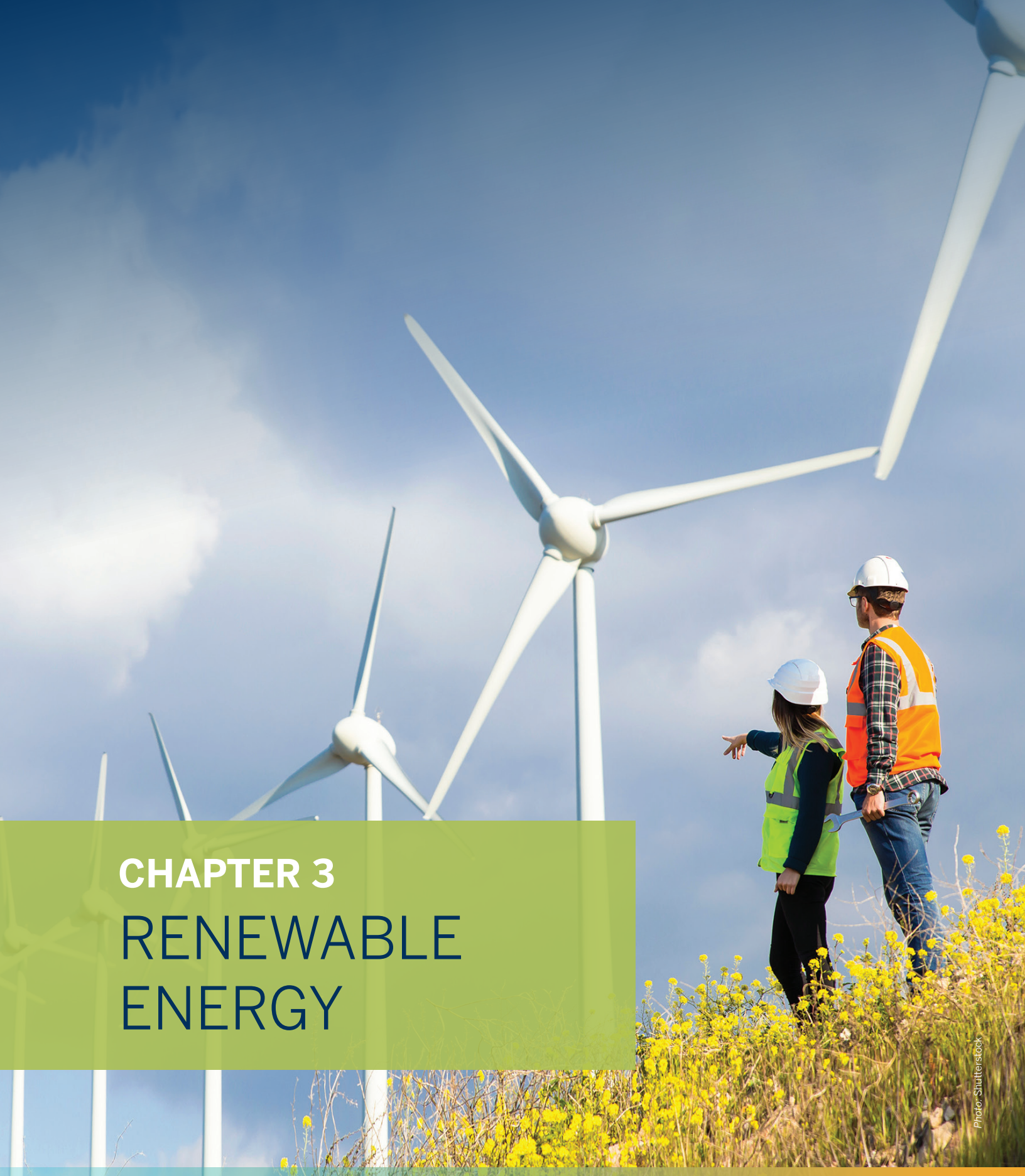

CHAPTER 3
RENEWABLE ENERGY

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MAIN MESSAGES

- **The global trend:** Sustainable Development Goal (SDG) 7.2 posits a substantial increase in the share of renewable energy in total final energy consumption (TFEC). Meeting this target will require the penetration of renewable energy to accelerate in all three end uses—electricity, heat, and transport. In 2017, the share of renewable energy in TFEC increased to 17.3 percent, up from 17.2 percent in 2016.[23] This rise reflects a more rapid growth in renewables (2.5 percent) compared with the overall growth of TFEC (+1.8 percent). Renewable energy consumption has grown fastest in the power sector; growth of renewables consumption in the heat and transport sectors has been much slower. Excluding the traditional uses of biomass (see box 3.1 for definitions), the share of renewables in TFEC rose to 10.5 percent in 2017, up from 10.3 percent in 2016.
- **The target for 2030:** Although there is no quantitative target for SDG 7.2, countries have agreed that the share of renewable energy would need to accelerate substantially to ensure access to affordable, reliable, sustainable, and modern energy for all. Despite impressive growth in renewable energy over the past decade, the world is not on track to meet the SDG 7.2 target.
- **Regional highlights:** At 69 percent of TFEC, Sub-Saharan Africa continues to show, by far, the highest share of renewable energy. The traditional uses of biomass, however, still account for almost 85 percent of renewable energy consumption in the region, while modern renewable energy is below the world average. Latin America and the Caribbean, on the other hand, had the largest share of modern renewables (29 percent) thanks to the extensive use of modern bioenergy and hydropower. In Asia, modern renewable energy shares remained below the global average at around 8 percent of the regional TFEC.
- **The top 20 energy-consuming countries:** The share of renewable consumption varies by country. Between 2010 to 2017, 13 out of the top 20 energy-consuming countries increased their share of renewables. The United Kingdom in particular saw the largest relative increase, led by wind energy. Yet in Brazil, India, Indonesia, Nigeria, Pakistan, and Turkey, renewables have grown more slowly than total energy consumption.
- **Electricity:** Renewable electricity consumption increased by almost 6 percent year-on-year in 2017. In relative terms, this meant that the share of renewables in global electricity consumption reached 24.7 percent, the highest of all end-use sectors. With this growth, the renewables share in electricity surpassed its share in heat for the first time in history. In terms of growth rate, however, this represents a deceleration compared with the record year-on-year growth recorded in 2016. Lower hydropower output was the main reason behind the slower increase in renewables.
- **Heat:** Renewables used for heating increased by 1.1 percent, reaching 23.5 percent of total final heat consumption in 2017, including traditional uses of biomass. The growth was led by modern renewable energy uses, which grew by 2.3 percent year-on-year in 2017. Overall, the share of modern renewables reached 9.2 percent of heat consumed globally, up from 9.1 percent in 2016. Consumption of biomass for its traditional uses remained almost unchanged (+0.3 percent year-on-year) in 2017 compared with 2016, still accounting for more than 14 percent of global heat consumption.
- **Transport:** The share of renewable energy in transport flattened in 2017, remaining at 3.3 percent in 2017. Most of the renewable energy consumed came in the form of liquid biofuels, mainly crop-based ethanol and biodiesel, thanks to policy support (among other factors) in Brazil, the European Union, and the United States. In 2017, consumption of electricity in the transport sector was 1.3 exajoules (EJ), of which 24 percent was renewable (0.3 EJ), representing 0.3 percent of global energy consumption in the transport sector.

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23 Revised historical data have altered the historical time series of renewable shares in this report; they now present lower values than the time series shown in previous editions. More details on this shift can be found in the section of this chapter entitled "Are We on Track?"

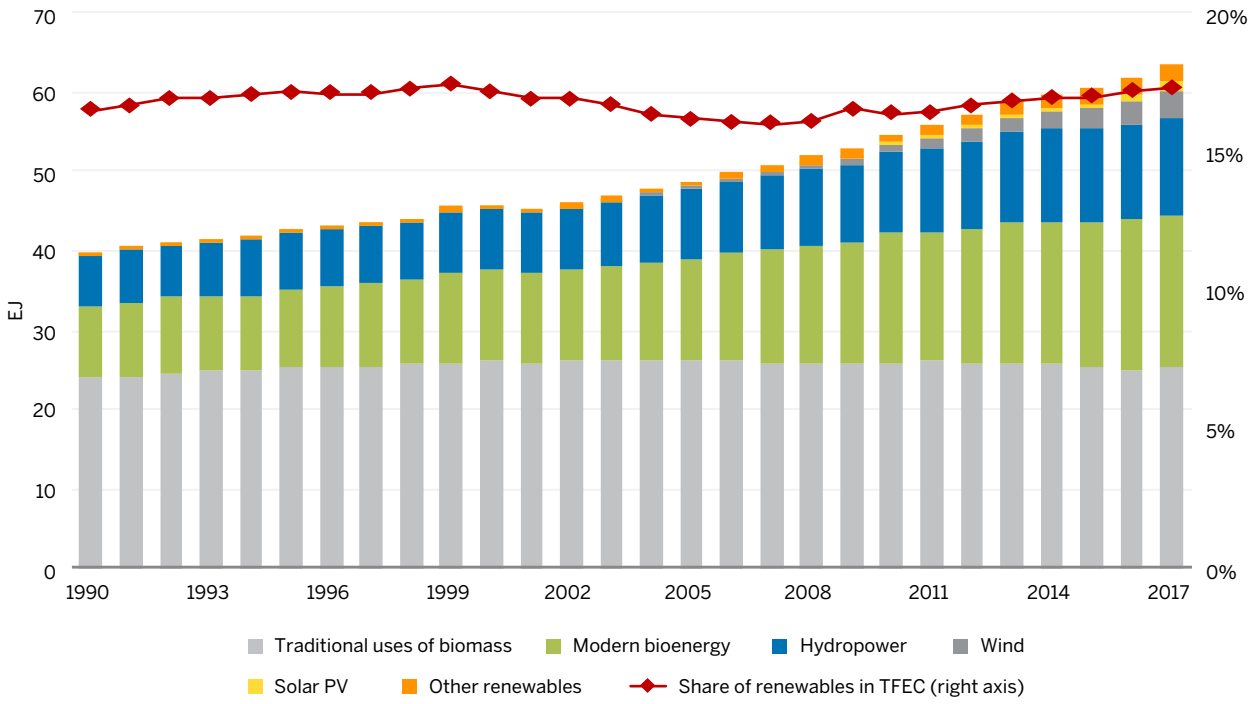
ARE WE ON TRACK?

In 2017, renewable energy consumption, including that of biomass for its traditional uses, increased by 2.5 percent year-on-year, a more rapid growth compared with global TFEC (+1.8 percent). As a result, the renewable energy share in TFEC increased from 17.2 percent in 2016 to 17.3 percent in 2017—still lower than the all-time record share of 17.5 percent, achieved in 1999 (Figure 3.1).[24]

Last year, SDG 7 reported that the 2016 share of renewables had reached 17.5 percent. New data submissions in 2018–19 indicate an important historical revision over published data from the previous year. Several African countries, as well as developing countries in Asia, revised downward historical data on solid biomass and charcoal consumption from 2000 to 2016. As a result, the share of renewables declined globally by 0.1–0.3 percentage points throughout the historical time series. On the one hand, this downward revision slightly increases the distance to target—i.e., the gap between the current status and the objective of achieving substantial increases in the share of renewables by 2030. The revision implies, however, that the consumption of biomass for traditional uses in developing (non-OECD) Asia and Africa was lower than previously estimated, suggesting that these regions are making better use of resources. The trend of rising shares of modern renewables was largely unaffected by the historical data revision.

Trends between 2000 and 2007 showed global declines in the share of renewables owing to faster growth from non-renewable sources to meet surging global demand, in particular coal consumption in some emerging economies. Since 2011, renewables have increased more rapidly than global energy consumption, leading to a steady increase in their share of TFEC. Overall, bioenergy, including traditional uses of biomass, remains the largest source, accounting for almost 70 percent of global renewable energy consumption, followed by hydropower, wind, and solar.

FIGURE 3.1 • Renewable energy consumption by technology, and share in total energy consumption, 1990–2017



Source: IEA and UNSD.

24 The data for figures 3.1–3.13 were obtained from the databases of the International Energy Agency and the United Nations Statistics Division. Those databases are accessible at https://www.iea.org/data-and-statistics and https://unstats.un.org/unsd/energystats/.

The share of renewable energy in TFEC continued to increase in 2017, albeit at a slower pace. This slowed growth is explained, first, by the surge in global energy consumption (1.8 percent in 2017, compared with 1.1 percent in 2016). Second, overall hydropower generation was lower, especially in Europe and China, more than offsetting the year-on-year increases seen in the Americas. Meanwhile, the absolute increase in generation from wind and solar doubled year-on-year, leading to an increase in the share of modern renewables (i.e., excluding traditional bioenergy), which reached 10.5 percent in 2017, up from 10.3 percent in 2016.

After declines in 2015 and 2016, traditional uses of biomass increased in 2017 in absolute terms because overall decreases in Asia could not offset additional consumption in Africa. Nevertheless, the share of such uses in TFEC continued to decline, falling below 7 percent for the first time. This trend needs to accelerate to ensure access to electricity through modern technologies. Despite progress, modern renewables must expand much more quickly to compensate for falling shares of traditional uses of biomass and to achieve the SDG 7.2 goal of substantially increasing the share of renewables by 2030 (Figure 3.2).

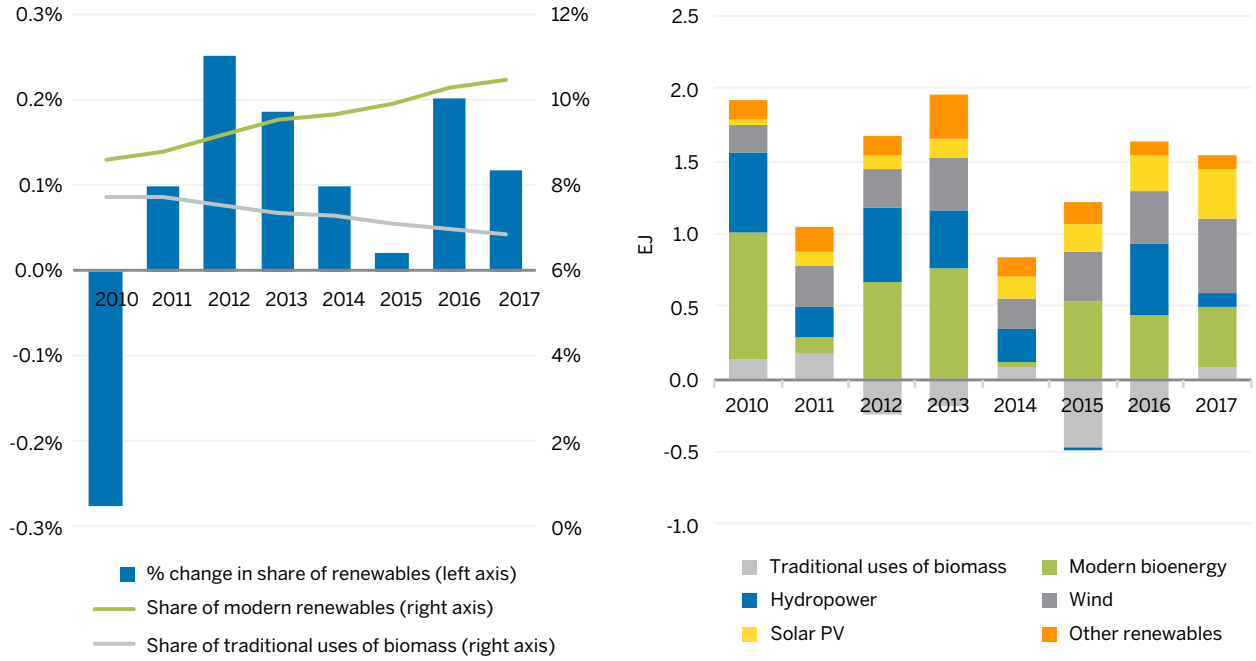
BOX 3.1 • "TRADITIONAL USES OF BIOMASS", DEFINED

The term "traditional uses of biomass" refers to the use of local solid biofuels (wood, charcoal, agricultural residues, and animal dung) burned with basic techniques, such as traditional open cookstoves and fireplaces. Owing to their informal and noncommercial nature, it is difficult to estimate the energy consumed in such practices, which remain widespread in households in the developing world. For purposes of this report, "traditional uses of biomass" refers to the residential consumption of primary solid biofuels and charcoal in non-OECD countries. Although biomass is used with low efficiency in OECD countries, as well—for example, in fireplaces burning split logs—such use is not covered by the traditional uses of biomass cited in this report.

Traditional uses of biomass tend to have very low conversion efficiency (5–15%) and, as local demand may also exceed sustainable supply, can often result in negative environmental impacts, notably deforestation. In addition, emissions of high particulate matter and other air pollutants are produced. When combined with poor ventilation, such pollutants create household indoor air pollution, which is responsible for a range of severe health conditions and a leading cause of premature death. Even though biomass as it is traditionally used is, in principle, renewable, policy attention should focus on reducing it and encouraging the adoption of more modern renewable heating and cooking technologies.

"Modern bioenergy" can be used efficiently for electricity generation, for industrial applications, for cooking in efficient wood or pellet stoves and boilers, and for the production of biofuels for transport. Modern bioenergy—along with solar PV, solar thermal, geothermal, wind, and hydropower—is one of the "modern renewables" analyzed in this report.

FIGURE 3.2 • Share of renewable energy, modern renewable energy, and traditional uses of biomass, 2010–17 (left) and Renewable energy consumption growth by technology (right)

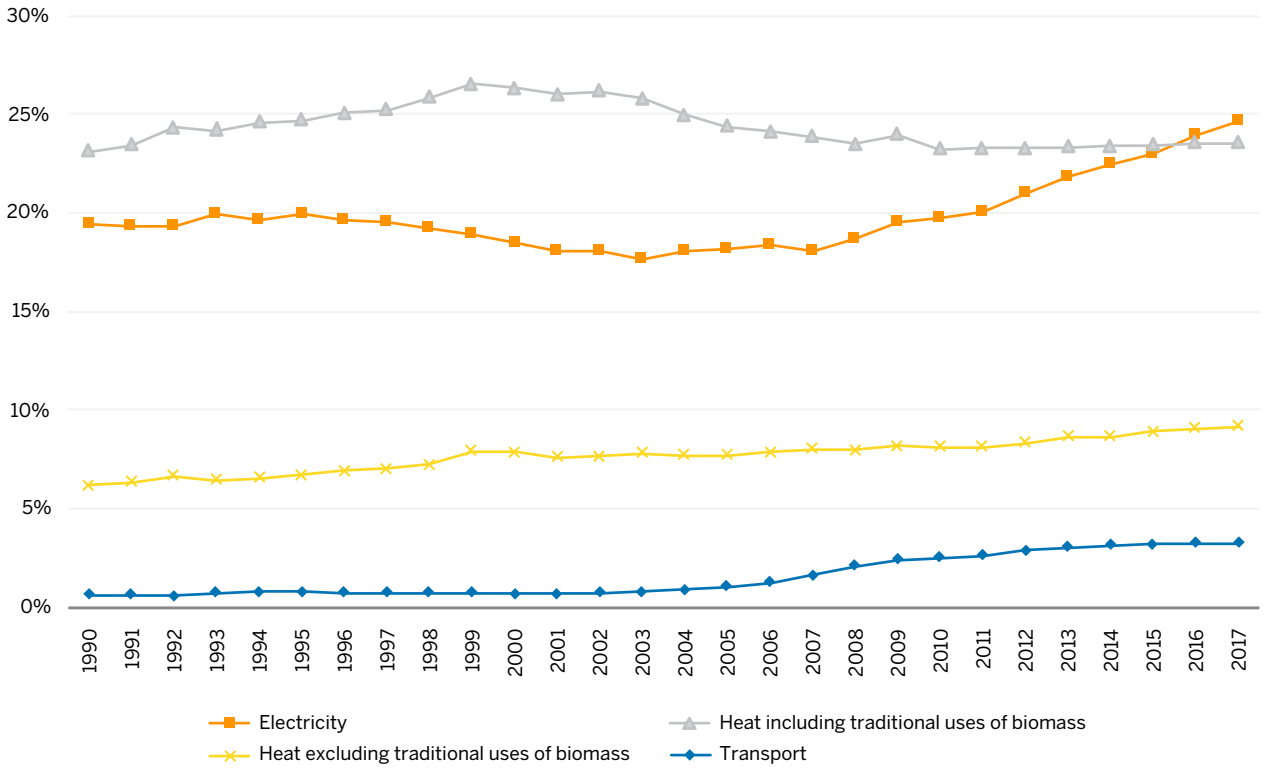


Source: IEA and UNSD.

LOOKING BEYOND THE MAIN INDICATORS

Renewable energy has three main end uses: electricity, transport, and heat.[25] The SDG 7.2 target calls for a "substantial increase" in the share of renewable energy, requiring an accelerated penetration of renewable energy in all three end uses. Electricity accounted for almost two-thirds of renewable energy consumption growth from 2016 to 2017, followed by heat (30 percent) and transport (6 percent). With this growth, renewables' share in electricity reached almost 25 percent and surpassed the renewable share in heat for the first time. The share of renewables (including traditional uses of biomass) in heat has been stable at around 23 percent since 2010 (Figure 3.3). The stability in shares stems from two concurrent drivers: first, slow declines in traditional uses of biomass for cooking and heating, and, second, greater use of modern renewable technologies. The year-on-year increase in the direct use of modern renewables for heat reached 2.3 percent in 2017. For the first time since 2001 the share of renewable energy in transport did not rise, remaining at 3.3 percent, which is the lowest share among end uses. Biofuels account for most of renewable consumption in transport, but renewable electricity use is also emerging thanks to the uptake of rail and electric vehicles.

FIGURE 3.3 • Renewable energy share by end use, 1990–2017



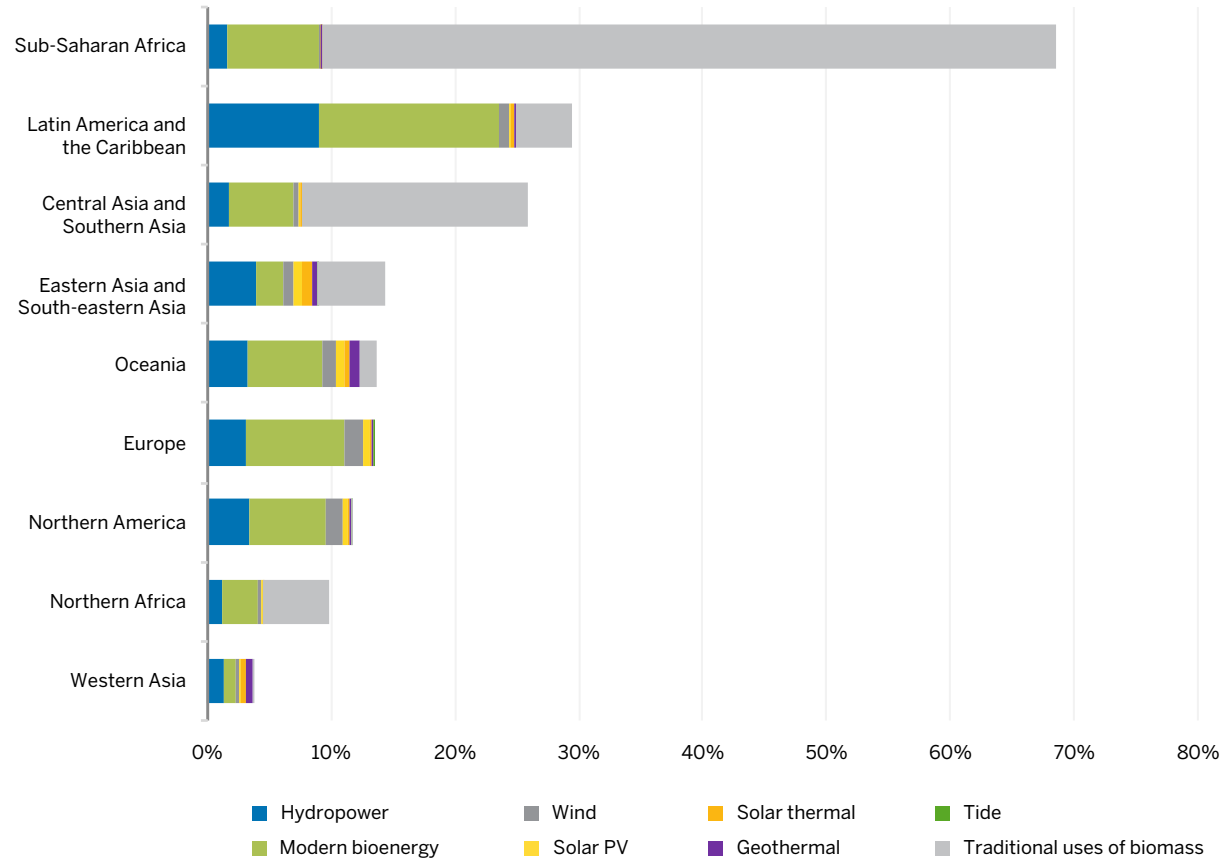
Source: IEA and UNSD.

The global figure on the share of renewables conceals regional disparities in the penetration of renewable energy and the role of traditional uses of biomass in country energy mixes (Figure 3.4). In 2017, Sub-Saharan Africa had by far the highest share of renewable energy in TFEC. But traditional uses of biomass account for almost 85 percent of

25 "End use" refers to the service for which energy is consumed. The services are classified into three categories: electricity end uses, transport end uses, and heating. For the sake of simplicity, the latter is referred to in this report as "heat." A fraction of electricity end uses overlaps with heat, as some electricity is consumed to produce heat. In this report, however, renewable electricity consumed to produce heat is accounted for under the electricity end use. Heat refers to the amount of non electric energy consumed for heating in industry and other sectors. It is not equivalent to the final energy end use.

total renewable energy consumption in the region. Latin America and the Caribbean had the largest share of modern renewables among all regions thanks to the extensive use of modern bioenergy in transport and industry, in addition to hydropower electricity generation. In Southern Asia as well as in Eastern Asia and South-eastern Asia, the penetration of modern renewables in TFEC remains below the global average at around 8 percent. Outside of Latin America, Middle Africa, Europe, Oceania, and Northern America had the highest share of modern renewables in final consumption in 2017, led by bioenergy and hydropower, with wind and solar PV making growing contributions.

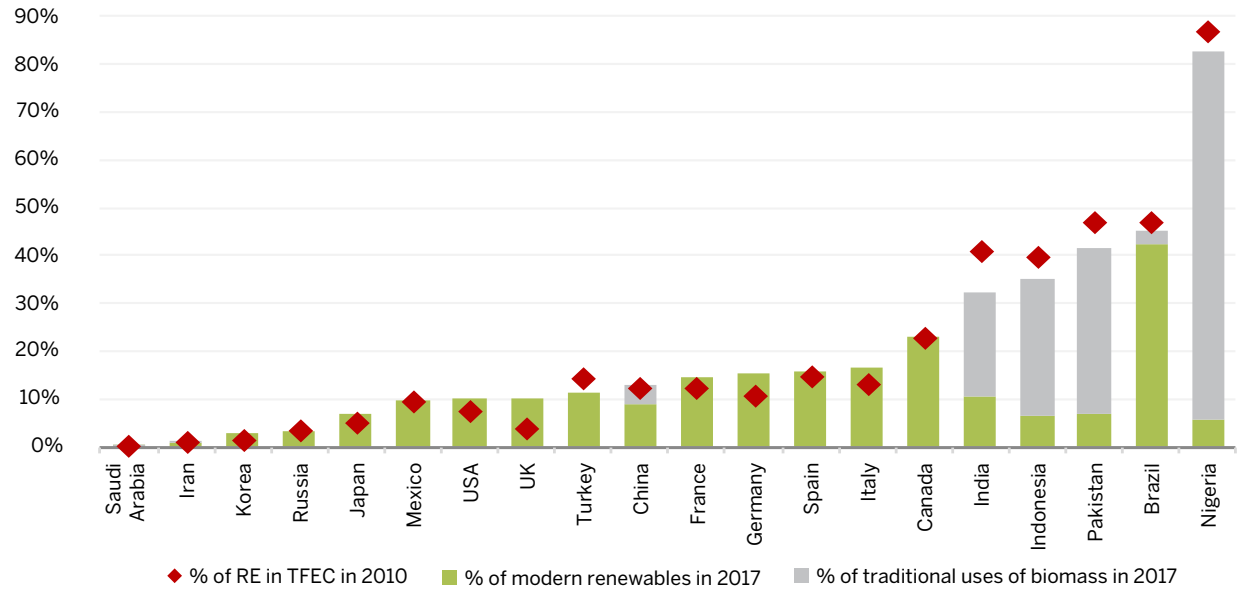
FIGURE 3.4 • Renewable share in total final energy consumption by region, 2017



Source: IEA and UNSD.

At the national level, the share of renewable consumption varies widely depending on resource availability, policy support, and the effect of energy efficiency on growth in demand for energy. Between 2010 and 2017, 13 of the 20 largest energy consumers increased the share of renewables (including traditional uses of biomass) in their consumption mix. The United Kingdom saw the largest relative increase, with its renewable share tripling between 2010 and 2017. Germany, Italy, France, and Japan also achieved remarkable growth, mostly in the power sector. In India, renewables penetration in TFEC has declined since 2010. Although wind, solar PV, and modern bioenergy grew, the upturn could not offset the welcome decline in the traditional uses of biomass and overall increases in energy consumption. In Indonesia, Pakistan, and Nigeria, modern renewables have grown far more slowly than non-renewable energy consumption (Figure 3.5). In absolute terms, China remains by far the largest consumer of all renewables, excluding bioenergy, while its share of renewables in TFEC—including traditional uses of biomass—was 13 percent in 2017. Among the 20 countries, Brazil was the absolute leader, with a 45 percent share of modern renewables, followed by Canada at 23 percent.

FIGURE 3.5 • Renewable energy share in TFEC, top 20 countries with the largest energy consumption, 2010 and 2017



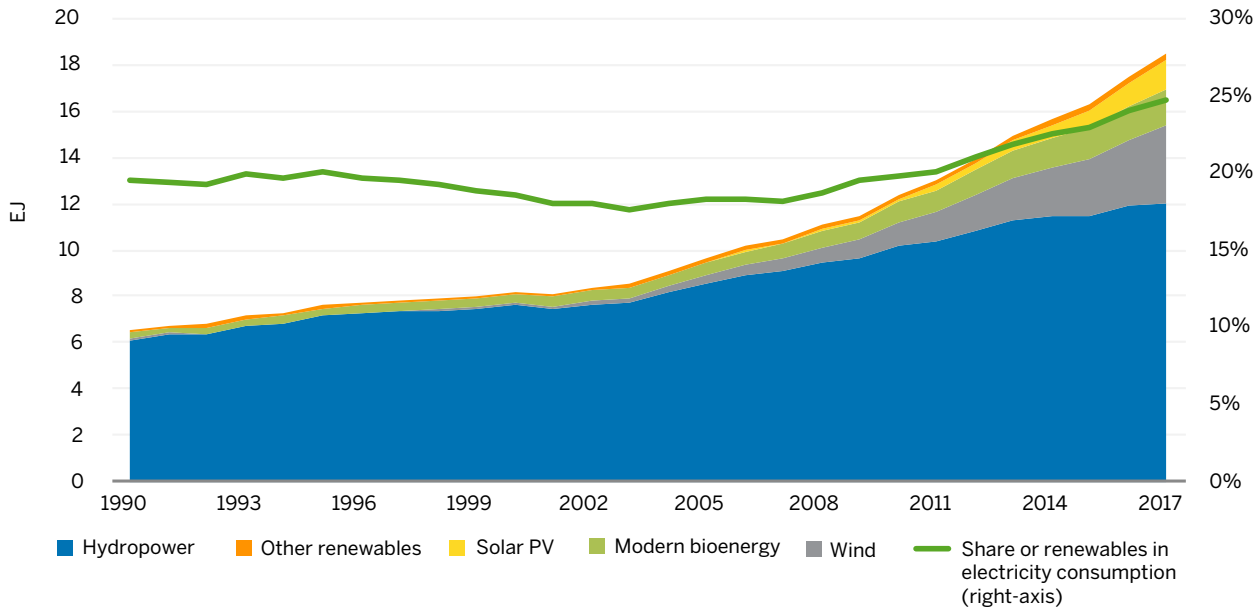
Source: IEA and UNSD.

RE = renewable energy, TFEC = total final energy consumption.

ELECTRICITY

In 2017, renewable electricity consumption grew by almost 6 percent. The share of renewables in global electricity consumption grew by 0.7 percentage points to reach 24.7 percent (Figure 3.6). The pace of growth slowed in comparison with 2016 despite slower overall growth in electricity demand. Lower hydropower output was the main reason behind the slowdown. From 2016 to 2017, hydropower generation declined in major hydropower-producing countries—Brazil, China, France, Italy, Spain, Pakistan, and Turkey—owing to low water availability. Nevertheless, hydropower remained the largest source of renewable electricity, accounting for two-thirds of all renewable power generation.

FIGURE 3.6 • Global renewable electricity consumption by technology, 1990–2017

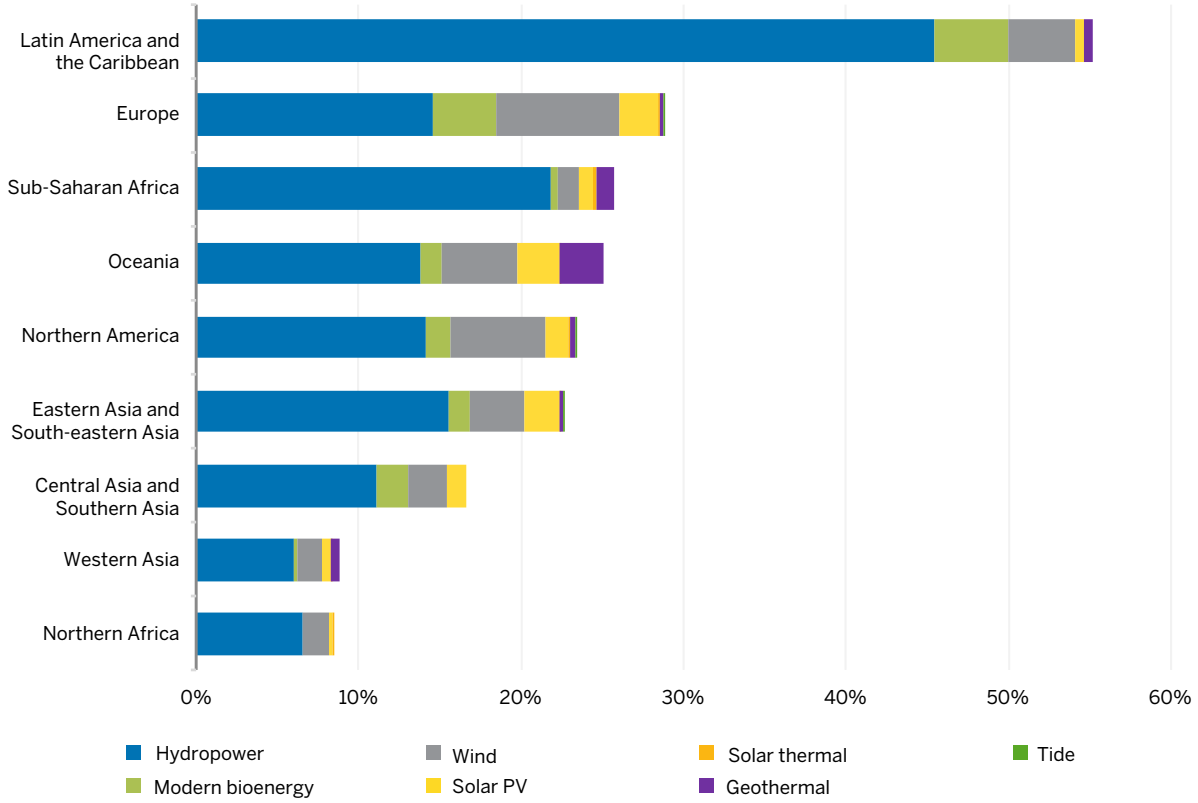


Source: IEA and UNSD.

In 2017, global solar PV and wind energy in electricity generation increased by 35 percent and 18 percent, respectively. Accordingly, wind and solar PV together were responsible for almost 85 percent of renewable electricity growth year-on-year.

In addition to policy support, resource availability explains regional differences in renewable electricity consumption. Latin America and the Caribbean commands the highest share of renewables in electricity consumption thanks to ample hydropower and bioenergy resources (Figure 3.7). In Europe, Northern America, and Oceania, hydropower remains the largest source of renewable generation, followed by wind and solar PV, which together provided on average 7–10 percent of total electricity generation in 2017. While hydropower remains the largest source of renewable electricity in Africa too, governments have been introducing policies to foster deployment of wind and solar technologies, which have benefitted from recent cost reductions.

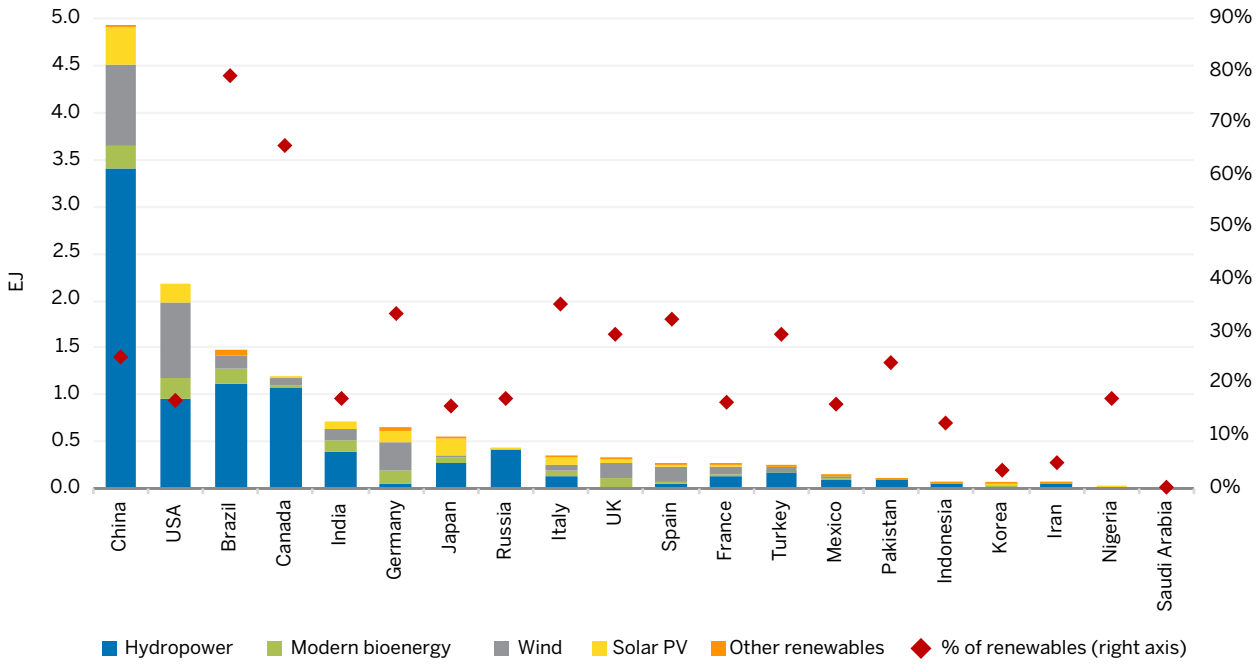
FIGURE 3.7 • Share of renewables in electricity consumption by region, 2017



Source: IEA and UNSD.

Among the top 20 energy consumers, the share of renewables in electricity ranges from less than 1 percent to 80 percent (Figure 3.8). In 2017, China consumed more renewable electricity than any other country globally in absolute terms, thanks to the country's hydropower generation. China was already the largest consumer of solar PV in 2016. As of 2017, the country also became the largest consumer of electricity from wind and bioenergy, surpassing the United States, which remained the second-largest consumer of renewable electricity in the world. Brazil and Canada have by far the highest share of renewables in electricity generation thanks to large hydropower capacities. In most European countries, wind and solar PV were the largest sources of renewable electricity, with their share ranging between 15–50 percent. Between 2016 and 2017, the United Kingdom's renewable electricity consumption increased by almost 20 percent, mostly thanks to offshore wind. With this growth, the country overtook Turkey, France, and Spain in just one year and became the tenth-largest renewable electricity consumer among the top 20 energy consuming countries.

FIGURE 3.8 • Consumption of electricity generated from renewable sources, top 20 countries, 2017



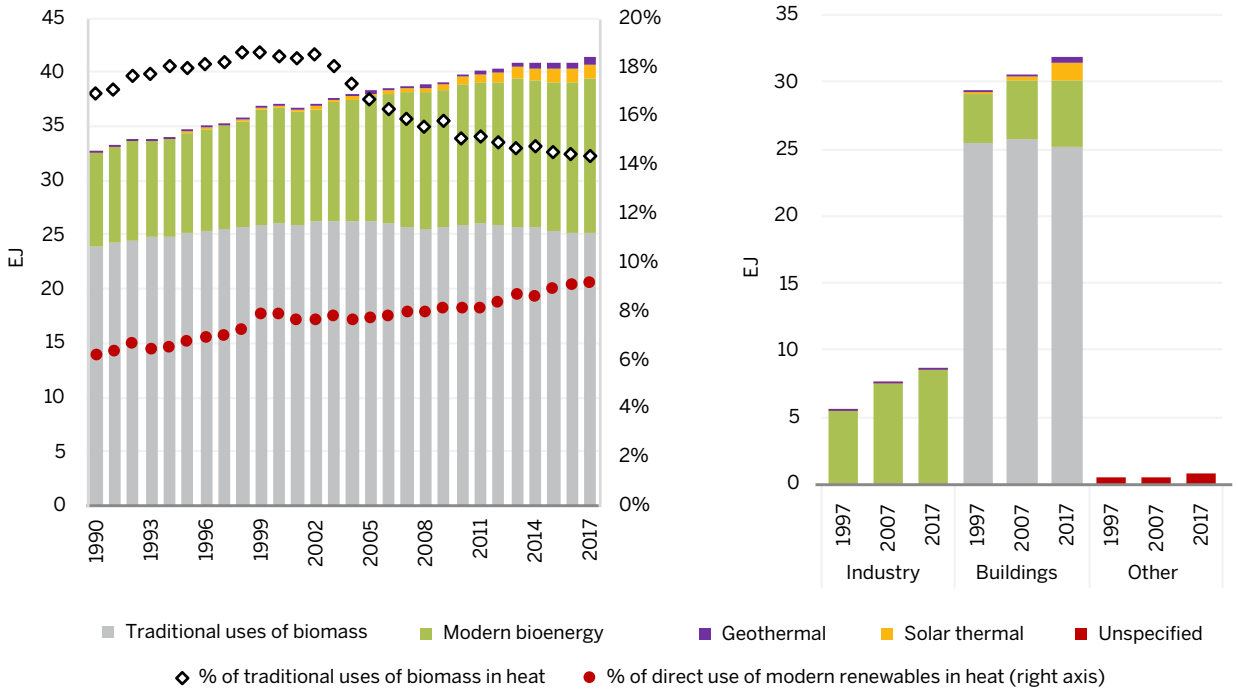
Source: IEA and UNSD.

RES = renewable energy sources, RES-E = renewable electricity

HEAT

Heat accounted for half of global final energy consumption in 2017, making it the largest energy end use worldwide (followed by transport and electricity generation). With coal, gas, and oil meeting more than three-quarters of global heat demand, the sector remains heavily dependent on fossil fuels. Traditional uses of biomass—which have low efficiency and generally result in adverse health and environmental effects—increased slightly (+0.3 percent) in 2017; such uses still account for more than 14 percent (25.2 EJ) of global heat consumption (Figure 3.9). Consumption of modern renewable energy for heat increased 2.3 percent in 2017, representing 9.2 percent of the heat consumed globally (up from 9.141 percent in 2016). A gradual transition away from the traditional uses of biomass to clean and modern cooking fuels, technologies, and services—mainly in developing countries, as indicated in the SDG 7.1 target—requires more policy attention. A faster deployment of modern renewables for heating, one that can replace traditional uses of biomass and fossil fuels, remains key to achieving both the SDG 7.2 and SDG 7.1 targets by 2030.

FIGURE 3.9 • Renewable heat consumption by source and sector



Source: IEA and UNSD.

Note: Indirect consumption of renewable heat through renewable electricity is not represented in this figure.

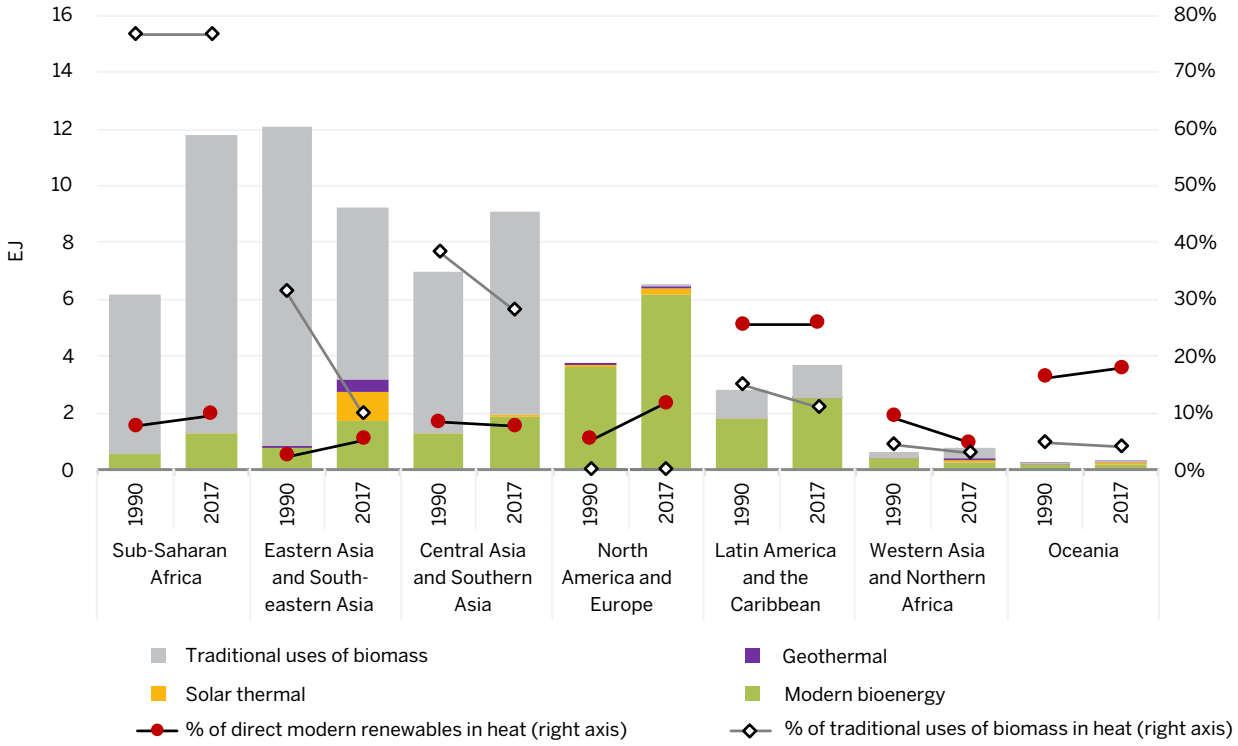
The consumption of modern bioenergy increased by 2 percent in 2017. Bioenergy makes up around 90 percent (14.2 EJ) of direct modern uses of renewables for heat and represents more than three-quarters of renewable district heat globally.[26] Industry is responsible for two-thirds of modern bioenergy use, most of which is concentrated in subsectors producing biomass residues on site, such as the wood, pulp, and paper industries, as well as the food and tobacco industries.

Global solar thermal consumption increased 3.3 percent in 2017, amounting to 1.3 EJ. The large majority corresponds to domestic solar water heaters, although large-scale systems for district heating and industrial applications continue to develop as a niche market. There is vast untapped potential for low-temperature industrial processes, but speeding deployment will require overcoming relatively high up-front costs and lack of awareness. China leads the solar thermal market, with 70 percent of global installed capacity in 2017, although capacity growth has slowed in recent years owing to reduced construction, market saturation, competition with other technologies, and the phaseout of incentives.

Meeting less than 0.5 percent of global heat demand, geothermal heat is the smallest renewable heat source. Bathing and space heating (via district heating) are the most prevalent applications globally. Development of geothermal systems remains limited to a few countries, with China and Turkey alone accounting for 84 percent of geothermal heat consumption worldwide. Direct use of geothermal heat increased 6.8 percent in 2017, contributing just over 0.6 EJ to the renewable heat supply.

26 Renewables also contribute to heat supply indirectly through renewable electricity used for heating. Taking these indirect uses into account, renewable electricity, used chiefly in buildings, is the second-largest modern renewable heat source after bioenergy. It accounted for an estimated one-third of the increase in total (direct and indirect) modern renewable heat consumption in 2017, owing to the combination of increasing penetration of renewables in the power sector and electrification of heating through the use of electric heat pumps and boilers.

FIGURE 3.10 • Renewable heat consumption by region, 1990 and 2017

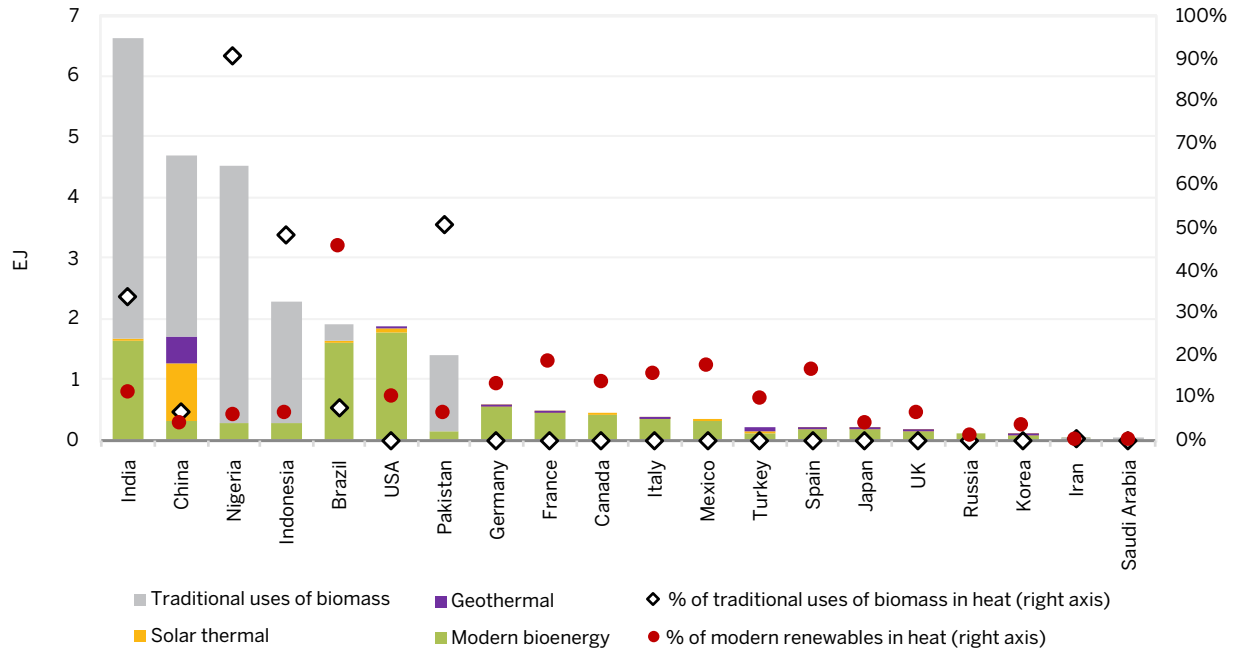


Source: IEA and UNSD.
Note: Indirect consumption of renewable energy through electricity for heat is not included in this figure.

The traditional uses of biomass are concentrated in Sub-Saharan Africa and Asia (Figure 3.10), with, in descending order, India, Nigeria, China, Indonesia, and Pakistan together accounting for more than 60 percent of global consumption. Stable traditional consumption of biomass at global scale hides disparate trends across regions: in Eastern Asia, consumption declined significantly over the past decade, especially in China, while in Sub-Saharan Africa consumption surged, driven by population increases.

Brazil, China, India, and the United States together accounted for more than 40 percent of global modern renewable heat consumption in 2017 (Figure 3.11). This results from the hefty consumption of bioenergy in the pulp and paper industry and for residential heating in the United States; the extensive use of bagasse in the sugar and ethanol industry in Brazil and India; and significant deployment of solar thermal water heaters in China. The European Union's Renewable Energy Directive, which promoted renewable heat consumption, was another factor, driving the expansion of residential wood and pellet stoves and boilers (e.g., in Italy, France, and Germany) and the use of biomass in district heating (e.g., Nordic and Baltic countries, Germany, France, and Austria). In addition, the growing consumption of renewable electricity through electric heaters and heat pumps in China, the United States, and the EU contributed indirectly to renewable heat consumption (IEA 2019b).

FIGURE 3.11 • Renewable heat consumption in top 20 countries, 2017

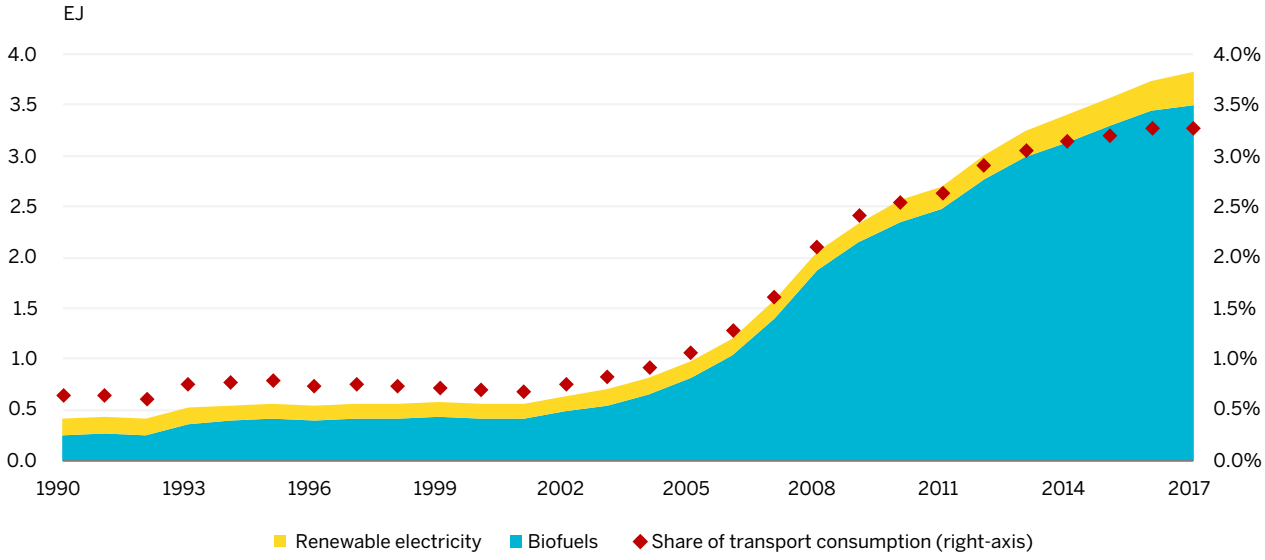


Source: IEA and UNSD.
Note: Indirect consumption of renewable energy through electricity for heat is not included in this figure.

TRANSPORT

The share of renewable energy in transport remained stable at 3.3 percent in 2017 year-on-year (Figure 3.12), the lowest of all end-use sectors. The majority of the renewable energy consumed came in the form of liquid biofuels, mainly crop-based ethanol and biodiesel blended with fossil transport fuels. Most of the remainder was from renewables-based electricity.

FIGURE 3.12 • Renewable energy consumption in transport, 1990–2017



Source: IEA and UNSD.

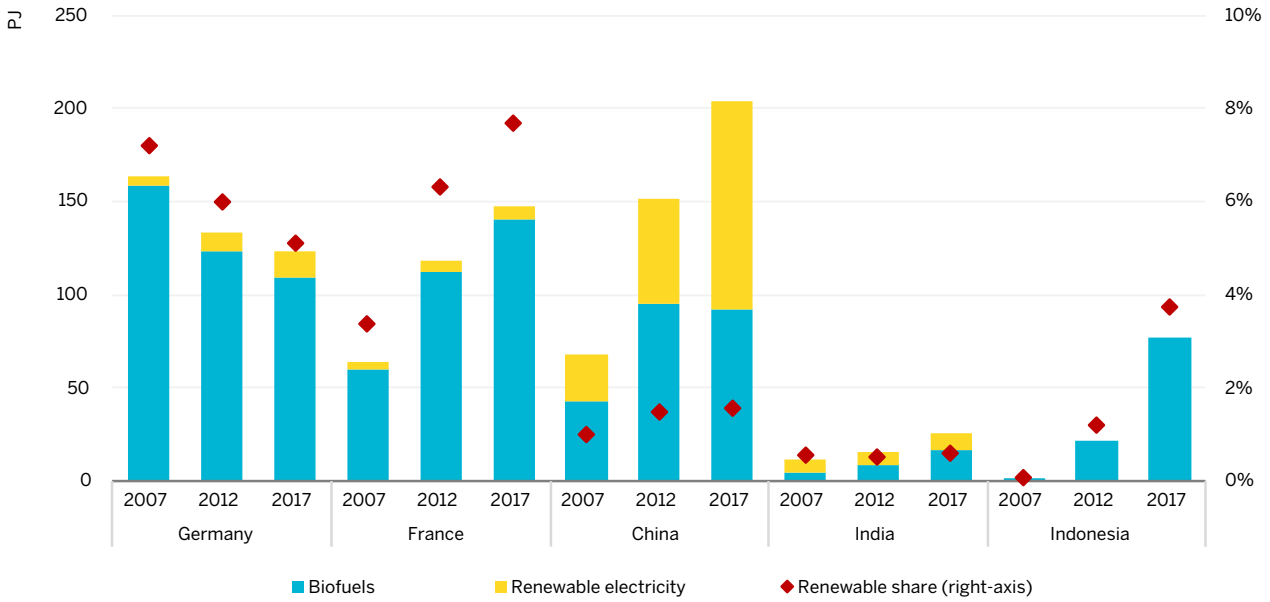
The share of renewable energy in transport is low (Figure 3.13). First, because biofuels are blended at low ratios with gasoline or diesel and, second, because the uptake of electric vehicles is still at an early stage. In addition, demand for fossil fuels for transport continues to grow. Petroleum-product consumption increased 15 percent from 2010 to 2017, with more than half of that growth occurring in the Asia-Pacific region. This has suppressed growth of the renewable energy share in China and India, even as renewable fuel consumption has grown.

Lack of broad policy support is also at work in the low uptake of renewable energy in transport. Around 130 countries consume no renewable energy in their transport sectors. Biofuel support policies exist in about 70 countries, and demand for electro-mobility is growing in China, Europe, and the United States. But many countries have no policies to support and stimulate low-carbon transport. As of 2017, only four countries had shares of renewable energy in transport that exceeded 10 percent: Brazil, Finland, Norway, and Sweden.

Furthermore, most of the transport-related renewable fuel consumption pertains to road vehicles, with minimal use in aviation and maritime transport. This is due to lower availability of economic and technically viable renewable fuels, compounded by even less policy support for their use in these long-haul sectors.

The United States and Brazil together accounted for 60 percent of renewable energy in transport in 2017. Shifting market dynamics in other key countries have produced variable growth in renewable energy consumption over the past ten years.

FIGURE 3.13 • Renewable fuel consumption in transport in selected countries



Source: IEA and UNSD.

In the transport sector, ethanol constitutes the largest share of renewable energy. But over 2013–17 the average annual increase in renewable energy consumption from ethanol was less than half that achieved in the previous five-year period. This is primarily because of the slowing expansion of ethanol consumption in the United States. Gasoline blended with ethanol at 10 percent covers almost all demand, while higher ethanol blends (such as 15 percent) is relatively minimal owing to limits in fuel-supply infrastructure and vehicle compatibility.

Europe has been a global leader in biodiesel consumption. But growth in demand has slowed. Consumption growth from 2013 to 2017 was a fifth of the levels reported for the preceding five years. A key factor was a decline in the German market, where consumption in 2017 was 20 percent lower than it was for 2008. In France and Spain, by contrast, markets continue to grow.

In 2017, global consumption of electricity in transport was 1.3 EJ, of which 24 percent was renewable (0.3 EJ). Rail consumed most renewable electricity in transport, with a smaller but growing share from road electric vehicles, a category that comprises cars, buses, and two- and three-wheel vehicles. The global electric car stock was around 3 million vehicles in 2017 and surpassed 5 million in 2018. China has significantly higher demand for renewables-based transport fuel. There, in 2017, over half of renewable energy in transport came from electricity, with the largest consumption coming from two- and three-wheeler vehicles.

New fuels with the potential to increase the renewable share in transport are entering the market. Consumption of hydrotreated vegetable oil, also known as renewable diesel, is on an upward trend, with demand growing in Europe and the United States. Technically a "drop-in" fuel, HVO can be used unblended in some diesel engines and offers the prospect of increasing the renewable share without changing vehicle fleets or modifying fueling infrastructure.

Biomethane (or biogas upgraded to the quality of natural gas) also offers a means of increasing renewable energy in transport. A like-for-like replacement for natural gas in suitable vehicles, it holds particular potential for road freight, where a strategic rollout of fueling infrastructure along key transport corridors could attract a relatively large share of demand, and for captive fleets, where vehicles operate on set routes and refuel at depots.

Progress is also evident in renewable aviation fuels. Flights using biofuel blends have surpassed 230,000; continuous biofuel supply is available at six airports; and there is policy support for their use in the United States and Europe. Nonetheless, aviation biofuels account for less than 0.1 percent of fuel demand. Renewable fuel consumption in marine transport remains nascent.

POLICY INSIGHTS: A FOCUS ON ELECTRICITY AND AUCTIONS

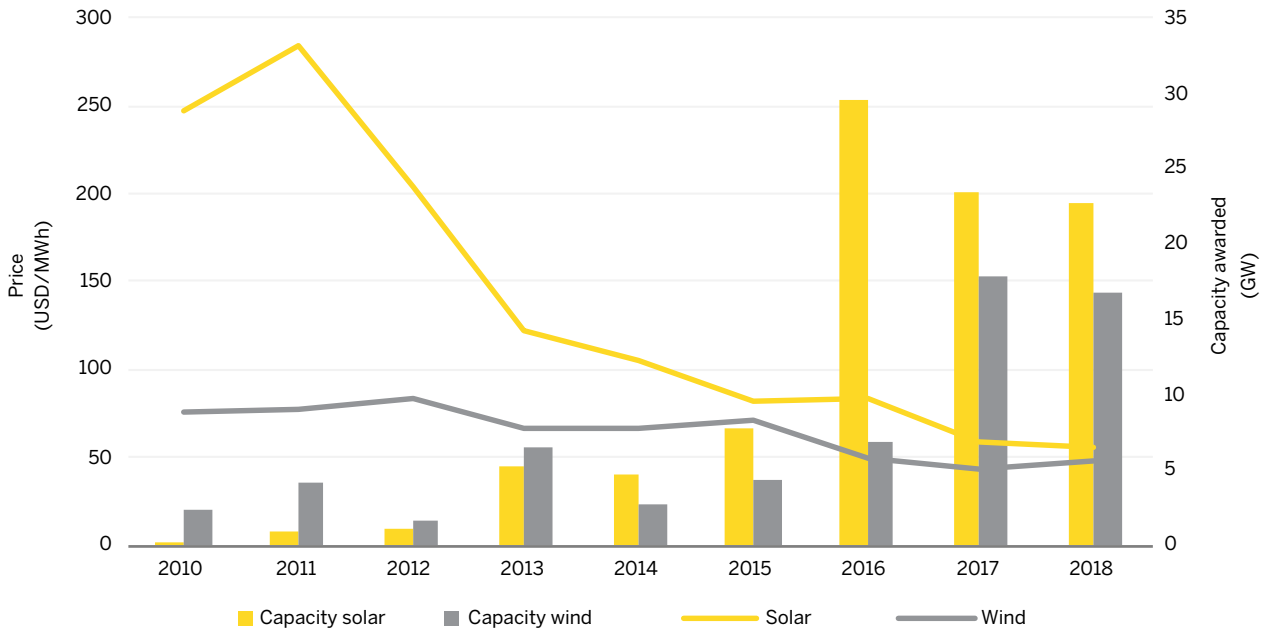
While modern renewable energy has seen robust growth in the past few years, deployment would need to accelerate much faster, especially in the heat and transport sectors, to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030. Most scenarios for the energy transition point in the same direction. At the core of an energy transition thorough enough to reach the target of SDG 7 is increased electrification of all end uses, combined with a decarbonized power sector.

Various policies and measures adopted worldwide have supported renewable energy deployment in the power sector. The focus here is on the increasingly prominent role of auctions.

Between 2014 and 2018, instruments for competitively-set tariffs (auctions) have gained popularity, especially for utility-scale applications, owing chiefly to their ability to procure renewables-based electricity at the lowest price. By 2018, more than 106 countries had adopted auctions at some point in time (REN21 2019; IRENA 2019a), with at least 68 countries announcing auctions during the reporting period covered here (2010–18) (ESMAP 2018).

As illustrated in Figure 3.14, price results for solar and onshore wind auctions have decreased in the past decade. In 2017, solar energy was contracted at a global average price of almost USD 58/MWh, down from USD 250/MWh in 2010. Wind prices also fell during that period, albeit at a slower pace—from USD 75/MWh in 2010 to USD 43/MWh in 2017. Plunging technology costs have led policy makers to consider auctions as a way to track the price of renewable energy in their country. This downward trend continued for solar PV, though at a slower pace, reaching USD 56/MWh in 2018, while onshore wind prices rose slightly, reaching USD 48/MWh.

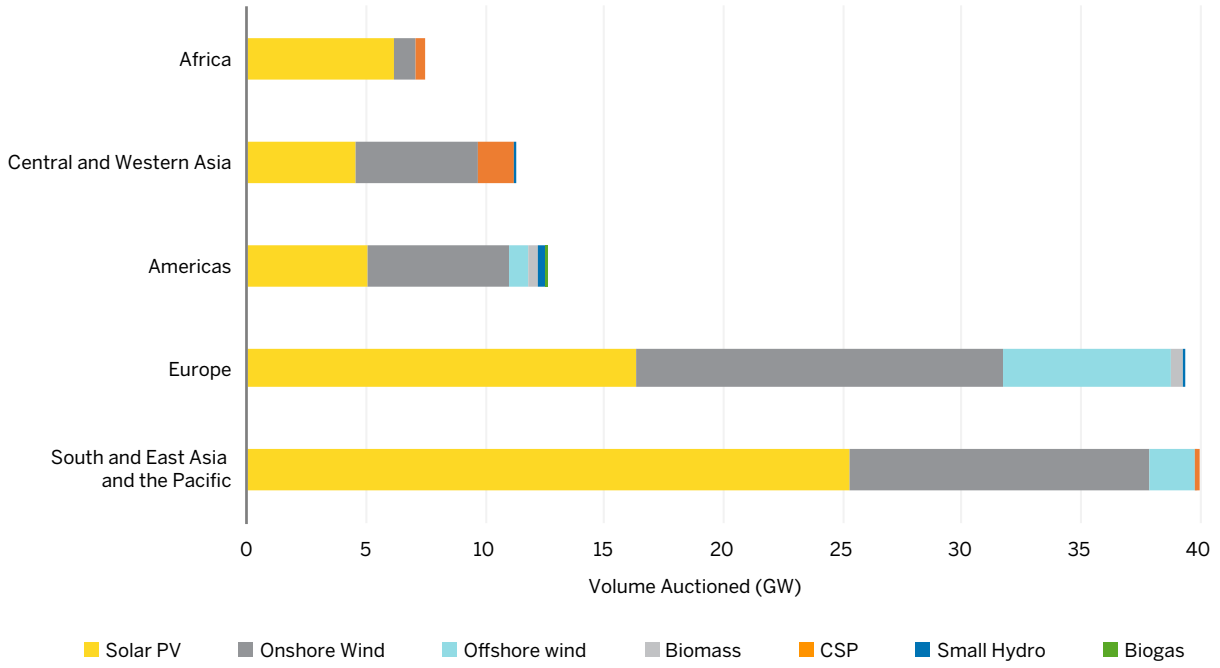
FIGURE 3.14 • Global weighted average prices resulting from auctions and capacity awarded each year, 2010–18



Source: IRENA (2019a), based on BNEF (2019a) and PSR (n.d.).

In the period between 2017 and 2018, an estimated total volume of 111 GW was auctioned or announced. Solar PV and onshore wind—the variable renewable energy sources—accounted, respectively, for 52 percent and more than 36 percent of the total volume (IRENA 2019a). As shown in Figure 3.15, the use of auctions varied across regions as a function of varying levels of development of the renewable sector, power market structures and macroeconomic contexts.

FIGURE 3.15 • Volume auctioned between January 2017 and December 2018, by region and technology (GW)



Source: IRENA (2019a), based on BNEF (2019a) and PSR (n.d.).

Most African countries that held auctions in 2017–18 were doing so for the first time. Their auctions were dominated by solar PV, where dedicated programs, such as the IFC's Scaling Solar Program, succeeded in attracting investments in Ethiopia, Madagascar, Senegal, and Zambia. The choice of auctions in Africa is driven for the most part by their potential for price discovery, especially when there is uncertainty regarding how to set the right price administratively (e.g., for a feed-in tariff). The flexibility in their design is also crucial: auctions can be tailored to specific contexts and designed to achieve low prices, through, for example, allocation of risks across multiple stakeholders. In this context, the right risk allocation and transparent processes are key to success in attracting private investment, both domestic and foreign. Auctions can be tailored to other policy purposes, as well, such as socioeconomic benefits, including job creation and development of a local industry.

Countries in Europe and Southern and Eastern Asia and the Pacific auctioned much higher volumes, predominantly solar PV and wind (both offshore and onshore). Some of those countries that had been supporting renewables through administratively-set tariffs (e.g., Germany, Japan, and Malaysia) turned to auctions to reduce the cost of support. In addition, members of the European Union have been required to follow the European Commission's Guidelines on State Aid for Environmental Protection and Energy for 2014–20, which established market-based mechanisms as the main instrument of support for renewables. The guidelines favor competition between renewable technologies but explicitly allow for technology-specific auctions. Many countries adopted technology-specific auctions (namely, in Europe, Southern Asia, Eastern Asia, and the Pacific) to support the introduction of specific technologies into the mix (e.g., offshore wind in Germany, Japan, and the Netherlands) or to achieve technology-specific targets (e.g., solar PV in India). Increasing generation from variable renewable energy sources poses system integration challenges that can also be addressed through auction designs that make geographical allocations sensitive to resource availability and network integration costs. Strategies include introducing hard limits on volumes that can be commissioned in congested zones, procurement of specific projects (e.g., solar PV and batteries combined), or implementing price adjustments to incentivize the production of power when and where it is most needed.

Moving toward a higher share of variable renewable energy will require a more comprehensive and integrated approach to power market design. The existing power markets (both regulated and liberalized) were originally designed around the technologies of the fossil fuel era, where large, centralized, and dispatchable generation provided electricity to a largely passive demand. Such system designs can limit the deployment of renewable power, increase electricity costs, and reinforce social inequalities (IRENA 2020b). The experience of auctions can assist in the redesign of power markets.

As the results of renewable energy auctions fall more and more in line with prices of conventional generation, they are being reshaped from support mechanisms to market mechanisms. In developed markets, their current role is centered more on overcoming market structure failures rather than on providing support (IRENA 2020a). In Latin America, in particular, auctions are already a functioning part of the power markets, and renewable energy generators are able to achieve cost-competitiveness with fossil fuels (Batlle et al. 2018; Roques et al. 2017). Policy makers are thus able to consider the restructuring of power markets, as auctions offer a viable solution for the large-scale procurement of low-cost renewable energy (IRENA 2020a, 2020b).

The restructuring of power markets should also enable responsive demand, including end uses, which are currently dominated by fossil fuel solutions. Sector coupling through heat pumps, electrified industrial loads, and electric vehicles, for example, could complement future power sector needs, providing the ability to shift demand during periods of high production of variable renewable energy. At the same time, further electrification using renewable energy would assist the decarbonization of all end-use sectors, and the direct use of renewables could complement nonelectrifiable loads.

The large-scale adoption of these technologies, however, will require proper planning for the energy sector as a whole. Electrified loads and renewable energy should be deployed in a coherent fashion that enables and exploits synergies between resources. Investments should prioritize long-term solutions so as to avoid stranding assets and locking consumers into technologies not suited for the renewable energy era.

As renewable energy technologies become mainstream, the policies driving their deployment are quickly evolving. This rapid evolution reflects many factors, among them changing market conditions, technical and socioeconomic hurdles, and the need to ensure a just transition. Through the increasing use of auctions, policy makers have sought to procure renewable electricity cost-effectively while fulfilling other, often country-specific social and economic goals. In other words, the trade-offs between achieving the lowest price and meeting other objectives can and should be considered when designing auctions. Design elements such as winner selection criteria, limits on project size, and qualification requirements, among others, can be introduced to include small and new players, foster the development of local industries, create local jobs, contribute to subnational development, and engage communities, even if at a marginally higher price for electric power. But it must be remembered that these design elements, effective as they are, are just a part of a broader policy framework devoted to more just and inclusive energy transition, one that promotes renewables deployment as a catalyst of inclusive and sustainable development and it rests on three transformative sets of policies: deployment, enabling, and integrating policies (IRENA, IEA, REN21, 2018).

BOX 3.2 • RENEWABLE ENERGY TO ADVANCE PROGRESS TOWARD SDG 8

An increase of renewable energy in the global energy mix translates into a number of tangible benefits, including progress toward SDG 8 on jobs and economic well-being. As renewable energy has developed into a jobs engine of growing significance, the linkages between SDG 7 and 8 are increasingly acknowledged.

IRENA's analysis shows that the number of renewable energy jobs worldwide has expanded from 7.3 million in 2012 to 11 million in 2018 (IRENA 2019b). Modeling suggests that the energy transition could expand renewable energy employment to 30 million by 2030 and 42 million by 2050 (IRENA 2020c). Although most jobs grew out of a modern energy context, recent growth in decentralized renewable energy solutions appears to be creating jobs, too. For instance, GOGLA and Vivid Economics estimated direct off-grid solar employment in Southern Asia and parts of Sub-Saharan Africa at 372,000 full-time-equivalent jobs (GOGLA 2018).

But in moving toward SDG 7, SDG 8, and the global energy transition, the centrality of jobs is about more than numbers. A decent job should provide an adequate wage or salary, SDG 8 states, irrespective of gender, in a safe and productive workplace. In the energy transition, well-trained workers who stay long enough in their jobs will be able to hone their skills and build the experience essential to success.

As of today, progress on employment related to achieving SDG 7 is evident but uneven. Most renewable energy jobs are concentrated in key markets—namely, Brazil, China, Europe, India, and the United States—the home states of the leading manufacturers and installers. Still, more countries are beginning to realize benefits of their own. They will be in a strong position to benefit further to the extent they can combine ambitious renewable energy deployment policies with related measures to build industrial capacities, expand education and skill-building, and ensure that the social benefits of the energy transition are broadly shared.

Benefits are still uneven with regard to the status of women. Although recognized as change agents in the promotion of renewable energy, women remain underemployed and underrepresented amongst entrepreneurs. A global survey indicated that women constitute only 21 percent of the wind energy workforce (IRENA 2020d), compared with 32 percent in renewables overall and 22 percent in traditional energy industries like oil and gas (IRENA 2019c). Substantial efforts are still needed to allow women to marshal their skills, talents, and perspectives in support of the coming transformation (IRENA 2019c; GWNET 2020).

Achieving SDG 7 and SDG 8 rests on the creation of more renewable energy jobs and on gaining a better understanding of the required skills. Additional data gathering and policy analysis are needed, which led IRENA and several international partners to launch a joint initiative at the start of 2020: for more information on the Sustainable Energy Jobs Platform, please visit: http://sejplatform.org/.

METHODOLOGY

DEFINITIONS

Renewable energy sources (RES)	Total renewable energy from: hydropower, wind, solar photovoltaic, solar thermal, geothermal, tide/wave/ocean, renewable municipal waste, solid biofuels, liquid biofuels, and biogases
Renewable energy consumption	Final consumption of direct renewables plus the amount of electricity and heat consumption estimated from renewable energy sources
Direct renewables	Final consumption of bioenergy, solar thermal, and geothermal energy
Total final energy consumption (TFEC)	The sum of the final energy consumption in the transport, industry, and other sectors (also equivalent to the total final consumption minus non-energy use)
Traditional uses of biomass	Final consumption of traditional uses of biomass. Biomass uses are considered traditional when biomass is consumed in the residential sector in non–Organisation for Economic Co-operation and Development (OECD) countries, excluding Eurasia. It includes the following categories in International Energy Agency statistics: primary solid biomass, charcoal and non-specified primary biomass, and waste. Note: This is a convention, and traditional consumption/use of biomass is estimated rather than measured directly.
Modern renewable energy consumption	Total renewable energy consumption minus traditional consumption/use of biomass.

METHODOLOGY FOR MAIN INDICATOR

The indicator used in this report to track SDG 7.2 is the share of renewable energy in total final energy consumption. Data from the International Energy Agency (IEA) and United Nations Statistics Division (UNSD) energy balances are used to calculate the indicator according to the formula:

$$\%TFEC_{RES} = \frac{TFEC_{RES} + \left(TFEC_{ELE} \times \frac{ELE_{RES}}{ELE_{TOTAL}}\right) + \left(TFEC_{HEAT} \times \frac{HEAT_{RES}}{HEAT_{TOTAL}}\right)}{TFEC_{TOTAL}}$$

where the variables are derived from the energy balance flows (TFEC = total final energy consumption as defined in Table 1, ELE = gross electricity production, HEAT = gross heat production) and their subscripts correspond to the energy balance products.

The denominator is the total final energy consumption of all energy products (as defined in Table 1) while the numerator, the renewable energy consumption, is a series of calculations defined as: the direct consumption of renewable energy sources plus the final consumption of gross electricity and heat that is estimated to have come from renewable sources. This estimation allocates the amount of electricity and heat consumption to renewable sources based on the share of renewables in gross production in order to perform the calculation at the final energy level.

METHODOLOGY FOR ADDITIONAL METRICS BEYOND THE MAIN INDICATOR

The amount of renewable energy consumption can be divided into three end-uses to refer to the energy service for which the energy is consumed: electricity, heat, and transport. They are calculated from the energy balance and are defined as follows:

Electricity refers to the amounts of electricity consumed in the industry and other sectors. Electricity used in the transport sector is excluded from this aggregation. Electricity used for heat-raising purposes is included because official data at the final energy service is unavailable.

Heat refers to the amount of energy consumed-for heat-raising purposes in the industry and other sectors. It is not equivalent to the final energy end use service. It is also important to note that in this chapter in the context of an "end-use", it does not refer to the same quantity as the energy product "Heat" in the energy balance as used in the formula above.

Transport refers to the amounts of energy consumed in the transport sectors. Electricity used in the transport sector is mostly comprised of the rail and road sectors (and in some cases, pipeline transport). The amount of renewable electricity consumed in the transport sector is estimated based on the share of renewable electricity in gross production.

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