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 CO_2.

- 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.

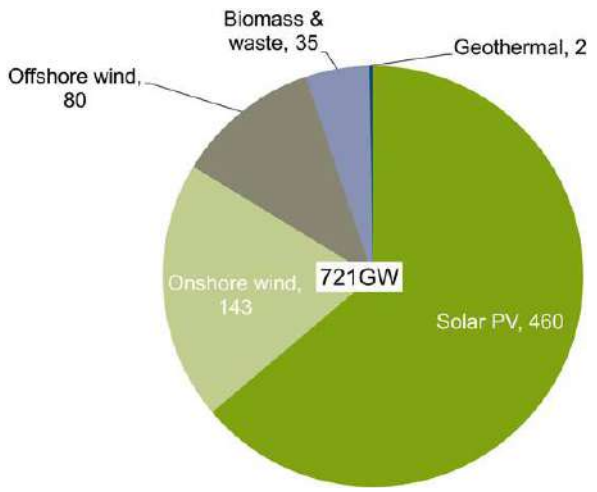
[2] The analysis covers 87 countries that have targets relating to 2030, or to earlier years. It does not seek to guess progress toward longer-term targets for years after 2030.

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.

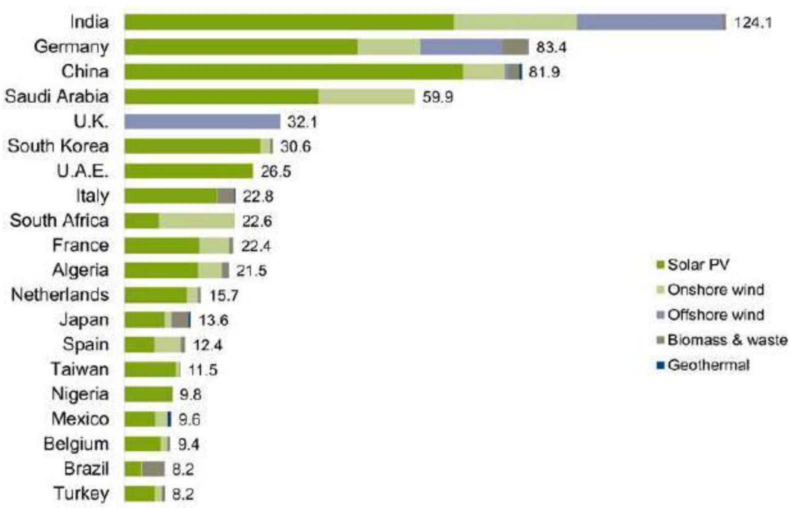
These targets for low-carbon power generation come from no fewer than 87 governments, representing both high-income countries that were early movers in green energy 10-20 years ago, and developing economies. Some of the latter are established backers of renewable power. Others have come to it more recently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

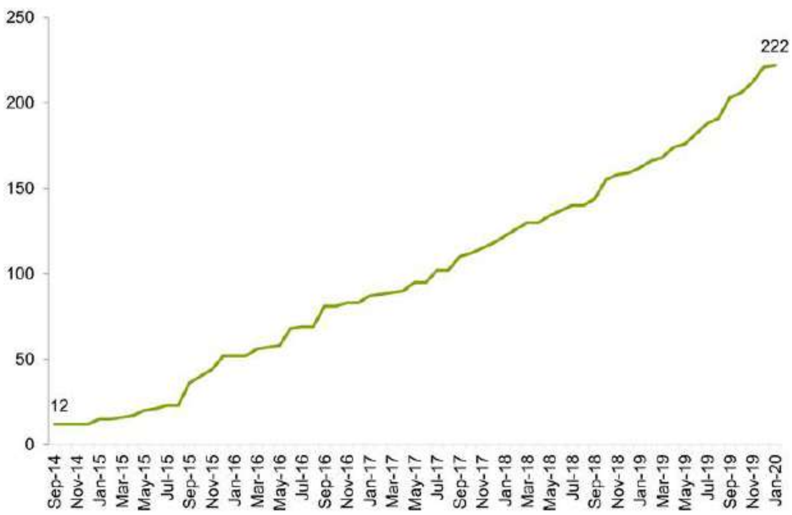
Developed economies[3] account for just over two-fifths (297GW) of the new non-hydro renewables capacity implied by 2030 government targets around the world,[4] with the two most populous developing economies of China and India accounting for 206GW and 'other developing countries' for the remaining 219GW.

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.

FIGURE 3. GROWTH OF CORPORATE MEMBERS OF RE100



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

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.

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.

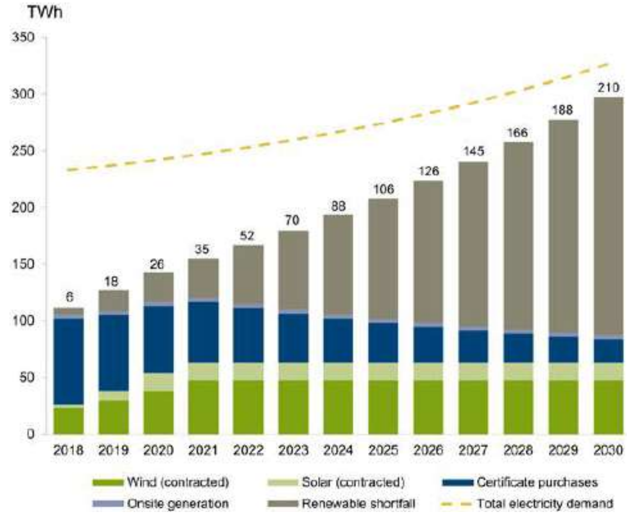
Corporations are making these efforts in order to help demonstrate the sustainability of their business models, as well as for economic reasons.[7] One audience is customers, since many of these, particularly the young, may want to choose brands that are perceived as environmentally friendly. Another 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 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.

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

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.

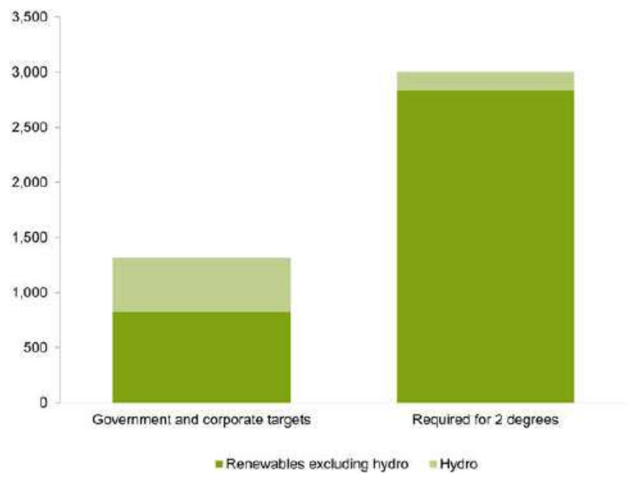
Both the amount of new capacity projected as a result of these commitments and the amount of investment (even at today's costs) look modest compared to what the world achieved in the 2010-2019 period. During that decade, as shown in Figures 14 and 19 in Chapter 1, some 1,213 gigawatts of renewable power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

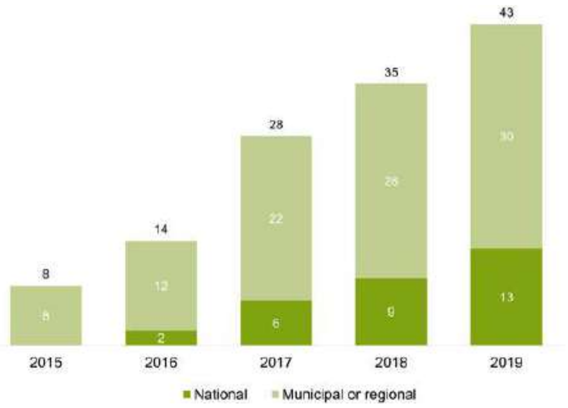
Electricity is a vital part of the overall energy system, and for that system's CO2 emissions, but it is far from the only part. In 2016, it was responsible for 42% of global energy-related emissions, with transport contributing 24% and buildings and industry a further 32%.

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.

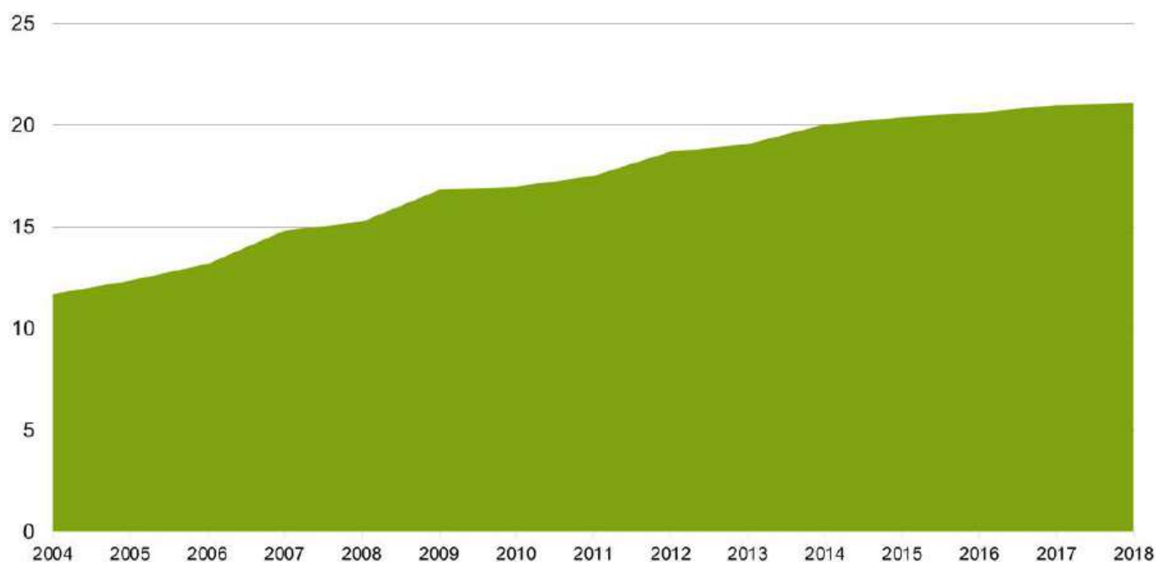
Heat – for residential or business buildings – has no one low-carbon answer. District heating linked to biomass or waste-to-energy plants may be a cost-effective option for the residential areas of some Northern Hemisphere cities, and biogas for others, particularly close to agricultural land. Biomass 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.

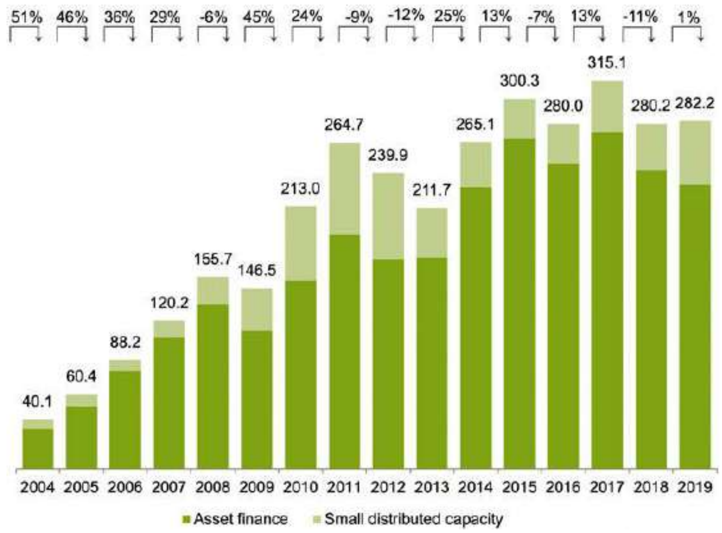
Global investment in renewables capacity has been relatively consistent since 2014, fluctuating in a $50 billion range between $265 billion and $315 billion. But beneath the headline figures, much has been changing on the unit costs of new additions, on the geographical split of investment, and on the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

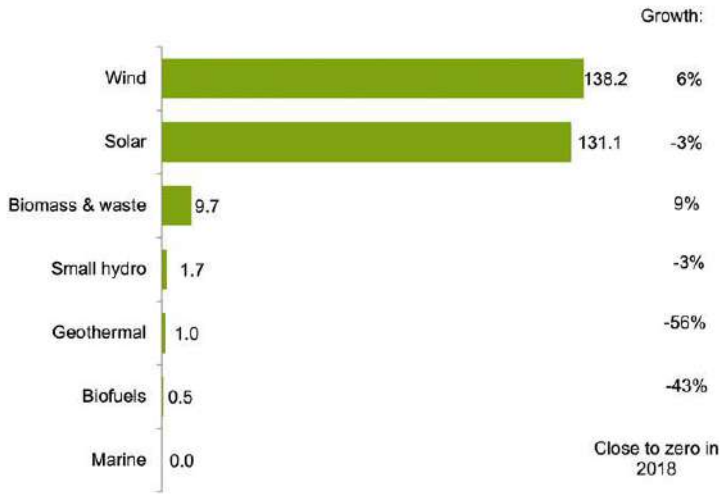
Biomass and waste-to-energy maintains a consistent third place among renewable energy sectors, with investment in 2019 up 9% at $9.7 billion. There were strong pockets of activity last year, notably in waste incineration plants in the U.K. and China.

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

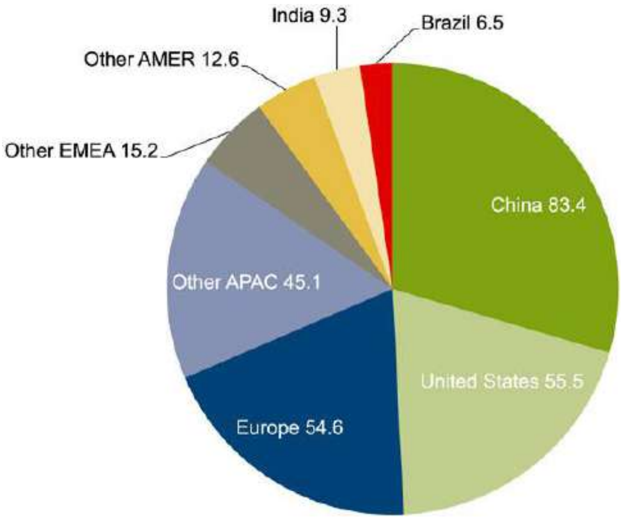
FIGURE 9. GLOBAL INVESTMENT IN RENEWABLE ENERGY CAPACITY BY SECTOR IN 2019, AND GROWTH ON 2018, $BN



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.

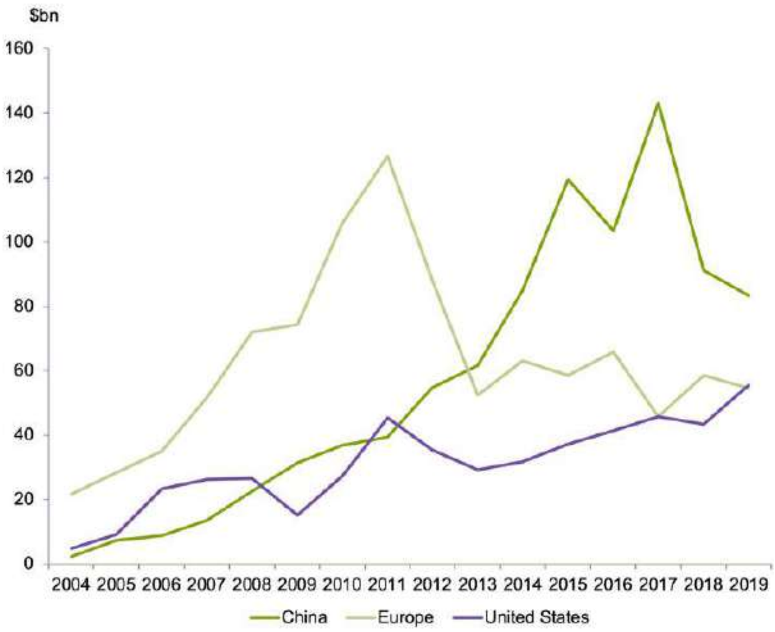
The ranking of the top 30 countries and markets is shown in Figure 11. The two most spectacular risers in the table were Taiwan, with a near-quintupling of its investment volume to $8.8 billion thanks mainly to a trio of offshore wind deals; and the United Arab Emirates, with a 13-fold increase to $4.5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

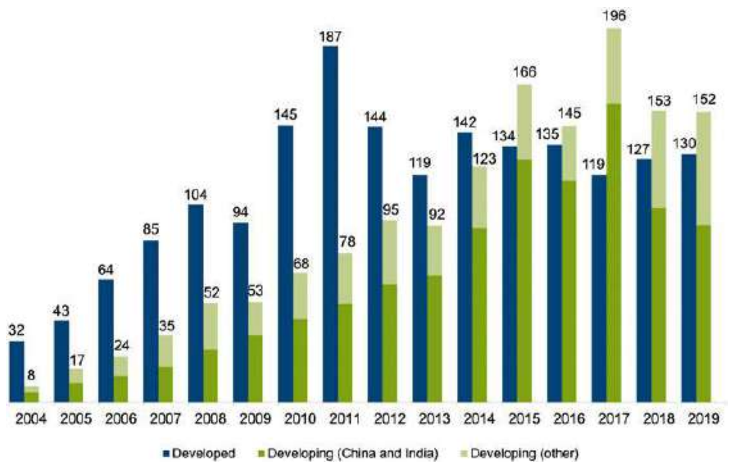


Source: UNEP, Frankfurt School-UNEP Centre, BloombergNEF

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%.

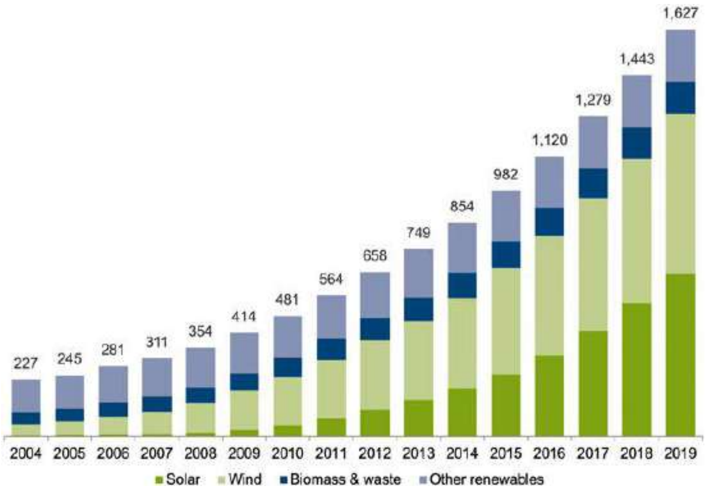
What 2019 did produce of note, however, was the highest ever figure for renewables capacity investment in 'other developing countries' – excluding China and India. This jumped 17% to $59.5 billion, and was double the equivalent total for 2016.

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.

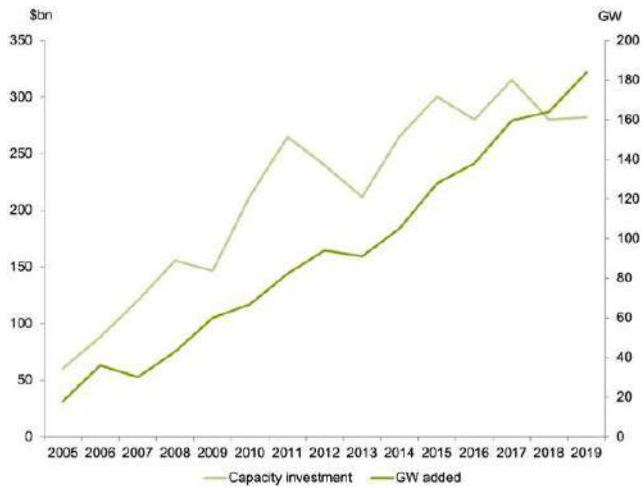
FIGURE 14. GLOBAL CAPACITY IN RENEWABLE POWER, 2004-2019, GW



"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

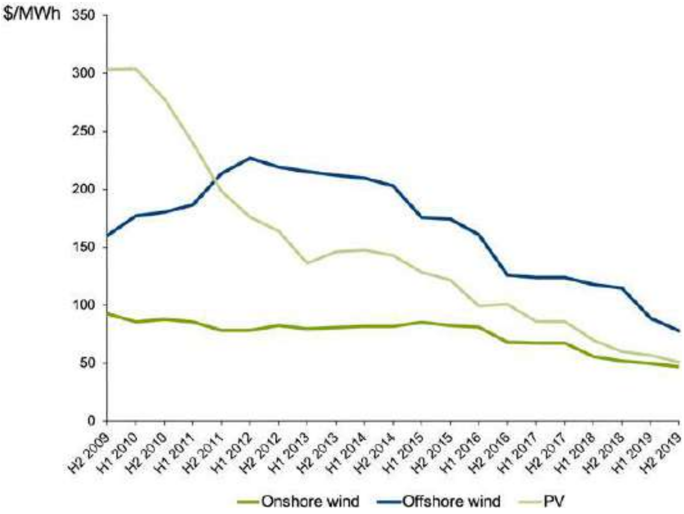
Figure 15 shows the comparison between billions of dollars invested and the renewable energy capacity added, during the whole 2004-2019 period. It comes with a caveat – dollars committed in one year often do not result in projects commissioned in the same year. The time from 'final investment decision' 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.

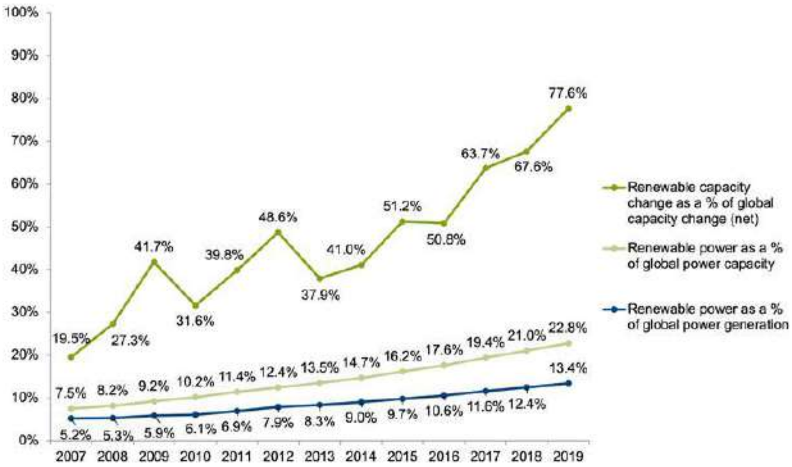
The global benchmark levelized cost of electricity, or LCOE, from onshore wind was $47 per megawatt-hour in the second half of last year, according to BloombergNEF analysis. This was down 10% on the same period in 2018, and 49% lower than in the second half of 2009. For offshore wind, the global benchmark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

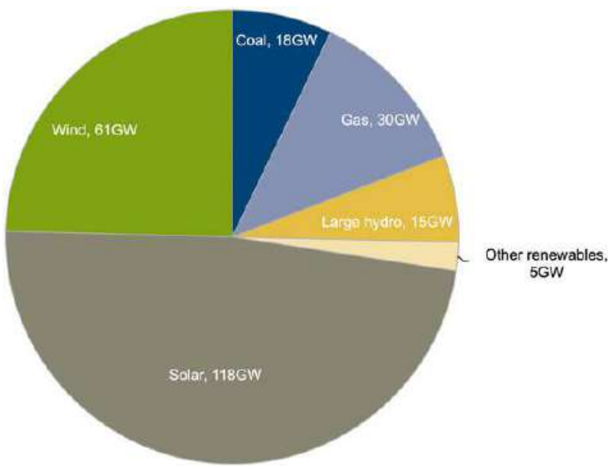
The big reductions in LCOE for wind and solar have come about as a result of a combination of lower capital costs, for instance as turbines have got bigger and more powerful and there have been further economies of scale in the manufacturing of solar panels; and improvements in the performance of equipment. 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