several countries that had become significant investors in previous years, including South Africa, Jordan, Egypt, Morocco and Kenya, had sizeable falls in investment, due in large part to gaps in auction programs, and this was overall the main reason for the decline in the region as a whole. Trade data suggest that some $5 billion of small-scale solar systems were sold to undisclosed customers in Middle East and Africa last year. The location of these is likely to become clearer in due course.

Figure 32 highlights the fact that United Arab Emirates (U.A.E) was, by a big margin, the star performer in renewables investment in the region in 2019. Its pre-eminence owed everything to one giant project – the $4.3 billion Al Maktoum IV, made up of 600MW of solar thermal power from a 'parabolic basin complex' and 100MW from a solar tower, with a further 250MW from PV panels.

It will cover an area of 44 square kilometres, and the tower will be 260 meters high. The thermal storage of the project is planned to be 15 hours, far longer than for most solar thermal plants in operation around the world. The financing package, in March 2019, was the biggest ever in solar, and the largest to date of the non-recourse project finance type in any renewable energy technology, excluding large hydro.

The total cost is $4.3 billion, with the debt portion at $2.6 billion, a debt-equity ratio of 60%. The 27-year project loans came from five Chinese banks, three Emirati lenders, plus Natixis of France and U.K.-headquartered Standard Chartered Bank. Of the approximate $1.7 billion of equity, 51% came from Dubai Electricity and Water Authority, 25% from developer ACWA Power and 24% from China's Silk Road Fund.

FIGURE 32. RENEWABLE ENERGY CAPACITY INVESTMENT IN MIDDLE EAST AND AFRICA BY COUNTRY, 2019, AND CHANGE ON 2018, $BN



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

The U.A.E. is likely to continue to feature strongly in solar in the years ahead, with for instance a 900MW, fifth phase of the Al Maktoum program under development, this time entirely made up of PV. Its neighbor, Saudi Arabia, is just starting to scratch the surface of its renewables potential, with $502 million invested in 2019, the country's highest yet. The largest Saudi deal last year was not in solar but in wind, via the financing of the 416MW EDF Dumat Al Jandal project.

Many of the other leading renewable energy players in Middle East and Africa ran into, at least temporary, delays with their investment programs. In South Africa, where commitments fell 76% to $1 billion, momentum has slowed as the government wrestles with financial problems at the energy utility, Eskom. With a long gap persisting between auctions, the only big project to get the investment go-ahead last year was the 100MW ACWA Redstone solar thermal plant, at an estimated $697 million.

However, there is a long-term intention to build a lot more renewables. South Africa's latest Integrated Resource Plan, mapping out the energy mix for the next decade and published in October 2019, envisions the nation's total electricity production capacity rising to 77.8GW by 2030 – with the bulk of the increase coming from some 52.1GW of renewable sources.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Kenya saw investment fall 45% to $727 million, one of its few large transactions being the Frontier Investment Management Eldosol and Radiant PV portfolio, at 80MW and $148 million. Meanwhile, Zimbabwe emerged for the first time as a location for non-hydro renewables investment, with two PV parks totalling some 350MW and an estimated $342 million, financed by Chinese money.

The three most active renewables markets in North Africa and the Levant (Morocco, Egypt and Jordan) saw a total of $15.7 billion invested during the five years from 2015 to 2019, but last year was a relatively weak one for all of them. The biggest asset financings were $302 million for the 420MW ONEE Morocco PV portfolio, and $325 million for the 250MW Lekela Power West Bakr wind farm in Egypt.

In all these countries, there were gaps between the auction rounds that have fueled the momentum of their renewable energy build-out. The fact that equipment prices, particularly for PV, have been falling so fast has tended to increase policy-makers' caution over the right timing for new capacity. Nevertheless, governments continue to voice support for renewables – Egypt, for instance, saying in October 2019 that it was cancelling a giant coal project, and looking at the possibility of 500MW of additional renewables capacity.

LATIN AMERICA

This report splits the Americas into three – the U.S., Brazil and 'Other Americas' regions (for instance in Figure 11 in Chapter 1). However, looking at Latin America and the Caribbean as a region (by excluding Canada and including Brazil) we see that it raised renewable energy capacity investment by 43% to a record $18.5 billion.

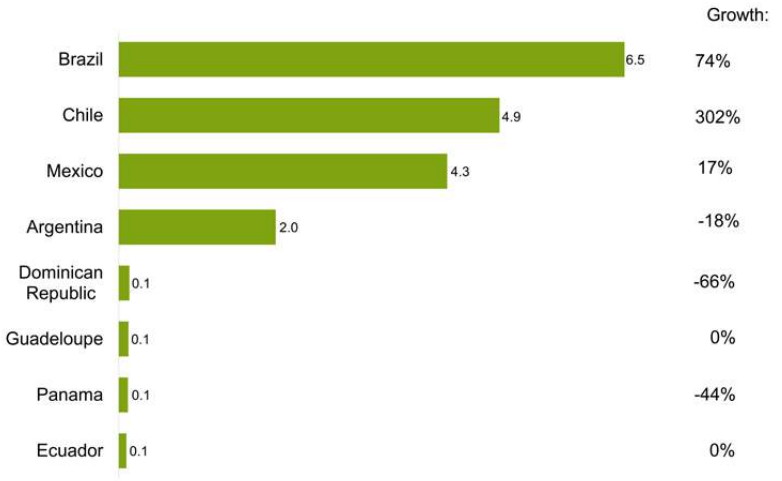
Latin America has three particular advantages over some other parts of the developing world when it comes to attracting investment. The first is excellent resources for wind, solar and biomass generation, in particular. The second is policy development that has emphasised the role of auctions in allocating new capacity, building on expertise that has been built up in the region over many years. The third, connected to the first two, has been the confidence of international developers such as Enel, EDF and Mainstream Renewable Power, and also of international lenders.

Figure 33 shows the quantum of renewables capacity investment in 2019 in Latin America and the Caribbean, by country. It is noticeable that activity last year was concentrated in just four countries, with other markets that either have been important in the past (e.g. Uruguay) or are now establishing credible auction programs (e.g. Colombia) not showing up in terms of actual dollars committed during the period.

Brazil re-established a clear lead in 2019 among investing countries in Latin America, after two years in which Mexico came close to overtaking it. Within its total of $6.5 billion, up 74% on the previous year, Brazil saw a 148% rise in wind financing to $3.4 billion and a 30% advance in solar to $2.5 billion.

On June 2019, Brazil held its 29th energy auction, securing power-delivery contracts for solar, wind, hydro and biomass. The auction had a record low solar average price of $17.5/MWh for 204MW from

FIGURE 33. RENEWABLE ENERGY CAPACITY INVESTMENT IN LATIN AMERICA BY COUNTRY, 2019, AND CHANGE ON 2018, $BN



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

six PV plants. Wind secured 95MW from three plants at $20.71/MWh, the second-lowest average wind price ever. A second auction, in October, secured power-delivery contracts from 3GW of wind, solar, hydro, biomass and gas plants, with slightly higher tariffs awarded than in June for both solar and wind.

Chile enjoyed a 302% jump in renewables capacity investment to $4.9 billion, its highest ever. Wind deals galloped to $2.7 billion, from almost nothing the previous year, while solar increased 85% to $2.2 billion. Much of the reason for Chile's increase came down to the timing of particular large financings, relating to projects that won capacity in previous years' auctions.

The Mexican total regained 17% to $4.3 billion, albeit still below the peak tally of $6.1 billion from 2016. Wind fell 15% to $887 million, but solar increased 31% to $3.4 billion. However, there was uncertainty over energy policy under the presidency of Andres Manuel Lopez Obrador, and there were no fresh auctions during 2019.

Argentina was the only one of the big four to suffer a drop in investment in 2019. It recorded a total of $2 billion, down 18%. The sector split showed solar almost halving to $268 million, while wind slipped 9% to $1.7 billion. The country held only one mini-auction during 2019.

Among the largest financings in the four countries last year were the Ventos De Santa Angela wind portfolio in Brazil, at 510MW and an estimated $578 million; the Loma Blanca & Miramar wind portfolio in Argentina, at 348MW and $558 million; the Mainstream Andes Renovables Phase I Condor wind projects in Chile, at 425MW and $835 million; and the FRV Potrero PV project in Mexico, at 297MW and $336 million.

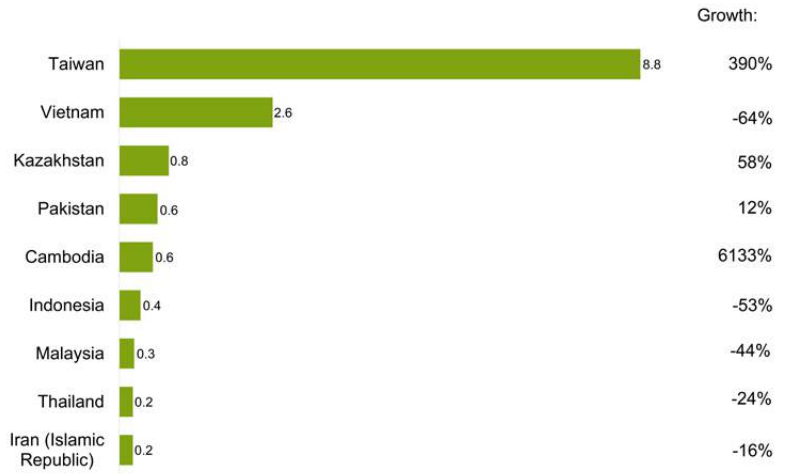
EMERGING ASIA-PACIFIC

Investment in non-OECD Asia-Pacific (excluding China and India) reached $15.2 billion in 2019, a record tally and up 17% from the previous year. However, as Figure 34 shows, more than half that total was accounted for by just one market – Taiwan. Renewables investment volumes in other parts of the region were distinctly mixed last year.

The all-time high tally for Taiwan in 2019, at $8.8 billion, owed something to $1 billion worth of small-scale solar, but the main contribution was from the financing of three large offshore wind arrays – the 640MW Wpd & Starwind Yunlin, the 900MW Orsted Greater Changhua, and the 376MW Swancor & Macquarie Formosa II Miaoli – together costing an estimated $7.8 billion.

These deals were notable for involving a large number of both local Taiwanese and international financial and supply chain players. The Yunlin project, for instance, got debt from 19 banks, including four from France, three from Germany, one loan each from the U.K. and the Netherlands, and three from Japan. Siemens Gamesa secured the turbine contract, and Dutch company Van Oord the engineering, procurement and construction work.

FIGURE 34. RENEWABLE ENERGY CAPACITY INVESTMENT IN NON-OECD ASIA (EXCLUDING CHINA AND INDIA), 2019, AND CHANGE ON 2018, $BN



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

The Taiwan offshore wind market is being driven by a 20-year feed-in tariff, which was trimmed in early 2019 but remained attractive enough to prompt nearly 2GW of financings during the year. Confidence is being supported by government ambitions for 10GW of additional offshore wind capacity between 2026 and 2035.

Vietnam saw a meteoric rise in solar investment in 2018 on the back of a generous feed-in tariff, but this faded markedly after June 2019, when the level of support was cut by the government. Overall renewable energy investment slipped 64% to $2.6 billion in 2019. The boom resulted in 5.4GW of solar being built in 2019, much of it financed in the previous year. By comparison, less than 200MW of PV were constructed in 2018 itself.

Among the PV projects financed in 2019 was the Trung Nam Construction Tra Vinh Duyen Hai, at 165MW and $153 million. Vietnam also saw significant projects funded in other technologies – including the 40MW Vietstar Ho Chi Minh Cu Chi waste-to-energy plant, at an estimated $400 million; and the Sowitec Quang Binh 1 wind farm, at $328 million for 252MW.

Three other markets in emerging Asia-Pacific came in above the $500 million mark for renewable energy investment last year. Kazakhstan chalked up a record tally of $832 million, up 58%, thanks to the financing of a string of medium-sized wind and solar projects developed by international players such as China Power International and Total Eren. The fossil fuel-rich Central Asian country introduced auctions for renewables in 2018, and its energy minister voiced an aspiration in early 2019 to more-than-double green energy capacity in that year.

Pakistan saw renewables capacity investment advance 12% to $647 million, but this was still below its five-year average of $1.2 billion. The majority of this (some $500 million) consisted of small-scale solar systems, many of them built by commercial and industrial firms, for self-consumption and for selling on power to other consumers. Cambodia was a new entrant in the list of investing countries, with a leap to $568 million in 2019, from almost nothing the previous year. It owed much of this jump to the financing of one big PV park; the 135MW Innergex Kandal project.

Several large economies are notable for their lowly position in, or absence from, Figure 34. Indonesia saw investment slip by half to just $359 million, almost all in its established geothermal sector, as institutional and regulatory barriers continued to prevent an upswing in solar and wind. In Malaysia, outlays fell 44% to $250 million, but an auction for 500MW of new solar capacity, closed in August 2019, was heavily over-subscribed and should lead to a flurry of financing activity.

The Philippines, which was an up-and-coming market in the middle of the decade with $2.4 billion invested in 2015 alone, had little more than $100 million committed to renewables in 2019. The previous feed-in-tariff schemes drove developments in the wind and solar sectors between 2014 and 2016, but a policy gap after the expiry of those led to green power activity stalling. In July 2019, the Department of Energy in Manila announced plans to auction 2GW of renewable energy capacity to encourage development, but these remain potential rather than certain.

In Thailand, renewables investment was just $229 million in 2019, compared to a high of $2.4 billion in 2016. A delay in the release of the government's revised Power Development Plan for the years to 2037, initially expected in the first half of 2018, along with a current supply overcapacity, led developers to adopt a wait-and-see approach, dampening investment appetite for new power plants in the country.

CAPACITY INVESTMENT – DEVELOPED COUNTRIES

- Investment in new renewable energy capacity in developed economies rose 2% in 2019, to $130 billion. There were sharp increases in outlays in the U.S., Spain, the Netherlands and Poland, and big falls in the U.K., Germany, Australia and Belgium.
- The U.S. had a particularly strong year for the financing of renewables projects, its total of $55.5 billion being the highest ever and up 28% on 2018. A rush to qualify wind projects for the Production Tax Credit was the single biggest feature of 2019.
- Europe saw capacity investment shrink 7% to $54.6 billion, a key reason being that fewer multibillion-dollar offshore wind financings took place during the year than in 2018. This may be a temporary blip, given the large pipeline of sea-based projects under development for the 2020s.
- Solar capacity investment in Europe jumped 25% to $24.6 billion, the highest since 2012. The increase took place despite the low cost per megawatt of many of the new PV projects built under auction programs or merely with private sector power purchase agreements.
- In Japan, dollar investment in new solar projects continued to edge down, partly due to lower capital costs. That country continued to be a significant location for the construction of new biomass capacity, and it stepped closer to starting an offshore wind program.

As Figure 13 in Chapter 1 showed, developed economies continued in 2019 to account for a minority of global investment in new renewable energy capacity. However, their total, at $130 billion, up 2% on 2018, was the highest for three years and still made up 46% of the amount committed worldwide.

Some 13 developed countries, on the definition used in this report, had renewable energy capacity investment of $1 billion or more last year, and six of them exceeded $5 billion (see Figure 11 in Chapter 1). The U.S. and Japan continued to be the two biggest developed economy investors in green energy, with the U.S. accounting for more than Europe as a whole for the first time ever.

UNITED STATES

Figure 35 reveals the technology split of 2019's record year of renewable energy capacity investment in the U.S. Overall outlays increased by 28% to $55.5 billion. Within this solar rose 16% to $23.3 billion while wind leapt 44% to $31.8 billion, almost entirely thanks to onshore projects. Other technologies saw minimal investment, with biofuels for instance down 38% at $320 million, the lowest tally for that sector since 2016.

Developers in the U.S. of both solar and wind are driving ahead with projects in order to qualify them for as much as possible of the soon-to-expire tax credits. In solar, the incentive is the Investment Tax Credit, or ITC. The rule is that if construction started in 2019, then the project owner (commercial developer or household) would be eligible to receive a credit equivalent to 30% of

FIGURE 35. RENEWABLE ENERGY CAPACITY INVESTMENT IN THE U.S. BY SECTOR AND SUB-SECTOR, 2019, AND CHANGE ON 2018, $BN

	2019	% growth on 2018
Biofuels	**0.3**	**-38%**
Biomass & waste	**0.0**	**-89%**
Geothermal	**0.0**	**-100%**
Marine	**0.0**	**(0 in 2018)**
Small hydro	**0.0**	**(0 in 2018)**
Solar	**23.3**	**16%**
(of which PV)	23.3	16%
(and solar thermal)	0.0	(0 in 2018)
Wind	**31.8**	**44%**
(of which offshore)	0.3	(0 in 2018)
(and onshore)	31.5	42%
Total	**55.5**	**28%**

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

the capital cost, but this proportion falls to 26% if construction only starts in 2020 and 20% if it begins in 2021. Thereafter, it falls to 10% or zero depending on the nature of the project.

The desire to qualify for the ITC and by that get help with the capital cost provided an incentive for developers, large and small alike, to secure finance for projects during 2019. This outweighed U.S. solar industry problems such as the tariffs imposed on equipment imported from China.

One of the largest PV parks to reach financial close in 2019 was Danish company Orsted's 546MW Permian project in Texas, which will also have 40MW of battery storage and is scheduled to come online in 2021. Another was the Cove Mountain complex in Utah, at an estimated $313 million for 234MW. Slated for completion in late 2020, it has agreements to sell power to Facebook data centers.

The biggest story of 2019 in U.S. renewables was the buoyancy of the onshore wind sector. Financings totalled $31.8 billion, up 44% on the previous year, which was itself a record. Booms and contractions in U.S. wind have often been caused by 'cliff edges' in the availability of Production Tax Credit (PTC) support, and 2019 proved no exception.

To qualify for any level of PTC at all, developers had to qualify their projects by the end of 2019, either by starting construction or by spending 5% of total project capital expenditure, and they had to commission them by the end of 2023.

In the event, this restriction was loosened by the U.S. Congress in December 2019, as part of a bill to keep the federal government running. The deadline for starting construction in order to qualify for 60% of the original PTC was shifted back by one year, to the end of 2020 – and the deadline for commissioning the project was extended to the end of 2024.[22]

However, investors could not know of this temporary reprieve at any earlier stage during last year. Since the money to pay for a large onshore wind project has to be secured a year or more in advance of commissioning, the impending phase-out of the tax credit meant strong pressure on developers and investors to sign financing deals during 2019.

Among the biggest deals in this context during 2019 was Apex's financing of the 525MW Aviator wind farm, for an estimated $683 million. The project, in Coke County, Texas will have 200MW of its capacity covered by a power purchase agreement, or PPA, with Facebook, and a 220MW deal with McDonald's – the first virtual PPA ever signed by the hamburger chain.

EUROPE

Capacity investment in Europe fell slightly short of that in the U.S. in 2019, slipping 7% to $54.6 billion, a couple of billion dollars below the region's five-year average.[23] Figure 36 shows the split of that investment last year, and highlights an intriguing contrast – wind investment fell by 24% to $26.4 billion, but solar saw a 25% increase to $24.6 billion.

Both offshore and onshore wind saw reductions in investment, the former of 38% to $7.5 billion, and the latter of 17% to $18.9 billion. The reasons were very different: offshore wind simply saw fewer deals falling into the 2019 calendar year, due to the timing of auction rounds; but onshore wind's decline reflected a drift to less favorable policy or planning conditions in key markets such as Germany and the Nordic countries.

Solar in Europe attracted more investment in 2019 than in any year since 2012, which was the tail-end of the booms in Germany and Italy driven by generous government-set feed-in tariffs. The sector in 2019 benefitted from the spread of low-cost projects in Spain and elsewhere, relying on tariffs set in auctions or via private sector power purchase agreements.

Biomass and waste-to-energy was a significant sector for Europe last year, with investment rising 12% to $3.1 billion, the highest since 2016. Waste-

FIGURE 36. RENEWABLE ENERGY CAPACITY INVESTMENT IN EUROPE BY SECTOR AND SUB-SECTOR, 2019, AND CHANGE ON 2018, $BN

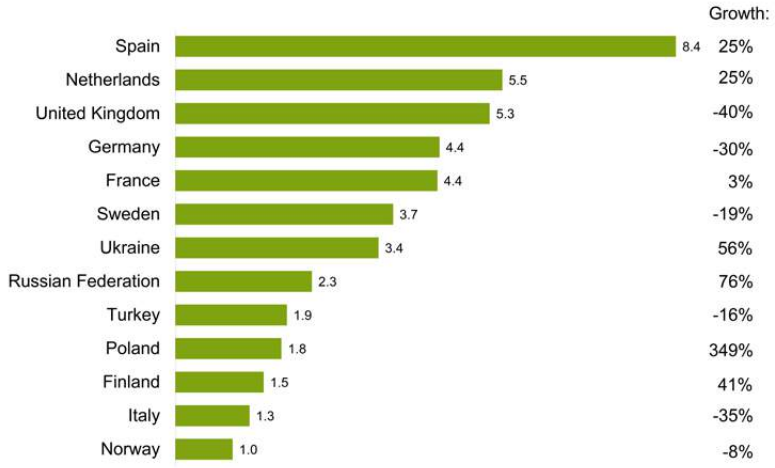
	2019	% growth on 2018
Biofuels	**0.0**	**-100%**
Biomass & waste	**3.1**	**12%**
Geothermal	**0.5**	**-40%**
Marine	**0.0**	**(0 in 2018)**
Small hydro	**0.0**	**(0 in 2018)**
Solar	**24.6**	**25%**
(of which PV)	24.6	25%
(and solar thermal)	0.0	-100%
Wind	**26.4**	**-24%**
(of which offshore)	7.5	-38%
(and onshore)	18.9	-17%
Total	**54.6**	**-7%**

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

[22] BloombergNEF: *Congress Hands U.S. Wind Another Holiday Gift* https://www.bnef.com/core/insights/22013

[23] The total for Europe includes several countries that are classified as developing in Figure 29 (including Russia, Ukraine and Turkey).

FIGURE 37. RENEWABLE ENERGY CAPACITY INVESTMENT IN EUROPE BY COUNTRY, 2019, $BN, AND GROWTH ON 2018



Countries with investments rounding up to $1 billion or more in 2019
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

to-energy took the lead, with projects worth hundreds of millions of dollars each in the U.K. and Russia.

Figure 37 illustrates the fact that capacity investment in Europe was widely spread between countries in 2019. This has not always been the case – in some earlier years, just a couple of markets (such as Germany and the U.K. in 2016) accounted for a large majority of the money committed in Europe. In 2019, no fewer than 12 countries attracted investment of more than $1 billion – if Russia and Turkey are included within the European region – and one other (Norway) had a total of just under that figure.

Spain invested more in renewables in 2019 than any other European country, the first time it has done so – although it came close in 2007 and 2008, when its previous boom put it just behind the then regional leader, Germany. The 2019 total for Spain, at $8.4 billion, was 25% up on the previous year and the country's highest since 2011.

What marks out the latest upswing in Spanish renewables investment is that capacity is being built at far lower capital cost per megawatt than it was a decade ago. Most of the financings in 2019 were in solar, which saw a 75% jump in investment to $6 billion, while wind deals fell 20% to $2.4 billion.

The lowest-cost PV projects in Spain are now happening at far below $1 million per megawatt. The Cobra Zero-E portfolio, for instance, is 900MW but reached financial close with an estimated cost of $658 million. This portfolio covers 18 plants in Teruel and Ciudad Real, capacity that won fixed tariffs in a renewable energy auction in 2017.

Europe's single biggest PV project, Iberdrola's 500MW Nunez de Balboa plant in Badajoz, was financed in 2019 and completed near the end of the year, at a cost in euros equivalent to about $330 million. Debt came from the European Investment Bank and Instituto de Credito Oficial, Spain's state financial agency.

The Netherlands and the U.K. came second and third in terms of dollars invested in 2019, respectively attracting $5.5 billion, up 25% on 2018, and $5.3 billion, down 40%. Both totals included offshore wind arrays – in the Dutch case, the 383MW Fryslan project, financed for an estimated $925 million; and in the British case, the 432MW Neart na Gaoithe project off the Scottish coast at $3.4 billion.

However, both countries also witnessed activity in other sectors too. The Netherlands saw $3.1 billion invested in large- and small-scale solar, as investors took advantage of the country's SDE+ auction program.[24] The U.K. had three waste-to-energy plants financed in 2019, totaling $1.4 billion, with the main revenues coming from 'gate fees' for accepting rubbish that might otherwise have been subject to landfill taxes.

Germany experienced a 30% fall in renewable energy investment last year, to $4.4 billion. Solar, led by small-scale, rose 15% to $3.4 billion, but wind financings came to just $1 billion, down 68% on 2018 and lower than any other year during the period since 2004. In 2013-2017, annual wind investment in Germany averaged $12 billion. Part of the reason for the weak number in 2019 was the absence of any large offshore wind financing

[24] SDE+ stands for Stimulation of Sustainable Energy Production, and is a subsidy for the production of renewable energy in the Netherlands

– highly unusual for one of the world's biggest offshore markets. This is likely to be a temporary blip, since Germany signalled last autumn that it wanted to increase its 2030 offshore wind target to 20GW, from 15GW.

However, the sharp slowdown in onshore wind activity is likely to be more lasting. Five consecutive wind auctions were undersubscribed, with many auction winners just wanting to add two to three turbines to existing wind parks. Contributing factors include a shortage of available sites, litigation and drawn-out lead times for projects.

In France, by contrast, wind made up the lion's share ($3.5 billion) of the country's 2019 investment total. Much of this was thanks to the financing of the 480MW Saint Nazaire project, the first one of France's offshore wind program to reach that stage. It has an estimated cost of $2.5 billion, with a consortium of banks providing $2.1 billion in debt, and equity coming from owners EDF and Enbridge.

Sweden continued to enjoy significant onshore wind investment, backed by corporate power purchase agreements. The country's green certificate scheme provides an additional incentive for some projects, but not all. The biggest step of 2019 was start of construction at the Enercon Markbygden wind farm phase two, at 844MW and with an investment cost of $1.1 billion. The project is likely to attract more investors and a buyer for the electricity in due course.

Ukraine and Russia are two names that have not featured often on the list of top investing countries in green power. However, Ukraine's commitment to wind and solar has been building up in recent years, reflecting its desire to diversify away from reliance on Russian gas, and in 2019 it invested $3.4 billion in renewables, up 56% on the previous year's then-record of $2.2 billion. Russia has raised its interest in clean power in the last two years, investing $1.3 billion in 2018 and $2.3 billion in 2019.

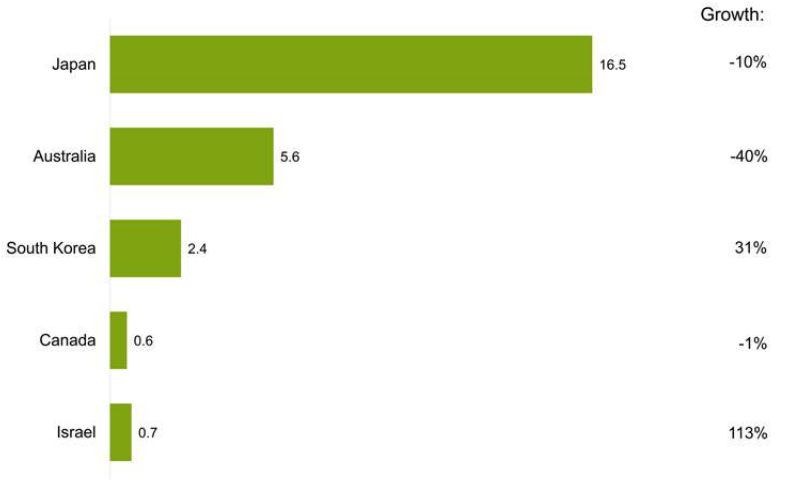
The largest Ukrainian financial close of 2019 was an estimated $975 million for the 750MW NBT Zofia wind farm phases two and three, but there were also large-scale PV projects getting the go-ahead, including the 323MW DTEK Pokrovskaya plant at a cost of $219 million. Both wind and solar were spurred ahead by feed-in tariffs – but these came under threat in early 2020, as the government threatened to cut them sharply, even for operating projects.

Russia is developing its wind and solar resources via a series of auctions, and 2019 saw the investment go-ahead for several large wind farms, including the Novawind Kochubeyevskaya, at 210MW and $359 million. However, its biggest deal of the year by far was the estimated $781 million financing of four waste-to-energy projects around Moscow, totalling 280MW. This new capacity is aimed at addressing the capital city's overflowing landfill sites.

OTHER DEVELOPED ECONOMIES

Figure 38 shows the capacity investment volumes in 2019 in five other developed countries – Japan, Australia, South Korea, Canada and Israel. The latter two countries have been significant investors in wind and solar respectively at times in the last decade, but last year activity levels were low in both.

FIGURE 38. RENEWABLE ENERGY CAPACITY INVESTMENT IN OTHER MAJOR DEVELOPED ECONOMIES, 2019, AND GROWTH ON 2018, $BN



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

Japan saw investment of $16.5 billion, down 10% on 2018 levels and its lowest total since 2011. Part of the reason for the fall was lower unit costs for solar, cutting the dollar amount committed per megawatt, and partly the country's continued grid and land constraints that held back developer activity and auction bidding. Overall, solar investment slipped 7% to $13.6 billion. One of the larger financings was $154 million for the 45MW Etrion Niigata Agano PV park.

Biomass investment in Japan climbed 26% to $2.6 billion, with the biggest transaction worth the equivalent of $395 million for the 75MW Gas and Power Hirohata Himeji plant. A change in the type of project eligible for feed-in tariffs is likely to push projects burning wood pellets and palm kernel shells to compete in a tender for a limited amount of capacity.

Japan looks likely to become a significant offshore wind market in coming years, but 2019 was too early for any actual financings. Its first commercial-scale project, the 220MW Hibikinada array, chose a preferred turbine supplier. It is likely to reach commissioning in 2025.

Australia saw record investment in renewables back in 2018, as developers rushed to meet the country's Large-scale Renewable Energy Target, and qualify for the associated certificates. These can then be sold to utilities. However, in 2019 it became clear that no further capacity was required to meet the LRET, so investors were thrown back on other ways of making projects bankable, including Victoria's own auctions and the signing of corporate power purchase agreements.

This led to a 40% fall in investment in Australian renewables in 2019, to $5.6 billion. Small-scale solar projects remained an area of strength, driven by reduced costs per MW, strong sunshine and high power prices, and there were a few large utility-scale projects financed – led by the Partners Group CWC Bango wind farm in New South Wales, at 244MW and $339 million.

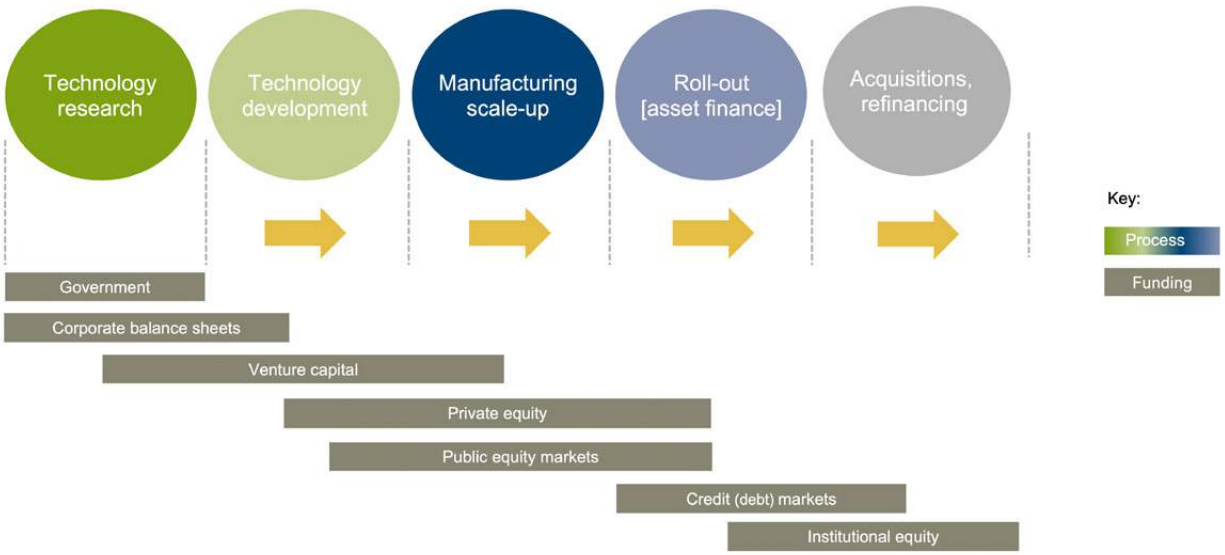
South Korea clinched investment of $2.4 billion in 2019, up 31% on the previous year and the highest figure to date for the country. Solar dominated, with commitments of $1.9 billion, but there were also smaller sums going to onshore wind and biomass and waste-to-energy.

BNEF estimates that 75% of South Korea's new PV installations in 2019 came from the sub-1MW segment, mostly 100kW ground-mounted projects developed by small-scale independent power producers or individuals. A temporary feed-in tariff for sub-100kW projects was introduced in late 2018, leading to rushed development activity in 2019 as spot renewable energy certificate prices continued to fall – making the new incentive increasingly attractive. One of the larger projects financed during the year was the DaeMyoung Energy Yeongam PV park, at 92MW and an estimated $189 million.

TOTAL RENEWABLE ENERGY INVESTMENT

- If you include research and development and the funding of specialized companies, as well as the financing of generation capacity, then the resulting figure for total renewable energy investment was $301.7 billion in 2019.
- This was 2% up on the 2018 total, and the third highest on record – after 2015 and 2017. Over the decade 2010-2019, total renewable energy investment was $2.8 trillion, or an average of $284 billion per year.
- Within the 2019 tally, asset finance of utility-scale projects dominated, with the funding of small-scale solar projects the second-biggest element. These types of investment were discussed in earlier chapters.
- Investment in specialist renewable energy companies via the public markets rose 11% to $6.6 billion, the highest for four years. Venture capital and private equity funding jumped 22% to $3 billion, also a four-year high – although still less than a third of the record figure set in 2008.
- Corporate research and development spending slipped 1% to $7.7 billion, after three years of increase. Government R&D spending edged up 4% to $5.7 billion.
- Acquisition activity in renewable energy dropped 34% in 2019, mainly due to a big fall in the sale and purchase of assets such as solar farms. Corporate mergers and acquisitions in renewables slipped 6% to $13.7 billion.

FIGURE 39. FINANCING CONTINUUM



FINANCING CONTINUUM

Earlier chapters of this report concentrated on investment in new renewable energy capacity. This chapter looks beyond that, to the full range of funding that was devoted to renewable energy in 2019.

Successive editions of the Global Trends report have highlighted the "financing continuum" that has made possible the growth of renewable energy around the world over recent years. Different types of investor have backed technologies such as wind, solar and bioenergy at different stages of their development. The continuum is shown in Figure 39.

At the left side are the early stages of the process. New technologies have to be investigated and researched in the lab and factory. This work may be done by the research and development departments of large companies, or by entrepreneurial start-ups or in public sector agencies, and it needs to be financed. Some of the money will come from government research programs and grants, and some from corporate balance sheets. Therefore government and corporate R&D are the first two elements identified in the charts in this chapter showing total renewable energy investment.

Moving slightly further to the right, there is the technology development stage, which can involve a range of different finance sources. Corporate R&D will still be involved in testing and finessing new products, but equity contributed by venture capital investors will too, by backing young companies with a promising technology.

Somewhat further along the line of maturity in Figure 39, private equity investors are likely to come in to back growing companies. Private equity will typically put in larger sums of capital than venture funds, and will look to crystallize a profit by selling shares when the business floats on the stock market, or is taken over. Public equity markets bring money from conventional institutional and private investors into the shares of renewable energy companies, enabling the latter to commercialize their technologies and build manufacturing capacity.

Both private equity and stock market investors are often involved at the stage of rolling out the technologies into utility-scale or small-scale renewable energy installations. Typically, for a wind farm or solar park, some 20-40% of the cash for construction and operation will come from these types of equity provider, or from the project developer themselves, while the remaining, larger share will come from lenders – usually banks but sometimes bond investors.

On the right side of Figure 39 is the stage of the financing continuum that deals with money and assets changing hands, rather than the provision of new money. Projects such as wind farms often are refinanced once they are operating, so that the owners can take advantage of lower-cost debt. Or they may be acquired by new owners for strategic reasons or because those new owners want to invest in operating-stage assets but not to be exposed to the higher risks that come from developing and constructing the project.

The next section in this chapter discusses those different stages of the financing continuum – both those involving only the provision of new money, and the later, acquisition stage. Those stages, other than the building of new capacity (which was the focus of the earlier chapters of this report), are examined in detail in Chapters 6 and 7.

OVERALL INVESTMENT

Figure 40 shows that a total of all the types of new investment described above came to $301.7 billion in 2019, up 2% on the previous year. This global aggregate was the third-highest on record, behind only 2015's $317.3 billion and 2017's $331.4 billion. It was also somewhat above the average for the last decade, of $284 billion.

The chart shows that there has been a sideways trend in the overall renewable energy investment total since 2015. A large part of the explanation lies, as expounded in Chapter 1, in the fact that wind and solar capital costs have been falling rapidly, with the result that more megawatts of new capacity can be added for the same dollar expenditure. This has restrained the trend in the asset finance of new projects, and the roll-out of small distributed solar capacity.

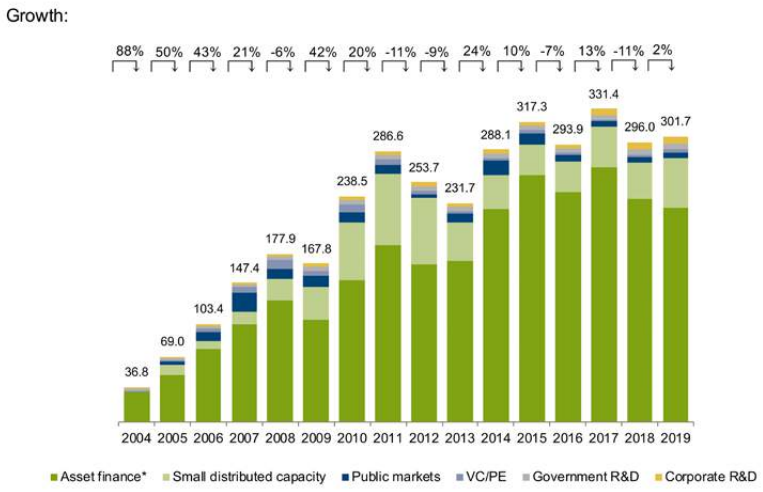
However, that is not the only reason for the lack of clear trend in Figure 40. Some other elements in the financing continuum have also been steady, or have oscillated. Public markets investment, for instance, grew 11% in 2019, to $6.6 billion – but this was far short of the decadal peaks, at well over $10 billion a year, seen at the time of the 'yieldco' boom in the U.S. in 2014-2015.[25]

Venture capital and private equity investment has been even more directionless, rising 22% in 2019 to $3 billion but remaining below the decade's average of $3.4 billion a year. Wind and solar equipment has become largely standardized and commoditized, leaving much reduced space for young companies to make technological breakthroughs. Other sectors that saw strong VC/PE interest 10-12 years ago, such as biofuels and marine energy, have not grown as hoped.

Corporate R&D spending slipped 1% to $7.7 billion last year, bringing to an end a steady upswing seen since 2015, while government R&D gained 4% to establish a new record at $5.7 billion.

Figure 41 illustrates the relative scale of the different elements of the financing continuum in 2019. At the left end, venture capital funding came in at $1.2 billion, with government and corporate R&D at $5.7 billion and $7.7 billion respectively, and public markets investment at $6.6 billion. This produced a total for company and early-stage investment of $23 billion.

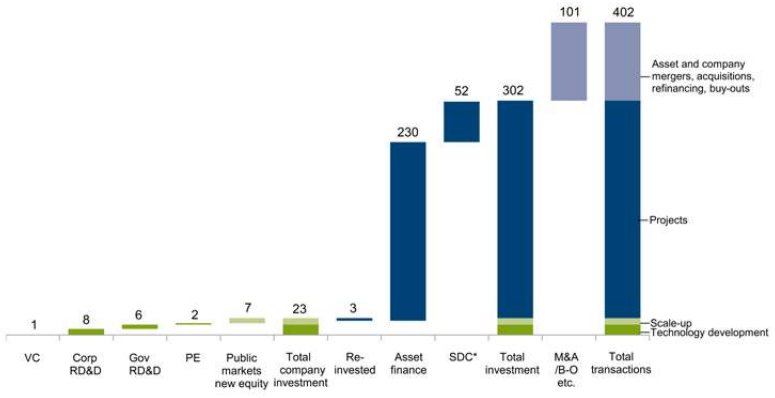
FIGURE 40. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY ASSET CLASS, 2004-2019, $BN



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

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 41. GLOBAL TRANSACTIONS IN RENEWABLE ENERGY, 2019, $BN



SDC = small distributed capacity. Total values include estimates for undisclosed deals. Figures may not add up exactly to totals, due to rounding.

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

[25] Yieldcos are companies set up to own operating-stage renewable energy companies, and to return the great majority of cash flows to investors.

FIGURE 42. GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2020 DATA TABLE, $BN

Category / Year / Unit	2004 $bn	2005 $bn	2006 $bn	2007 $bn	2008 $bn	2009 $bn	2010 $bn	2011 $bn	2012 $bn	2013 $bn	2014 $bn	2015 $bn	2016 $bn	2017 $bn	2018 $bn	2019 $bn	2018-19 Growth %	2004-19 CAGR %
1 Total Investment																		
1.1 New investment	36.8	69.0	103.4	147.4	177.9	167.8	238.5	286.6	253.7	231.7	288.1	317.3	293.9	331.4	296.0	301.7	2%	15%
1.2 Total transactions	45.2	95.2	136.9	204.3	236.2	229.3	295.8	361.6	319.3	298.7	376.9	425.4	427.8	477.7	437.4	402.4	-8%	16%
2 New Investment by Value Chain																		
2.1 Technology development																		
2.1.1 Venture capital	0.4	0.6	1.2	2.1	3.3	1.6	2.6	2.6	2.4	0.8	1.0	1.4	0.8	0.8	0.2	1.2	508%	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	5.1	5.1	5.5	5.7	4%	8%
2.1.3 Corporate R&D	1.9	1.9	2.2	2.3	3.3	3.3	3.8	4.3	4.1	4.0	4.3	4.1	4.3	6.9	7.8	7.7	-1%	10%
2.2 Scale-up																		
2.2.1 Private equity expansion capital	0.3	1.0	2.9	3.5	6.7	3.0	5.3	2.4	1.6	1.3	1.7	1.8	1.7	0.7	2.2	1.8	-22%	12%
2.2.2 Public markets	0.3	3.6	8.9	19.7	10.5	11.7	10.6	9.9	3.8	9.8	14.9	12.0	6.2	5.6	6.0	6.6	11%	24%
2.3 Projects																		
2.3.1 Asset finance	32.1	50.0	79.2	106.3	133.5	111.8	152.2	189.6	170.1	171.5	228.4	267.7	247.5	272.6	242.0	230.1	-5%	14%
Of which re-invested equity	-0.1	-0.2	-2.2	-3.1	-4.4	-3.7	-1.8	-2.1	-2.9	-1.2	-3.5	-6.7	-4.1	-2.9	-5.8	-3.4	-41%	26%
2.3.3 Small distributed capacity	8.0	10.1	9.0	13.9	22.2	34.7	60.9	75.1	69.9	40.2	36.7	32.6	32.5	42.5	38.2	52.1	37%	13%
Total Financial Investment	32.9	55.0	90.0	128.5	149.6	124.4	169.0	202.4	174.9	182.2	242.6	276.1	252.1	276.9	244.6	236.3	-3%	14%
Gov't R&D, corporate RD&D, small projects	11.9	14.0	13.4	18.9	28.4	43.4	69.5	84.1	78.8	49.4	45.5	41.1	41.8	54.5	51.4	65.5	27%	12%
Total New Investment	44.8	69.0	103.4	147.4	177.9	167.8	238.5	286.6	253.7	231.7	288.1	317.3	293.9	331.4	296.0	301.7	2%	14%
3 M&A Transactions																		
3.1 Private equity buy-outs	0.8	3.7	1.8	3.3	5.1	1.9	1.9	2.9	3.0	0.5	4.1	3.6	3.2	10.6	13.0	3.2	-76%	10%
3.2 Public markets investor exits	0.4	2.3	2.6	3.9	0.9	2.4	4.8	0.2	0.4	1.7	1.6	1.5	6.4	2.8	0.1		-100%	-100%
3.3 Corporate M&A	2.2	7.6	10.3	19.8	16.5	22.4	18.7	29.6	9.3	16.2	11.2	18.4	29.5	13.3	14.6	13.7	-6%	13%
3.4 Project acquisition & refinancing	5.1	12.5	18.7	29.9	35.8	34.9	32.0	42.3	53.0	48.7	71.9	84.6	94.8	119.6	123.8	83.8	-32%	21%
4 New Investment by Sector																		
4.1 Wind	18.4	26.3	35.4	58.8	73.9	72.5	97.8	83.3	78.3	83.3	111.1	119.7	123.5	133.4	132.7	142.7	8%	15%
4.2 Solar	10.7	15.3	21.6	37.5	60.5	63.6	102.0	160.1	144.0	120.4	147.8	176.6	145.9	180.8	143.5	141.0	-2%	19%
4.3 Biofuels	3.9	9.8	26.3	26.4	17.6	9.4	10.1	10.5	7.7	5.1	5.5	3.6	2.1	3.3	3.3	3.0	-10%	-2%
4.4 Biomass & w-t-e	7.9	9.3	12.0	15.9	16.4	13.4	17.3	20.9	15.4	14.6	13.1	10.4	15.2	7.4	11.5	11.2	-2%	2%
4.5 Small hydro	2.8	7.5	6.8	6.5	7.6	6.0	8.2	7.7	6.3	5.7	7.4	4.2	4.3	4.0	2.3	2.5	6%	-1%
4.6 Geothermal	1.1	0.8	1.3	1.7	1.7	2.5	2.8	3.8	1.7	2.4	2.9	2.5	2.7	2.4	2.5	1.2	-50%	1%
4.7 Marine	0.0	0.1	0.1	0.7	0.2	0.3	0.3	0.3	0.3	0.2	0.4	0.2	0.2	0.2	0.2	0.2	-8%	12%
Total	44.8	69.0	103.4	147.4	177.9	167.8	238.5	286.6	253.7	231.7	288.1	317.3	293.9	331.4	296.0	301.7	2%	14%
5 New Investment by Geography																		
5.1 United States	6.0	11.3	28.5	30.5	34.7	23.0	34.6	50.3	40.7	36.1	38.4	46.9	44.4	48.6	47.1	59.0	25%	16%
5.2 Brazil	0.7	2.4	4.1	9.9	11.1	6.9	7.2	10.2	7.8	3.9	7.7	6.4	5.7	6.2	3.8	6.8	78%	16%
5.3 AMER (excl. US & Brazil)	1.7	3.7	3.5	4.8	5.6	5.0	12.0	9.8	10.4	12.5	15.2	11.5	6.5	13.2	10.7	12.8	20%	14%
5.4 Europe	23.3	31.6	40.7	64.5	79.1	76.5	112.2	131.7	91.1	57.7	68.7	61.1	71.5	49.1	60.8	58.4	-4%	6%
5.5 Middle East & Africa	0.6	0.8	1.2	1.8	2.2	1.5	4.0	3.1	9.9	7.2	8.4	11.6	7.1	10.7	16.5	15.4	-7%	24%
5.6 China	3.0	8.5	10.5	17.2	25.8	36.7	42.4	45.7	56.6	63.4	88.7	121.1	105.6	148.4	95.9	90.1	-6%	25%
5.7 India	2.7	3.0	4.8	6.1	5.3	4.3	7.7	12.4	6.7	5.0	7.4	8.0	12.5	13.7	11.6	11.2	-4%	10%
5.8 ASOC (excl. China & India)	6.7	7.6	10.0	12.6	14.1	13.9	18.5	23.5	30.4	45.8	53.7	50.6	40.7	41.6	49.6	48.2	-3%	14%
Total	44.8	69.0	103.4	147.4	177.9	167.8	238.5	286.6	253.7	231.7	288.1	317.3	293.9	331.4	296.0	301.7	2%	14%

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

Moving further to the right in Figure 41, there is a relatively small adjustment of $3.4 billion for re-invested equity. This is money raised on public markets or from private equity that then finds itself going into the construction of new renewable energy capacity. Then there are the two largest aggregates – asset finance at $230.1 billion, and small distributed capacity (solar systems) of $52.1 billion. That takes the chart to total new investment in renewables in 2019, of $301.7 billion.

Finally, on the right, there is a column for acquisition activity (asset purchases and refinancings plus company takeovers and buy-outs). This came to $100.7 billion in 2019. Adding that to the new investment total takes us to a total of $402.4 billion for the value of all financial transactions in the sector.

Figure 42 draws all these elements together, to show a time series and average growth rates over the period covered. The lower half of the table shows total renewable energy investment broken down, first by sector and second by country group.

The sector split shows the dominance of wind and solar since 2008, when the biofuel boom in the U.S. and Brazil started to abate. In 2019, wind and solar together accounted for $283.7 billion of total investment, with the other sectors only contributing $18.1 billion.

The geographical view shows how Europe held a clear lead in overall renewable energy investment in the early years, but was overtaken by China in 2013, and in 2019 for the first time was behind both China and the U.S. This time series also shows the gradual emergence of the Middle East and Africa as a significant investor in renewable energy.

The middle part of the table shows the time series for acquisition activity. Corporate M&A has moved up and down, influenced by the timing of large deals and also the general level of confidence in the sector. Asset acquisitions and refinancings were on a strong upswing from $32 billion in 2010 until they hit $123.8 billion in 2018, before falling to $83.8 billion. The acquisition trend is discussed in Chapter 7 of this report.

Taking the decade 2010-2019 as a whole, total renewable energy investment (including early-stage and corporate as well as the financing of capacity) came to $2.8 trillion, and the value of acquisition deals to almost exactly $1 trillion.

INVESTMENT IN RENEWABLE ENERGY COMPANIES

- Research and development spending in renewable energy edged up 1% to $13.4 billion in 2019. Half of that went to solar and a fifth to wind, and corporate R&D significantly outstripped government spending for the third year running.
- Venture capital and private equity (VC/PE) investment in renewable energy rose 22% to $3 billion, its highest level since 2015, but less than a third of its peak in 2008.
- VC/PE investment in solar rose 29% to $1.8 billion, and more than doubled to $529 million for wind, while falling just over a third to $396 million for biofuels. Many of the largest deals were equity injections into project development companies.
- Early-stage and late-stage venture capital both saw large percentage increases from low levels, but PE expansion capital fell by 22% to $1.8 billion. India was the biggest market for VC/PE, up 169% at $1.4 billion.
- In public markets, investment in renewable energy companies grew 11% to $6.6 billion. Initial public offerings (IPOs) jumped 47% to $2 billion, secondary issues and PIPE (private investment in public equity) edged up 4% to $2.9 billion, and convertibles slipped 6% to $1.7 billion. Up or down, all these figures were a fraction of the peaks set earlier this decade, or last.
- The WilderHill New Energy Global Innovation Index, or NEX, which tracks the performance of about 100 clean energy companies, rose by just under 60 points to end the year at 221.76. The NEX's gain of 37% outstripped the S&P500 Index by eight percentage points and the MSCI World Index by 11 percentage points.

Total annual investment in renewable energy has held roughly steady for the last four years, but the amount of capacity built each year for the same outlay continues to grow. The engine for this progress is research and development, which has delivered a continuous stream of efficiency gains and cost reductions, and means that around two-thirds of the world's population now live in countries where wind or solar are the cheapest forms of generation.[26] Improved cost-competitiveness has contributed to the increased appetite for renewable energy generation, evidenced by the installation figures year-by-year shown in Figure 14 of Chapter 1 of this report.

RESEARCH AND DEVELOPMENT

In 2019, R&D spending in renewable energy rose 1% to $13.4 billion. As usual, solar took the lion's share, securing $6.7 billion, just over half the total, followed by wind at $2.7 billion, or one fifth, as shown in Figure 43. Biofuels came third with $1.8 billion, or just over 13%. Small hydro saw the strongest growth, up 29% to $742 million, but from a low base.

Investment in solar R&D continued last year – inching up 1% – even as fierce competition drove one fifth of manufacturers out of business.[27]

[26] https://about.bnef.com/blog/peak-emissions-are-closer-than-you-think-and-heres-why/
[27] BloombergNEF: 2019 PV Manufacturing Capacity Review. https://www.bnef.com/core/insights/22045

The industry continues to increase the number of busbars – the silver lines that collect the current – on each solar cell. This raises the energy yield by reducing electrical resistance and shading of the underlying cell, and reduces the silver paste required because each busbar is thinner. A few years ago, the standard number was four, but now it is nine.

Another recent development has been the bifacial solar cell, which collects direct sunlight on top and reflected light underneath. On sandy ground this can increase the energy yield by as much as 9%, and some big U.S. developers expect this to reduce the levelized cost of solar energy by 5%.[28] In 2019, only 4-5% of modules shipped were bifacial, but BNEF expects that to rise to 15-21% in 2020, and for them to become the industry standard in the next few years.

In wind, a lot of R&D is about size. For many years the industry talked of cracking the 10MW turbine, and finally in 2018 MHI Vestas upgraded its 164-9.5MW machine to achieve that output. Then last year General Electric unveiled plans for its huge new 12MW Haliade-X offshore turbine. The company claims that not only is the machine 20% more powerful, but also that it will have a capacity factor – actual output as a proportion of rated capacity – five points higher than the industry standard.[29] GE is testing the turbine onshore in Rotterdam, and will supply Haliade-X turbines for the Dogger Bank Wind Farm off the coast of Yorkshire. The developers, SSE Renewables and the Norwegian company Equinor, expect the 3.6GW wind farm to start generating in 2023.[30]

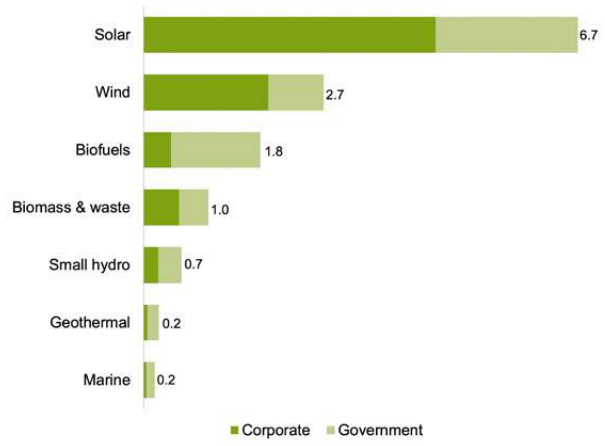
BNEF expects increasing turbine sizes to lead to a host of knock-on cost reductions, causing the total capital costs of offshore wind to fall 16% to $2.4 million per megawatt by 2030, in spite of future projects being built further offshore and in deeper water.[31]

One option in deeper water is to build floating turbines, tethered to the sea floor by cables rather than supported on a rigid structure. This reduces costs in several ways: they need less steel; turbines can be towed into position rather than installed with expensive specialist ships; and they can be manufactured identically, rather than designed for each different site.

Over the past decade, testing of floating turbines has moved from individual machines to multi-turbine demonstration projects, and costs have fallen by 86%. BNEF says the technology is steadily approaching commercial viability, and expect costs to fall a further 56% by 2030, when a floating project will be only 9% more expensive than a bottom-fixed one. By then, installed capacity should reach 1.2GW, with France the largest market.[32] In Japan, there are sites with combined capacity of 1.8GW where developers have yet to decide on whether to use fixed or floating foundations.

In marine energy, research and development efforts continue to produce wave power machines that can survive the harsh sea environment. Power take-off is a particular focus for a program overseen by Wave Energy Scotland.

FIGURE 43. R&D INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2019, $BN



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

[28] BloombergNEF: *Bifacial Modules: If You Book Them, They Will Come*. https://www.bnef.com/core/insights/21571
[29] https://www.ge.com/renewableenergy/wind-energy/offshore-wind/haliade-x-offshore-turbine
[30] https://doggerbank.com/
[31] BloombergNEF: *Tomorrow's Cost of Offshore Wind.* https://www.bnef.com/core/insights/21481
[32] BloombergNEF: *Floating Wind Drifts Toward Viability*. https://www.bnef.com/core/insights/20531

Tidal stream technology, by contrast, is much closer to being proven, with the 6MW MeyGen array off the north coast of the U.K. and some smaller projects producing consistent electricity through the seasons. The emphasis of R&D now in tidal stream is to reduce costs per MWh to closer to those of offshore wind, partly by producing larger machines and partly by making them cheaper to install and maintain.

In spite of all this activity, corporate R&D remained almost static, slipping just 1% to $7.7 billion, but sticking at the substantially higher levels seen since 2017 compared to the previous decade – as shown in Figure 44. Corporate R&D has also overtaken government spending in the last three years, again in contrast to the general picture in the previous decade.

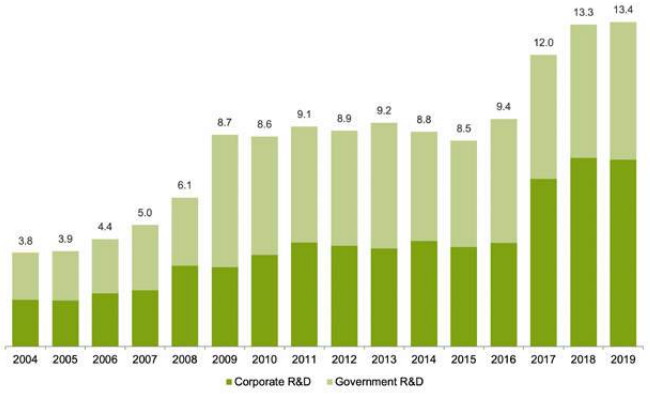
VENTURE CAPITAL AND PRIVATE EQUITY

Venture capital and private equity investment in renewable energy rose 22% to $3 billion, as shown in Figure 45. This was its highest level since 2015, but less than a third of its peak in 2008. Early-stage and late-stage venture capital investments both saw large percentage increases from low levels, but PE expansion capital fell by 22% to $1.8 billion to scarcely a quarter of its 2008 peak.

The main renewable energy technologies, and the companies that manufacture them, are now mature, so there is less need for these earlier-stage forms of financing than there was more than a decade ago.

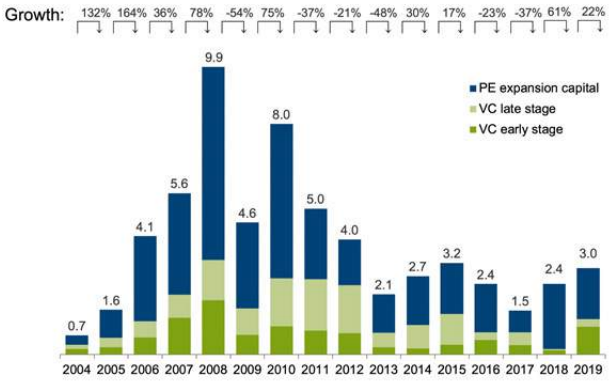
Two other factors have also contributed to the lower trajectory in VC/PE financing of renewables

FIGURE 44. CORPORATE AND GOVERNMENT RENEWABLE ENERGY R&D 2004-2019, $BN



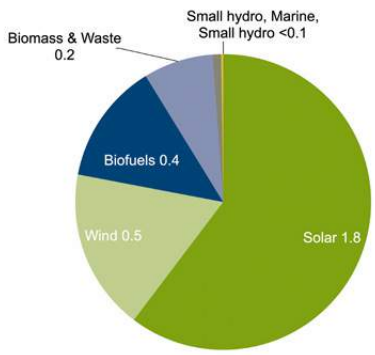
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 45. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY STAGE, 2004-2019, $BN



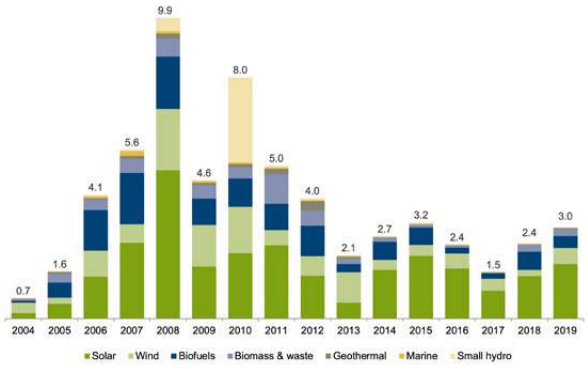
Buy-outs are not included as new investment. Total values include estimates for undisclosed deals
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 46. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2019, $BN



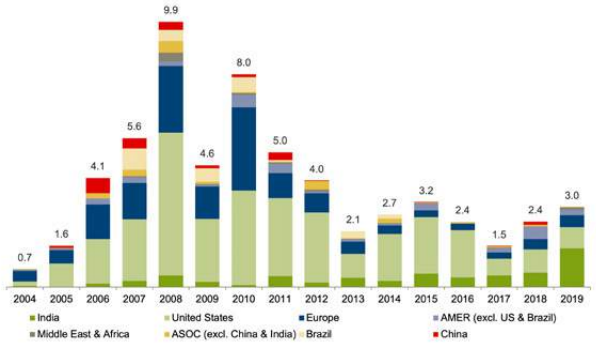
VC/PE new investment excludes PE buy-outs. Total values include estimates for undisclosed deals.
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 47. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2004-2019, $BN



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

FIGURE 48. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY REGION, 2004-2019, $BN



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

compared to the earlier period. One is that much of the research in the main sectors of wind, solar and biomass and waste-to-energy is now taking place inside large companies rather than in small ventures.

The other is that early-stage funds had distinctly mixed results with their investments in green energy previously, with many of their investee companies struggling in the face of the fierce competition in solar manufacturing, in particular. Some of those investors have now moved onto other low-carbon industries such as electric transport and energy storage. See the low-emission transport box on page 18. Electric vehicles saw two VC/PE deals of more than $1 billion in 2019, and batteries one.

Nevertheless, renewable energy did see sizeable year-on-year increases in some of its own sectors in 2019. The sector split is shown in Figure 46, and the historical series by sector in Figure 47.

VC/PE investment in solar rose 29% to $1.8 billion, and for wind it jumped 157% to $529 million, with project developers rather than manufacturers or technology pioneers often taking the new capital. In the tiny marine sector, where technology development is at an early stage, VC/PE investment quadrupled to $6 million on the basis of just two small deals, involving Scottish and French tidal turbine developers.

By geography, India was by far the biggest market, with VC/PE investment up 169% at $1.4 billion, as shown in Figure 48. In second place came the U.S., down 8% at $797 million, and Europe was third, climbing 14% to $443 million.

FIGURE 49. SOME OF THE LARGEST VC/PE EQUITY RAISINGS IN RENEWABLE ENERGY IN 2019, $M

Company	Location	Sector	Type	Business model	$m
Greenko Energy Holdings	India	Solar	PE - Expansion capital	Project developer	824
ReNew Power	India	Wind	VC - Series A / First round	Project developer	300
Madison Energy Investments	United States	Solar	PE - Expansion capital	Project developer	200
Hero Future Energies	India	Wind	PE - Expansion capital	Project developer	150
Avaada Energy	India	Solar	VC - Series A / First round	Project developer	144
SSP BV	Spain	Solar	PE - Expansion capital	Project developer	110
Bioenergy Development Group	United States	Biomass & Waste	PE - Expansion capital	Anaerobic digestion	106
AMP Americas	United States	Biofuels	VC - Series B / Second round	Biogas for transport	75
GaN Systems	Canada	Solar	VC - Further / Pre-IPO round	Semiconductors	67
Yellow Door Energy Equipment Leasing	United Arab Emirates	Solar	VC - Series A / First round	Solar leasing	65
iLNG BV	Netherlands	Biofuels	PE - Expansion capital	Biomethane for transport	61
Enerkem	Canada	Biofuels	VC - Series A / First round	Waste-to-fuels	57

The table shows the largest deals with disclosed values. Other deals might have got onto this list, if their values had been disclosed.
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

India secured four of the five largest deals, two each in wind and solar, as shown in Figure 49, several of which attracted foreign investors. In the year's biggest VC/PE deal, worth $824 million dollars, the wind, hydro and solar developer Greenko Energy Holdings was bought out by GIC, Singapore's sovereign wealth fund, and the Abu Dhabi Investment Authority. In the next largest, Canada Pension Plan Investment Board, the Abu Dhabi Investment Authority and Goldman Sachs acquired a minority stake in ReNew Power, a wind and solar generator, for $300 million.

Abu Dhabi also acquired a minority stake in Hero Future Energies, a wind and solar operator, paying $150 million via the state-owned Masdar Capital.

In the fourth big Indian VC/PE deal, Avaada Energy, a wind and solar operator, raised $144 million from European investors including a Dutch development bank.

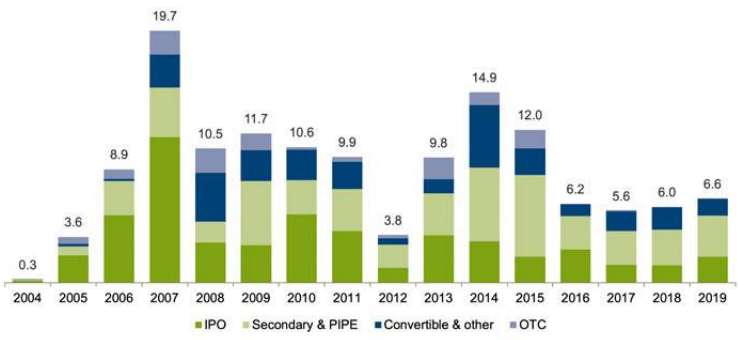
In the U.S., solar developer Madison Energy Investments raised $200 million in expansion capital from the private equity firm Stonepeak Partners. In the second-largest U.S. deal, Bioenergy Development Group, which builds and operates anaerobic digestors, raised $106 million by selling a minority stake to Newlight Partners. In Europe's only big deal with disclosed size, SSP, a Spanish solar developer that trades as Soto Solar, raised $110 million from a Singaporean investor.

PUBLIC MARKETS

In public markets, investment in renewable energy companies grew 11% to $6.6 billion, just a third of the peak reached in the boom year of 2007, as shown in Figure 50. Public markets are quieter these days because the main sectors, solar and wind, are now dominated by well-established global companies with less need to tap investors.

The amount of money raised through IPOs jumped 47% to $2 billion, but again, this was scarcely a sixth of its 2007 peak. Investment in secondary and PIPE offerings inched up 4% to $2.9 billion, while that in convertibles fell 6% to $1.7 billion.

FIGURE 50. PUBLIC MARKET NEW INVESTMENT IN RENEWABLE ENERGY BY STAGE, 2004-2019, $BN

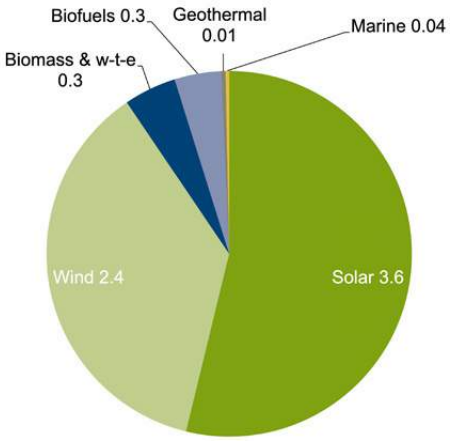


PIPE = private investment in public equity, OTC = over-the-counter.
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

As usual, solar received the most public market investment, up 19% to $3.6 billion, and wind the second largest, up 63% at $2.4 billion, as shown in Figure 51. Biofuel investment more than trebled to $306 million, while small hydro also jumped thanks to a single IPO in which the Indonesian hydro-power generator Kencana Energi Lestari raised $21 million.

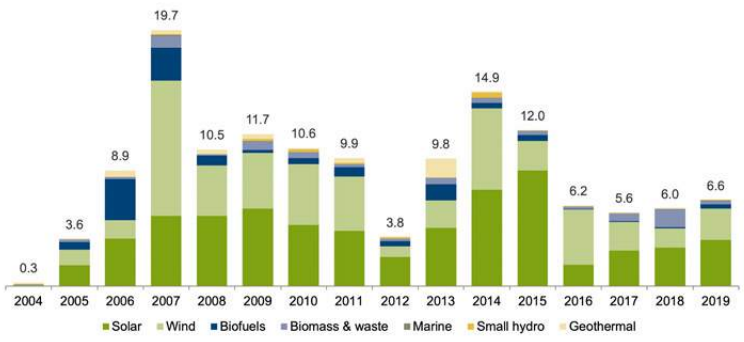
Figure 52 puts last year's numbers in their historical context, and shows that public market investment in each sector peaked some years ago: 2007 for wind, 2006 for biofuels and 2015 for solar. Wind, in particular, is now dominated by big companies that can finance new investments from retained profits or from borrowing, while the biofuel sector is struggling to make progress on second-generation fuels as quickly as hoped.

FIGURE 51. PUBLIC MARKETS NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2019, $BN



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 52. PUBLIC MARKETS INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2004-2019, $BN



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 53. BIGGEST PUBLIC EQUITY RAISINGS IN 2019, $M

Company	Location	Sector	Business model	Type of share issue	$m
Greencoat UK Wind	United Kingdom	Wind	Quoted fund	Secondary & PIPE	488
Xinyi Energy Holdings	China	Solar	Developer	IPO	466
Sterling & Wilson Solar	India	Solar	Installer	IPO	414
China Ruifeng Renewable Energy Holdings	Hong Kong	Wind	Renewable energy generator	Convertible & Other	314
Northland Power	Canada	Wind	Developer	Secondary & PIPE	264
TerraForm Power	United States	Solar	Yieldco	Secondary & PIPE	251
Neoen	France	Solar	Developer	Convertible & Other	222
GCL System Integration Technology	China	Solar	Module manufacturer	Secondary & PIPE	213
Ming Yang Smart Energy Group	China	Wind	Blade manufacturer	IPO	207
US Solar Fund PLC	United Kingdom	Solar	Quoted fund	IPO	200
The Renewables Infrastructure Group	Guernsey	Wind	Quoted fund	Convertible & Other	196
Longyan Zhuoyue New Energy	China	Biofuels	Biodiesel maker	IPO	191
SunPower Corp	United States	Solar	Module manufacturer	Secondary & PIPE	177
The Renewables Infrastructure Group	Guernsey	Wind	Quoted fund	Secondary & PIPE	174
Aquila European Renewables Income Fund	United Kingdom	Wind	Quoted fund	IPO	173

The table shows the largest deals with disclosed values.
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

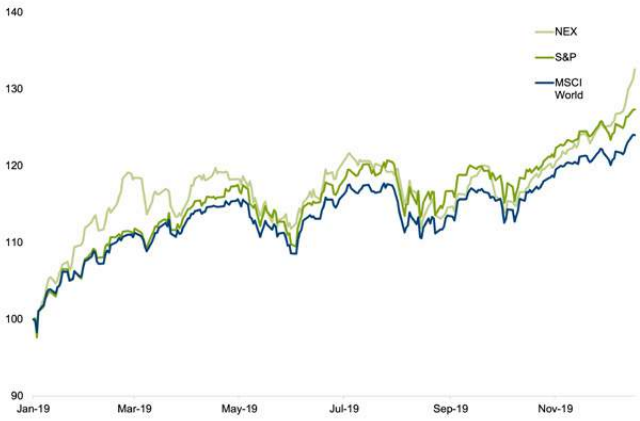
The biggest public market deals of 2019 are shown in Figure 53. Among the fifteen largest, six were secured by investment funds and yieldcos, with U.K.-quoted wind funds prominent among them. In the largest deal, Greencoat UK Wind raised $488 million in a secondary offering. Another U.K.-quoted fund, The Renewables Infrastructure Group, or TRIG, found its fundraising three times over-subscribed, and raised almost twice as much as originally expected. It ended up launching two issues – one secondary, one convertible – and raised a total of $370 million. Yet another U.K.-quoted fund, Aquila European Renewables Income Fund, raised $173 million through an IPO. Terraform Power, the U.S. 'yieldco' now controlled by Brookfield Renewable Partners, raised $251 million through a secondary offering.

Project developers, which tend to need regular injections of capital, were also prominent. The largest of these was a $466 million IPO by Xinyi Energy Holdings, which builds and operates solar plants. The next largest was another IPO, in which the Shapoorji Pallonji Group of India floated its subsidiary Sterling & Wilson Solar, raising $414 million.

Renewable energy stock prices performed unusually well in 2019. The NEX Index – which covers the broader 'clean energy' sector, including renewables, electric vehicle manufacturing and energy efficiency – rose by just under 60 points during 2019 to end the year at 221.76. The NEX's gain of 37% outstripped the S&P500 Index by eight percentage points and the MSCI World Index by 11, as shown in Figure 54. This outperformance over one year contrasts with the record over the last decade, when the NEX fell by roughly 13% but the S&P500 gained 187% and the MSCI World Index doubled in value.

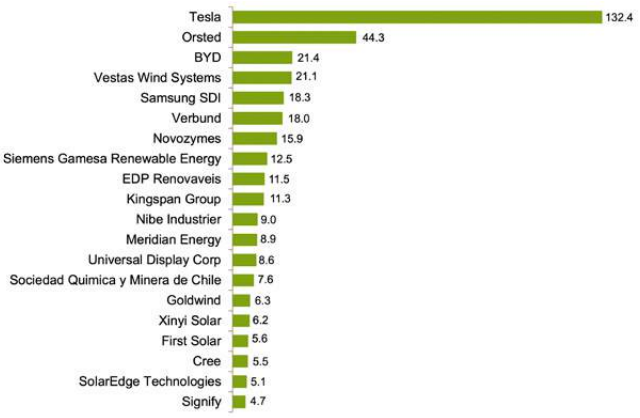
This longer-term underperformance has come despite the robust growth of renewable energy over the same period, during which investors poured $2.4 trillion into wind and solar capacity (see Chapter 1). But the sheer weight of investment may have been part of the problem. In solar, for example, the influx of $1.4 trillion over the last decade has led to persistent overcapacity, meaning it is still hard for manufacturers to turn a profit. In Figure 55, it is notable that the three solar manufacturers that made it into the NEX's top 20 companies on February 6 were valued at between $5.1 billion and $6.2 billion, less than one twentieth of the most valuable stock in the index.

FIGURE 54. NEX VS SELECTED INDICES, 1 JANUARY 2019 TO 17 FEBRUARY 2020



Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

FIGURE 55. LARGEST COMPANIES IN THE NEX INDEX, BY MARKET CAPITALIZATION, $BN



Top companies as of February 6, 2020
Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

Nevertheless, the NEX rose in 2019 because gains strongly outweighed losses overall. Among the renewable energy stocks that were strong gainers during the year, PV manufacturer JinkoSolar rose 129%, inverter maker SMA Solar Technologies 108% and PV installer Vivint Solar 94%. Developers also did well: for instance, Orsted, the Danish former oil and gas producer that abandoned fossil fuels for wind projects and wants to become the first 'green energy supermajor', jumped 61% during the year, and Canada's Boralex 50%.

It is always possible that the performance of clean and renewable energy stocks in 2019 will prove to be yet another false dawn, but some investors believe that this time the change is structural. It was, after all, a year of climate disasters and sweeping change in public opinion. In January 2020, Larry Fink, CEO of BlackRock, which manages investments of $7 trillion, warned all his firm's investee companies that climate change was now the defining factor: "In the near future – and sooner than most anticipate – there will be a significant reallocation of capital."[33]

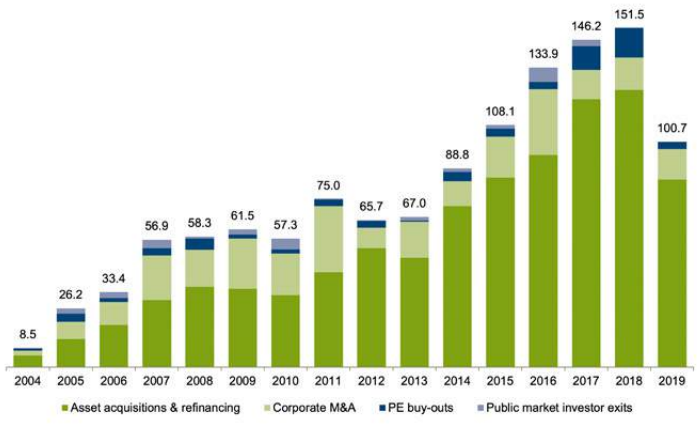
[33] https://www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter

ACQUISITION ACTIVITY

- The value of renewable energy acquisitions and refinancings fell sharply in 2019, ending a five-year run of strong growth. The $100.7 billion of deals was 34% down from the historic high of $151.5 billion in 2018.
- Less money changed hands in every asset class: public market exits were non-existent, private equity buy-outs dropped from $13 billion to $3.2 billion, and there was $40 billion less in asset acquisitions.
- The volume of corporate M&A held up better, however, dropping just 6% to $13.7 billion. The biggest deal saw RWE acquire E.ON Climate & Renewables for $3.9 billion.
- As in previous years, most acquirers bought power generators and developers rather than equipment manufacturers or service providers.
- Wind and solar deals accounted for almost 97% of the total. But while wind stayed relatively strong, solar plummeted 59% to $24.5 billion, its lowest level since 2013.
- In the U.S., asset acquisitions fell 49% to $23.3 billion, but they remained high in Europe at $44.2 billion. Some of the biggest targets were offshore wind farms in Germany, the Netherlands and the U.K.

The value of acquisitions fell sharply in 2019, ending a five-year run of strong growth. Deals worth $100.7 billion were recorded globally, down 34% from the peak of $151.5 billion in 2018.

FIGURE 56. ACQUISITION TRANSACTIONS IN RENEWABLE ENERGY BY TYPE, 2004-2019, $BN



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

All asset classes saw declines, but to varying degrees: public market exits disappeared altogether, while private equity buy-outs shrank by 76% to just $3.2 billion (see Figure 56), having peaked the previous year at $13 billion. Less precipitous but nonetheless significant was the 32% drop in asset acquisitions to $83.8 billion, which was $40 billion less than in the previous year.

In contrast, the volume of corporate M&A deals remained relatively high – at $13.7 billion, it was only marginally lower than the $14.6 billion seen in 2018. Further discussion of activity in each deal type follows under the section headings below.

As in previous years, most acquirers bought power generators and developers rather than equipment manufacturers or service providers.

Indeed, acquisitions of generating assets accounted for 83% of all money changing hands – despite the dramatic reduction in volume in 2019 – while generators or developers were the target in eight of the 10 largest corporate M&A deals. The year's two largest private equity buy-outs saw investors buy a major Spanish wind developer and a German offshore wind farm.

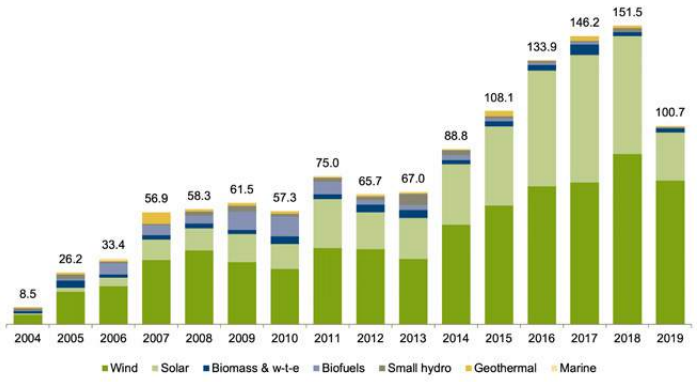
The decline in renewable energy acquisitions took place amid global economic uncertainty and after sharp sell-off on stock markets in late 2018, partly due to worries about a possible trade war between the U.S. and China.

In theory, this fragility helped to create a more deal-friendly environment as over 30 central banks around the world cut interest rates in 2019 in a bid to shore up their economies. Given that most acquisitions involve debt in one form or another, cheaper borrowing would have been welcome news for acquirers considering taking the plunge. However, the multibillion-dollar deals that helped to produce an acquisition record in 2018 were thinner on the ground in 2019.

Sector-specific factors such as falling wind and solar development costs together with ongoing reductions in subsidy levels may have acted as a brake on acquisition values. The average global price of wind turbines per MW fell 3% between the second half of 2018 and the equivalent in 2019, while capex for PV projects in China, the world's largest solar market, fell 7% in the same period.[34&35]

In recent years, activity has become increasingly concentrated in wind and solar (see Figure 57). In 2019, they took almost 97% of the total, which was a slight increase on the year before. Among the remainder, slightly less than $2 billion was recorded in biomass and waste-to-energy, a record low for that sector, while less than $1 billion was seen in geothermal, small hydro and biofuels. The marine sector has seen very little acquisition activity in recent years.

FIGURE 57. ACQUISITION TRANSACTIONS IN RENEWABLE ENERGY BY SECTOR, 2004-2019, $BN



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

[34] BloombergNEF: *2H 2019 Wind Turbine Price Index.* https://www.bnef.com/insights/21979
[35] BloombergNEF: *1H 2019 LCOE Update.* https://www.bnef.com/insights/20423

There was a clear contrast between the two biggest sectors in 2019: while wind activity remained high at $73 billion, down only 15% on 2018 and higher than in 2017, solar plummeted 59% to $24.5 billion, its lowest level since 2013. The big solar deals that characterised 2018 – such as the U.S. PV capacity acquisitions by Clearway, ConEdison Development and Capital Dynamics – were absent in 2019.

CORPORATE TRANSACTIONS

In contrast to the declines in asset acquisitions and PE buy-outs (see sections below) the volume of corporate transactions was more resilient, dropping just 6% to $13.7 billion in 2019. This was slightly up on 2017 but a small fraction of the $29.5 billion trade in companies that took place in 2016. As in previous years the targets were mostly renewable energy developers or generators, but in a break with the past more than half the deals took place in Asia.

In the biggest deal of the year, RWE acquired E.ON Climate & Renewables and its 5GW of renewable generating capacity for $3.9 billion (see Figure 58). The transaction formed part of a wider $27 billion asset swap between two German utilities that are pursuing very different strategies – RWE has divested from downstream areas to concentrate on generation of all types, while E.ON has chosen to focus on downstream distribution and retail. The deal is further evidence of the growing trend towards specialization among European utilities.

A larger renewable generation portfolio for RWE could bring advantages such as lower financing, development and operating costs and enable RWE better to compete with other European renewable energy majors, such as Iberdrola and Enel. The rationale for vertical integration had been that a combination of generation and retail provided power utilities with a market hedge. However, wholesale power market dynamics have been changing, due to the rise of fuel switching and growth of renewables.

Generating assets were the target in two further European corporate transactions: the purchase by French independent power producer Total Eren of NovEnergia and its 669MW of operating assets in Portugal, Italy, France, Spain, Poland and Bulgaria for $1.1 billion, and the acquisition by Italian utility Edison of EDF EN Italia and its 77MW of solar and 256MW of wind assets, for $194 million. The latter deal makes Edison Italy's second-largest wind plant operator.

One of China's largest PV module makers, JA Solar, was the target in the second-largest corporate deal of 2019, a $1.6 billion takeover that paved the way for the company to list on the Shenzhen Stock Exchange in December. Frustrated by its valuation on Nasdaq, JA Solar delisted its American depository receipts in July 2018 and saw itself acquired by Shenzhen-listed Qinhuangdao Tianye Tolian Heavy Industry Co.

FIGURE 58. LARGEST CORPORATE M&A DEALS IN RENEWABLE ENERGY IN 2019, $M

Acquirer	Target	Country of target	Sector	Business model	$m
RWE	E.ON Climate & Renewables	Germany	Wind	Renewable energy generator	3936
Qinhuangdao Tianye Tolian Heavy Industry	JA Solar	China	Solar	Solar manufacturer	1580
John Hancock	Duke Energy Renewables	United States	Wind	Renewable energy generator	1250
Total EREN	Novenergia Holding	Luxembourg	Wind	Renewable energy generator	1126
Shanghai Aiko Solar Energy	Guangdong Aiko Solar Energy Technology	China	Solar	Solar manufacturer	968
American Electric Power	Sempra Renewables	United States	Wind	Renewable energy generator	894
ORIX Corp	IL&FS Wind Energy	India	Wind	Renewable energy generator	675
Petroleum Nasional	Amplus Energy Solutions	India	Solar	Renewable energy developer	388
Jarvarmi	Magma Energy Sweden	Sweden	Geothermal	Renewable energy generator	300
Xinyi Energy Holdings	Xinyi Solar Farm Group 1	Hong Kong	Solar	Renewable energy developer	261
Zhejiang Energy Group	Zheneng Jinjiang Environment Holding	China	Biomass & Waste	Waste-to-energy generator	231
Shenzhen Keenstar	EGing Photovoltaic Technology	China	Solar	Solar manufacturer	207
Edison	EDF EN Italia	Italy	Wind	Renewable energy generator	194
Enviva Partners	Enviva Wilmington Holdings	United States	Biomass & Waste	Pellet producer	170

The table shows the largest deals with disclosed values. Other deals might have got onto this list, if their values had been disclosed. Some deals were for partial control only.

Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

By moving assets into an already-listed stock, a so-called 'backdoor listing', JA Solar was able to sidestep the lengthy waiting times and costs associated with a conventional initial public offering on an exchange in China. Another giant of the Chinese solar industry, Shanghai Aiko Solar Energy, performed a similar move, in a deal valued at $968 million that enabled it to list on the Shanghai Stock Exchange at the end of 2019. Both Aiko and JA Solar have since said they plan to make substantial investments in new manufacturing capacity in China.

Shares in Chinese solar company Hanergy Thin Film Power Group were acquired by a related company, Hanergy Mobile Energy Holding, for an undisclosed amount. This deal has not been included in the acquisition figures for 2019 shown in this report, due to the lack of information. Once the world's most valuable solar company, Hanergy Thin Film's shares were suspended in 2015 after questions over its finances prompted a one-day sell-off that erased almost half of its $40 billion value.

In the largest U.S. deal, Duke Energy Renewables, the renewables arm of utility Duke Energy, sold a minority share of its wind and solar portfolio, amounting to 1.2GW of generation capacity, to insurer John Hancock for $1.25 billion. The sale enabled Duke to unlock capital that will help it to realise its development pipeline and take advantage of the federal Investment Tax Credit (ITC) and Production Tax Credit (PTC) incentives before they expire.

Appetite for generating capacity drove another U.S. utility, American Electric Power (AEP), to buy Sempra Renewables and its 724MW of operating wind generation and battery assets for $894 million. The purchase, which includes all or part of seven wind farms and one battery installation in seven states, brings AEP's renewable generation portfolio to 1,075MW. A separate agreement to purchase a 75% interest in the Santa Rita East Wind Project currently under construction in Texas will add a further 227MW.

PRIVATE EQUITY BUY-OUTS

PE buy-outs fell to nearer long-term average levels in 2019 after two years of exceptionally high investment volumes. Some $3.2 billion was recorded, just a quarter of the $13 billion seen in 2018 and a third of the $10.6 billion the previous year. As with corporate transactions, the main focus was on wind rather than solar and on generating assets or companies instead of manufacturing businesses.

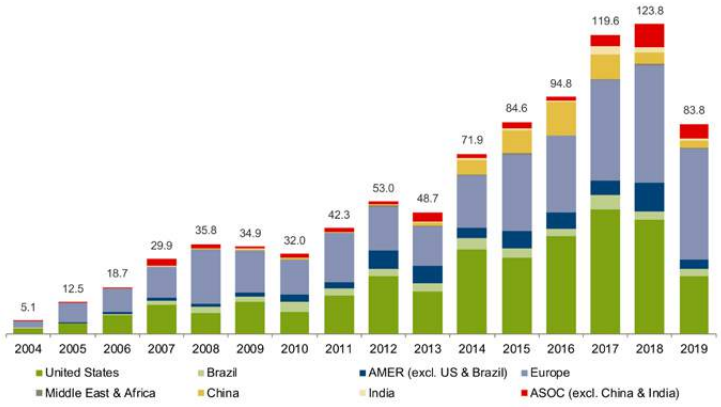
About half of all investment was accounted for by one large deal – the acquisition of more than 90% of Spanish wind-power developer Eolia Renovables de Inversiones by Alberta Investment Management Corp (AIMCo) for $1.6 billion. With 669MW of renewable assets, the purchase beefs up AIMCo's infrastructure holdings and coincides with a move by Alberta, home to most of Canada's oil industry, to get 30% of its energy from renewables by 2030.

Another notable PE deal was the purchase by Macquarie Infrastructure and Real Assets of Ocean Breeze Energy, owner of the 400MW Bard Offshore 1 wind farm in the German North Sea. The project was developed by Bard Engineering but ownership was transferred to Italian bank Unicredit when the developer was declared bankrupt in 2013. Macquarie's Green Investment Group was also active in acquiring offshore wind projects in 2019.

ASSET TRANSACTIONS

After five consecutive years of growth, culminating in $123.8 billion of asset acquisitions in 2018, the volume of asset purchases and refinancings fell sharply in 2019 to $83.8 billion (see Figure 59). Solar, having featured prominently the previous year, was confined to a smaller clutch of deals, the largest of which was the 807 million-euro ($899 million) debt refinancing of French developer Tenergie's 255MW Phoenix V PV portfolio. It is possible that more transactions for 2019 will come to light in the coming months, in which case these numbers will be revised.

FIGURE 59. ASSET ACQUISITIONS AND REFINANCINGS BY REGION, 2004-2019, $BN



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

The frenzy of deal-making in 2018 clearly illustrated that there was a big pool of investors interested in newly developed renewable assets with long-term power purchase agreements. While there were projects for sale in 2019, the market appeared to have peaked and was beginning to bear the hallmarks of an asset bubble: for example, the average U.K. solar M&A price rose 19% in 2018 compared with the year before. And despite the squeeze on equity returns, demand remained high with investors reportedly looking to increase their risk to get higher returns.

Activity in the U.S. was hardest hit, falling by 49% to $23.3 billion. Solar deals completely disappeared while the wind market faced pressures from the scheduled phase-out of qualification for the PTC by the end of 2019. With developers scrambling to qualify their projects, either by starting construction or by spending 5% of total project capex, 2019 would have been "an abnormal time" to dive into the sector, a senior executive at Sustainable Power Group, told an audience at the S&P Global Platts' Global Power Markets conference in Las Vegas.

The volume of asset acquisitions in Europe, in contrast, remained high at $44.2 billion, down just 5% from 2018 (see Figure 59). Some of the biggest acquisitions were of wind farms in the seas off Germany, the Netherlands and the U.K. These included the 2.5 billion-pound ($3.1 billion) purchase of 40% of the 714MW East Anglia One Offshore Wind Farm by Green Investment Group, the renewable energy investment arm of Australian group Macquarie.

Deals in German waters included the acquisition of an 80% stake in the 402MW Veja Mate offshore wind farm for an estimated $1.9 billion by INGKA Holding, the group that controls IKEA, together with CommerzReal, WPD Invest and KGAL Group. In addition, The Renewables Infrastructure Group and Glennmont Partners each bought 25% of the 330MW Gode Wind I project, in deals worth $495 million apiece, while Credit Suisse Energy Infrastructure Partners acquired a 25% stake in the 385MW Arkona Becken Sudost Offshore Wind Farm for $553 million.

There were heavy falls in acquisition and refinancing activity in Asia. The volume in China fell to $3.2 billion from $4.7 billion, and elsewhere in the region (excluding India) it declined by an even greater extent, ending the year at $5.6 billion, down from $9.2 billion in 2018. As in Europe, some of the largest deals targeted offshore assets: Electricite de France, for instance, bought 35% of the 502MW Dongtai offshore wind farm phases IV & V in China's Jiangsu Province for $663 million, while Japanese power utility JERA acquired a 49% stake in the 376MW Formosa II Miaoli offshore wind farm off Taiwan.

GLOSSARY[36]

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

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

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

Frankfurt School – UNEP Collaborating Centre
Frankfurt School of Finance & Management
Adickesallee 32-34
60322 Frankfurt am Main
http://fs-unep-centre.org
www.frankfurt-school.de
E-Mail: fs_unep@fs.de
Phone: +49 (0)69 154008-647
Fax: +49 (0)69 154008-4647

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