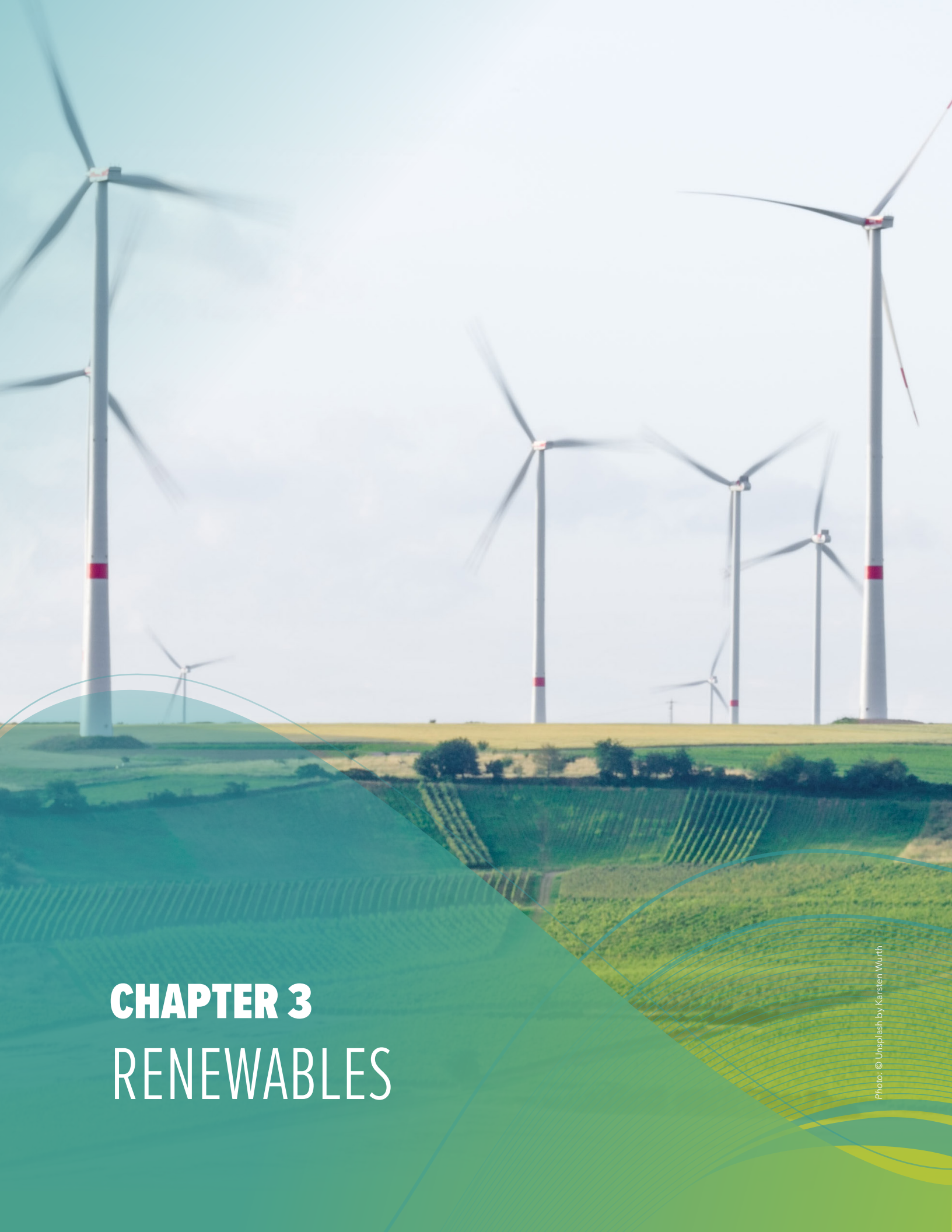


CHAPTER 3
RENEWABLES

Photo: © Unsplash by Karsten Wurth

Main Messages

- **Global trend.** In 2020, renewable energy consumption, including traditional uses of biomass, continued to grow at 2.6 percent year-on-year globally, despite a turbulent year due to the Covid-19 pandemic. This growth was driven largely by increases in renewable power generation, notably due to record additions of solar PV and wind capacity. Reduced energy consumption during the Covid-19 pandemic made 2020 a statistical anomaly, causing the share of renewables in total final energy consumption (TFEC), the central metric for SDG7.2, to increase by an unprecedented 1.4 percentage points to 19.1 percent.[43] However, this notable increase is not expected to repeat itself in 2021, as TFEC is anticipated to rebound close to pre-pandemic levels with the recovery of economic activity and restrictions of movements being lifted in most countries. When looking only at modern uses of renewables, their share of TFEC stood at 12.5 percent in 2020, only 3.8 percentage points more than a decade earlier, as the increase in TFEC exceeded those in modern uses of renewable energy consumption, underscoring the importance of energy efficiency (SDG7.3) and energy conservation actions.
- **Target for 2030.** While no quantitative milestone has been set for SDG target 7.2 which calls for "increasing substantially the share of renewable energy in the global energy mix", custodian agencies indicate that current trends are neither in line with the target's ambition nor with internationally agreed-upon climate objectives. To meet these objectives, the share of modern uses of renewables in TFEC would need to almost triple to 33-38 percent by 2030 depending on different pathway assumptions. Reaching these levels requires sustaining the accelerated renewables deployment seen in the electricity generation sector and considerably stepping up the share of renewables in heating and transport, alongside substantial progress in energy conservation.
- **Electricity.** Renewable electricity use grew more than 7 percent year-on-year in 2020, with the share of renewables in global electricity consumption increasing from 26.3 percent in 2019 to 28.2 percent. This is the largest annual progress recorded over the past three decades. Greater reliance on renewable electricity combined with the stabilization of global electricity demand in 2020 allowed nonrenewable electricity consumption to drop 2.8 percent year-on-year. Hydropower remains by far the largest source of renewable electricity globally, followed by wind and solar photovoltaic (PV). Yet the deployment of both wind and solar PV is accelerating; they recorded the largest absolute annual growth in 2020, and together represent two-thirds of the global increase in renewable electricity consumption observed since 2015.
- **Heat.** Renewable energy consumed for heating increased 0.9 percent to 42 exajoules (EJ) in 2020. Unfortunately, traditional uses of biomass represented almost 60 percent of this growth increasing the scale of negative health, social and environmental impacts of the lack of access to clean cooking. This was mainly caused by the Covid-19 pandemic that disrupted clean cooking fuel deliveries and imposed working restrictions reducing consumer ability to afford modern fuels, pushing many back to the traditional uses of biomass. The traditional

43 This calculation for the heat sector does not include renewable electricity used for heating or ambient heat harnessed by heat pumps. This exclusion reflects limited data availability at a global scale and the difficulty of quantifying the portion of electricity consumption devoted to heating.

use of biomass still accounted for nearly 14 percent (24 EJ) of global heating needs in 2020. In 2020, the share of modern uses of renewables in the global energy consumed for heating reached just 10.4 percent, only 1.2 percentage points higher than in 2015. The most-energy-intensive industries, such as steel, cement, chemicals, and aluminum, still rely heavily on fossil fuels for high-temperature heat. Processes based on renewable-derived alternatives like hydrogen are being explored. Yet the penetration of renewable energy remains challenging in these energy-intensive sectors, and it is therefore crucial to reduce the material intensity of industry, notably construction, to achieve a greater share of renewables in heat.

- **Transport.** The transport sector, affected as it was by policy responses to the pandemic, saw a 14 percent (-16.6 EJ) decline in global final energy consumption in 2020. Biofuel for transport declined in lockstep with oil consumption, leading to the largest reduction amongst renewable energy sources between 2020 and 2019, at an estimated 4 percent (-0.16 EJ). This was the first reduction in annual production in two decades. Biofuels—primarily crop-based ethanol and biodiesel—still supplied 90 percent of renewable energy used for transport. The remainder was mostly from renewable electricity, with its share in the TFEC for transport increasing to 0.4 percent (0.41 EJ) owing to rising sales of electric vehicles and a larger share of renewables in electricity used for transport. This brings the total share of renewable energy to 4 percent (up from 3.6 percent in 2019) for this sector, only 0.9 percentage point higher than in 2015.
- **Regional highlights.** In 2020, almost half of the global year-on-year increase in modern uses of renewable energy consumption was in Eastern Asia—led by China—where wind, hydropower, and solar PV dominated growth. Europe accounted for more than one-quarter of this increase in modern uses of renewable energy consumption, owing to favorable conditions for hydropower and the growth of wind and solar PV capacity. The share of renewables in TFEC increased in all regions in 2020, and grew the fastest in Latin America and Europe, supported in both cases by significant declines in TFEC. Sub-Saharan Africa accounts for the largest share of renewables in its energy supply at 71 percent, due to the predominance of traditional uses of biomass for heating and cooking in this region. Meanwhile, Latin America and the Caribbean has the largest share of modern uses of renewables in TFEC at 29%, owing to hydropower generation and the consumption of bioenergy in industrial processes and biofuels for transport in this region.
- **Top 20 energy-consuming countries.** Among the top 20 energy-consuming countries, Brazil and Canada continued to have the largest shares of modern uses of renewables in 2020, owing to their heavy reliance on hydropower for electricity and bioenergy for heat and transport. Except Türkiye, all countries saw an increase in the share of modern uses of renewables in their TFEC in 2020, with Indonesia achieving the largest year-on-year growth, followed by Brazil and the United Kingdom. Between 2010 and 2020, this share had declined in 3 of the 20 countries (Nigeria, Pakistan, and Türkiye), despite growing consumption of modern uses of renewable energy in all of them. In the same period, the consumption of nonrenewable energy increased in 11 of these countries. This highlights the importance of containing overall energy consumption and expediting the shift away from fossil fuels to achieve greater shares of renewables in the energy mix.
- **Installed renewable energy-generating capacity in developing countries.**[44] A record 268 watts per capita of renewable capacity were installed in 2021, representing a year-on-year growth rate of 9.8 percent. Despite this promising trend, more needs to be done toward indicator, 7.B.1, to "expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing states and landlocked developing countries, in accordance with their respective programmes of support." This is especially crucial because the positive global and regional trends mask the reality that countries in the greatest need of support are being left behind, even among developing nations. Only four developing countries have more than 1,000 watts per capita, and they are the same as last

44 See chapter 7 for a list of the developing countries considered under this indicator.

year: Bhutan, Paraguay, the Lao People's Democratic Republic [PDR], and Uruguay. While renewables capacity per capita registered high growth in the developing world (at a compound annual growth rate [CAGR] of 9.6 percent over 2016–21), growth was lower for small island developing states (8.5 percent), least-developed countries (5.5 percent), and landlocked developing countries (3.8 percent). This trend underscores the urgent need for greater policy support and investment to ensure that all developing countries have the capabilities to contribute to global climate change mitigation efforts and meet SDG 7.

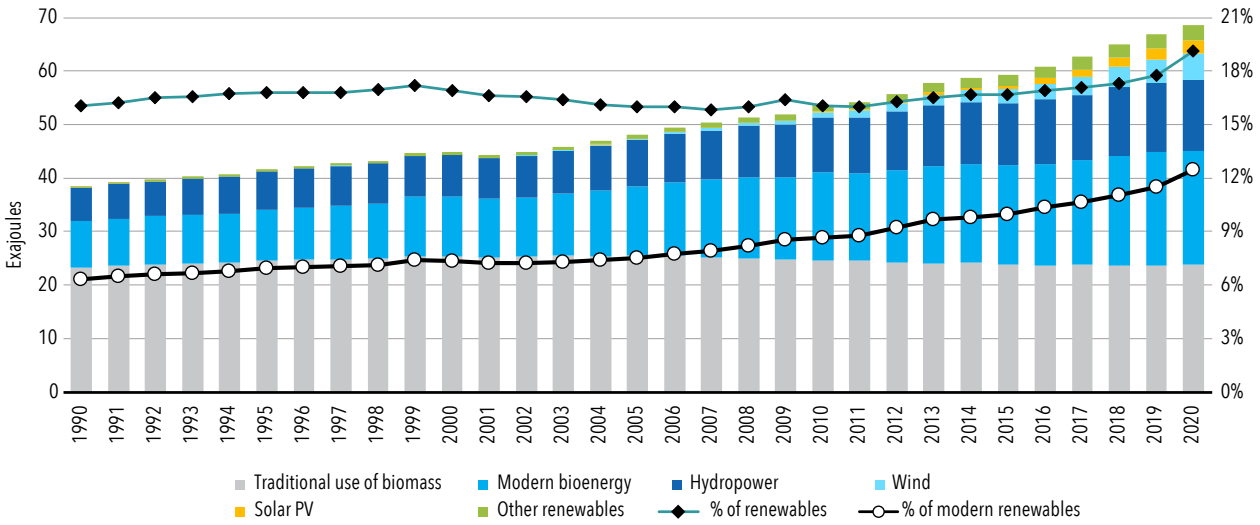
- **Recent trends.** Economic recovery packages in the wake of the Covid-19 pandemic, as well as the global energy crisis sparked by the war in the Ukraine led many countries to strengthen policy support for renewables in 2022. In addition, high fossil fuel prices worldwide have made solar PV and wind generation more competitive against other fuels, despite inflation, rising interest rates and component shortages contributing to renewable project prices also being on the rise. In 2022, 295 GW renewable generation capacity was added globally, with renewables accounting for 83% of all new power capacity added. Getting renewable deployment on track to reach SDG indicators 7.2.1 and 7.B.1, as well as achieve the ambitions of the Paris Agreement, will require ambitious targets, stronger and sustained policy support for renewables and energy conservation in all sectors, greater mobilization of public and private capital, as outlined in chapters 5 and 6, and holistic and concerted policy strategies to diversify and strengthen renewable technology supply chains which remain highly concentrated in just a small number of countries.

Are We on Track?

Globally, the share of renewable sources in TFEC remained relatively steady over the past three decades, with a slow upward trend in recent years (+3 percentage points over the past 10 years), owing mostly to the accelerated deployment of renewable electricity technologies.

In 2020, governments worldwide imposed restrictions on most social and economic activities to slow the spread of the pandemic. This curtailed transport, industrial production, and services, and prompted a significant energy demand shock, with global TFEC dropping 4.7 percent year-on-year. At the same time, global renewable energy consumption, including traditional uses of biomass,[45] grew 2.6 percent from the year before to 68.6 EJ. This increased renewables' share to 19.1 percent of TFEC in 2020, or 1.4 percentage points higher than the previous year (figure 3.1).[46]

Figure 3.1 • Renewable energy consumption and share in TFEC by technology, 1990–2020



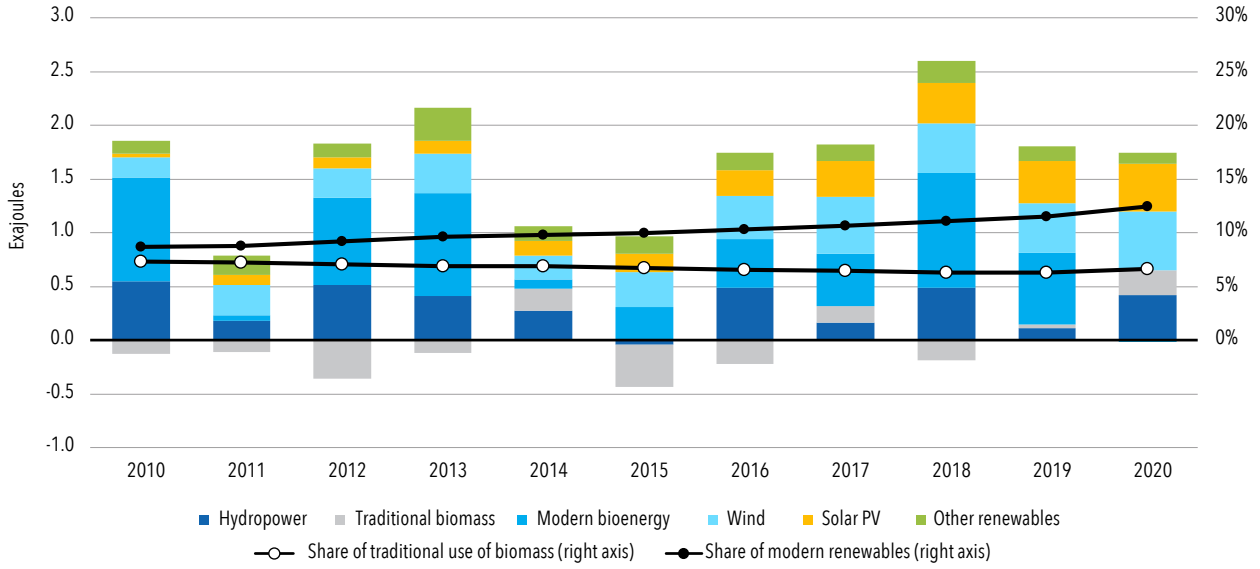
Sources: International Energy Agency and United Nations Statistics Division.
PV = photovoltaic; TFEC = total final energy consumption.

45 The term "traditional uses of biomass" refers to the use of local solid biofuels (wood, charcoal, agricultural residues, and animal dung), which are burned using basic methods, such as traditional open cookstoves and fireplaces. The low conversion efficiency of such methods can result in adverse environmental effects, as well as indoor pollution causing health hazards. The energy consumed in such practices, which are still widely used in households in parts of the developing world, is difficult to estimate due to their informal and noncommercial nature. For purposes of this report, "traditional uses of biomass" refer to the residential consumption of primary solid biofuels and charcoal in non-OECD countries. Although biomass of low conversion efficiency is used in OECD countries as well—for example, in fireplaces burning split logs—such use is not covered by the phrase. Modern uses of bioenergy—along with solar PV, solar thermal, geothermal, wind, hydropower, and tidal energy—is one of the "modern uses of renewable" sources analyzed in this report.

46 The data in this report reflect revisions from last year's edition. Traditional uses of biomass for heat were revised upward by 0.13 EJ (+0.5 percent) globally for 2019, with the majority of the change accounted for by Vietnam (+0.10 EJ, +597 percent) and Indonesia (+0.05EJ, +8 percent), and to a lesser extent by Uganda (-0.06 EJ, -11 percent). Global modern uses of biomass were revised upward by 0.12 EJ (+0.6 percent), with Uganda (+0.17 EJ, +102 percent) and Poland (+0.12 EJ, +40 percent) accounting for the largest upward revision and South Africa (-0.06 EJ, -53 percent) and the United Kingdom (-0.05 EJ, -16 percent) seeing the largest downward changes. Global solar thermal heat consumption was also revised slightly upward (+0.013 EJ, +0.9 percent for the year 2019), primarily due to changes in China. The regional groupings discussed in this section follow the United Nations' M49 regional classification (https://unstats.un.org/unsd/methodology/m49/https://unstats.un.org/unsd/methodology/m49/).

From 2019 to 2020, wind, solar PV, and hydropower made the largest contributions to the growth of renewable energy use, followed by traditional uses of biomass and geothermal energy (figure 3.2).

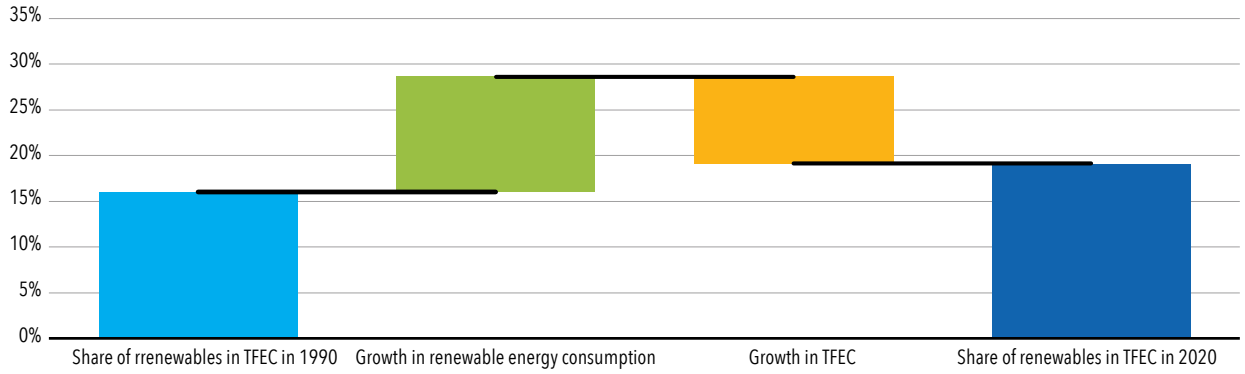
Figure 3.2 • Increase in renewable energy consumption by technology and share of modern uses of renewable energy and traditional uses of biomass in TFEC, 2010–20



Sources: International Energy Agency and United Nations Statistics Division.
Note: In 2020, modern uses of bioenergy consumption remained stable as declining consumption in the residential and transport sectors offset increasing consumption in the electricity and industry sectors.
PV = photovoltaic.

Since 1990, global renewable energy consumption grew almost 80 percent, but this increase corresponds only to a quarter of the increase in TFEC over the same period. The share of renewable energy in TFEC has remained relatively steady as a result (figure 3.3). Two trends have coexisted during the past decade and a half: the share of modern uses of renewables–that is, excluding traditional uses of biomass–in TFEC increased from 8.7 percent in 2010 to 12.5 percent in 2020, with the strongest growth in the power sector, whereas traditional uses of biomass declined 7 percent from their highest point in 2006, although stabilizing since 2016. Achieving SDG 7 and providing access to affordable, reliable, and sustainable energy for all requires considerable and sustained acceleration in the uptake of modern uses of renewables, in the transition to more efficient uses of biomass and substantial progress in energy conservation.

Figure 3.3 • Impact of increase in TFEC on the growth of renewables' share in TFEC globally, 1990–2020



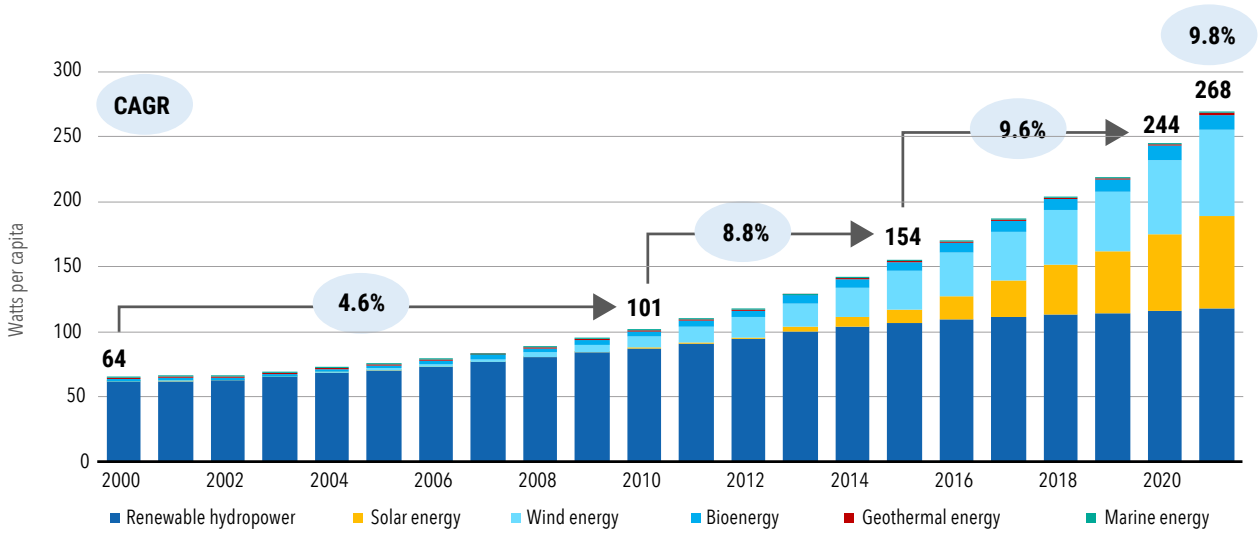
Sources: International Energy Agency and United Nations Statistics Division.
TFEC = total final energy consumption.

Over the past decade, modern uses of bioenergy use saw the largest absolute increase, accounting for almost one-third of the increase in modern uses of renewable energy consumption, and followed by hydropower, wind, and solar PV. In that period, solar PV and wind grew the fastest, with average annual growth rates of 39 percent and 17 percent, respectively.

Overall, bioenergy, including traditional use of biomass, remained the largest renewable source of energy. It accounted for 13 percent of global final energy consumption and represented two-thirds of renewables' portion in 2020, followed by hydropower, wind, and solar PV.

In developing countries, the share of installed renewable energy–generating capacity in electricity has continued to grow over the past 10 years. It grew at an increasing CAGR of 8.8 percent in 2010–15 to 9.6 percent between 2015 and 2020, with growth being consistent, at 9.8 percent, in 2021 (as shown in figure 3.4). This growth is mainly driven by the increasing affordability of solar and wind energy, which have become less expensive than the cheapest new fossil fuel alternative (IRENA 2022a).

Figure 3.4 • Installed renewable energy–generating capacity in developing countries, 2000–21; and CAGR for selected periods



Sources: International Renewable Energy Agency.
CAGR = compound annual growth rate.

Looking Beyond the Main Indicators

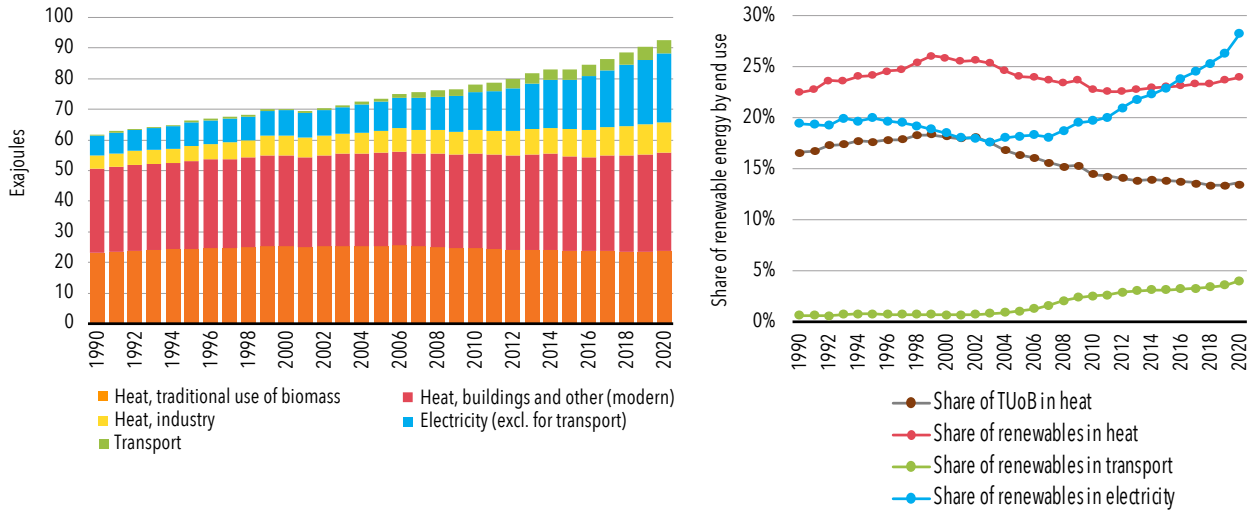
Ensuring access to affordable, reliable, sustainable, and modern energy for all implies a substantial increase in the share of renewable energy in all three main end-use categories: electricity, transport, and heat, which accounted, respectively, for 22 percent, 29 percent, and 49 percent of TFEC in 2020 (figure 3.5).

Electricity has had the largest and most dynamic share of renewables in final consumption, increasing from 26.2 percent in 2019 to 28.3 percent in 2020. Renewable electricity accounts for one-third of global renewable energy consumption (half of modern uses of renewable energy consumption) and almost nine-tenths of its year-on-year increase. The rapid increase in renewables' share in the electricity sector is partly driven by continuous addition of new capacity, most of it wind and solar PV. In 2020, this trend was also supported by a 0.2 percent decline in final electricity consumption.

In the **heat** sector, renewable sources accounted for 24 percent of the energy consumed. More than half of that corresponds to traditional uses of biomass, which increased 1 percent in 2020. Excluding traditional uses of biomass, the consumption of modern uses of renewables for heat increased 0.9 percent year-on-year, whereas global heat demand saw a modest decrease (-0.6 percent year-on-year), owing to reduced economic activity. This allowed nonrenewable energy used for heat to decline by 1 percent in 2020.

Including renewable electricity use, the **transport** sector represents only 9 percent of global modern uses of renewable energy consumption. It is the end-use sector with the lowest renewable energy penetration, at only 4 percent of final energy consumption in 2020. Biofuels supply the large majority (90 percent) of renewable energy consumption in transport, whereas renewable electricity use is slowly emerging, owing to the uptake of electric rail transport and electric vehicles.

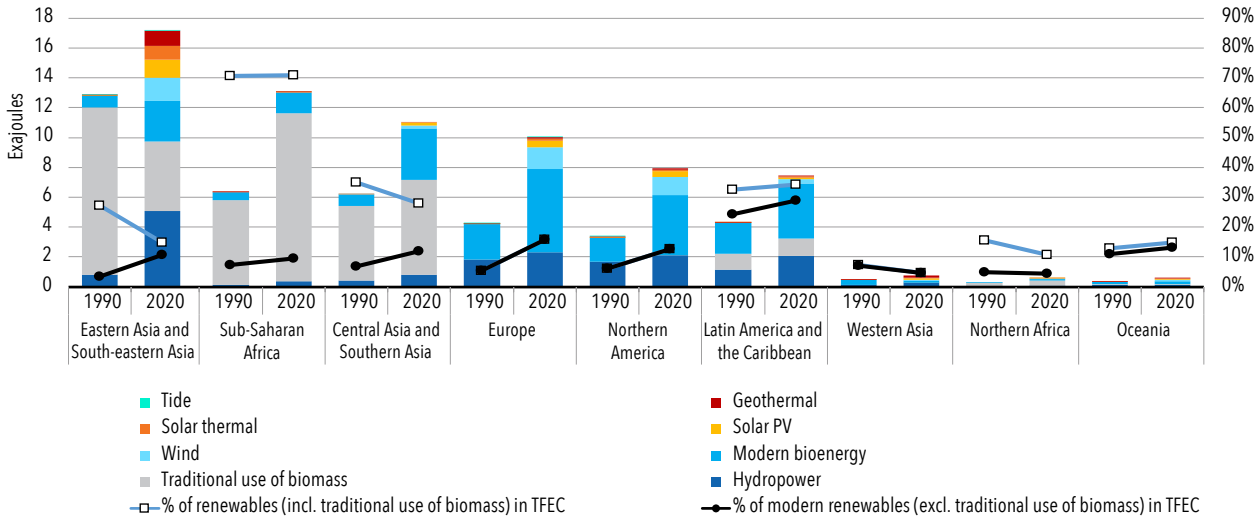
Figure 3.5 • Renewable energy consumption and share by end use, 1990–2020



Sources: International Energy Agency and United Nations Statistics Division.
Note: Electricity used for transport is included under transport.
TUoB = traditional use of biomass.

Strong disparities exist across regions. Sub-Saharan Africa has the largest share of renewable sources in its energy supply, with traditional uses of biomass representing more than 60 percent of the total energy consumed in this region (figure 3.6). Meanwhile, Latin America and the Caribbean has the largest share of modern uses of renewables in TFEC (29 percent of TFEC in 2020), owing to the significant use of hydropower in electricity generation and the consumption of bioenergy for industrial processes (especially in the sugar and ethanol industry) and biofuels for transport.

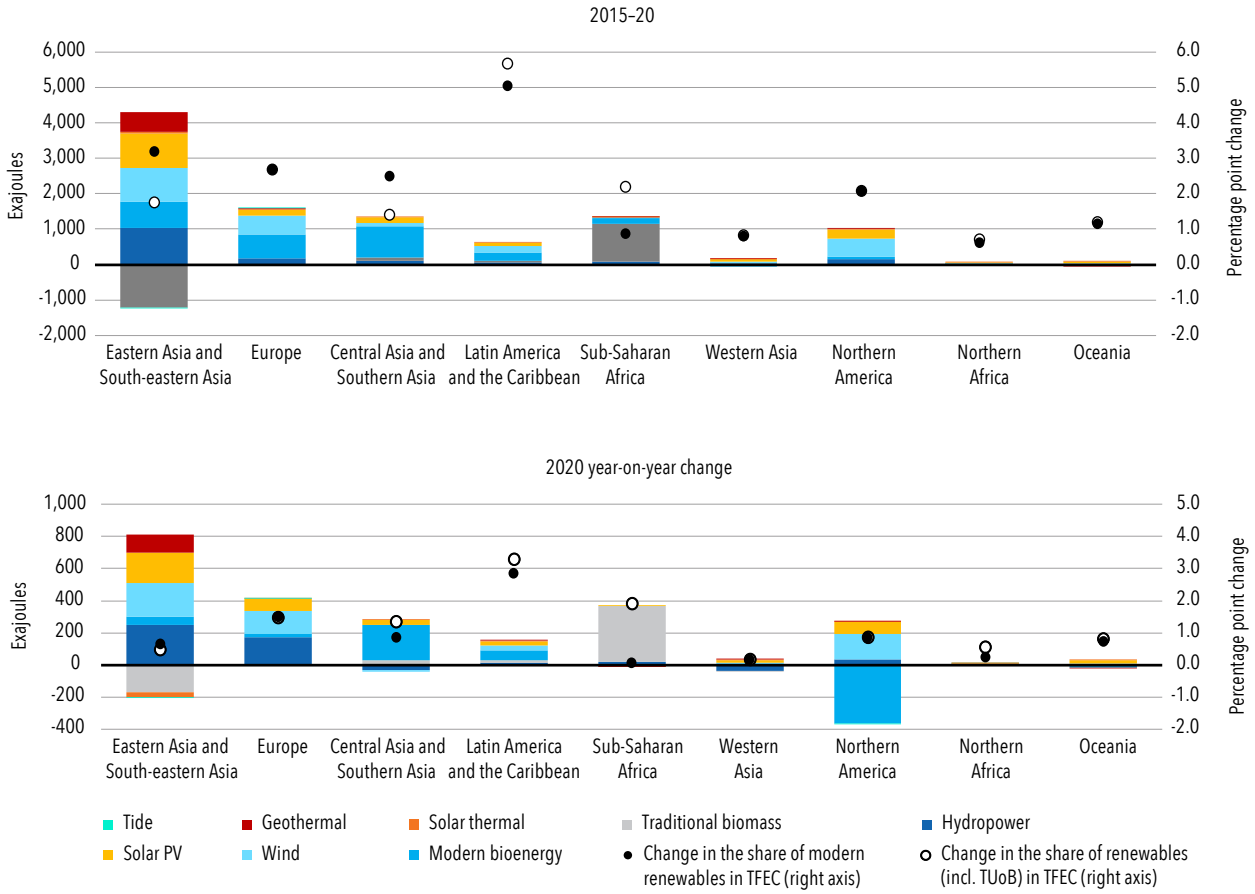
Figure 3.6 • Renewable energy consumption and share in TFEC by region, 1990 and 2020



Sources: International Energy Agency and United Nations Statistics Division.
PV = photovoltaic; TFEC = total final energy consumption.

In 2020, almost half of the global year-on-year increase in modern uses of renewable energy consumption was accounted for by Eastern Asia, due primarily to the deployment of wind, hydropower, and solar PV, as well as, to a lower extent, geothermal (figure 3.7). Europe accounted for more than one-quarter of this year-on-year growth, owing to favorable conditions for hydropower and the expansion of wind and solar PV capacity. The share of renewables in TFEC grew the fastest in Latin America and Europe (respectively +2.8 and +1.5 percentage points in 2020), supported in both cases by significant declines in TFEC (-7.7 percent and -5.5 percent, respectively—the largest declines after Northern America). Consumption of modern uses of bioenergy declined 8 percent year-on-year in Northern America (due in part to reduced activity, and, hence consumption, in the pulp and paper industry, and lower demand in the residential sector amid a mild winter in 2019–20). While traditional uses of biomass continued to decline in Eastern and South-eastern Asia, this trend was offset by increasing consumption in Sub-Saharan Africa, in part driven by population growth.

Figure 3.7 • Change in renewable energy consumption and the share of renewables in TFEC by region, 2015–20; and year-on-year change, 2020

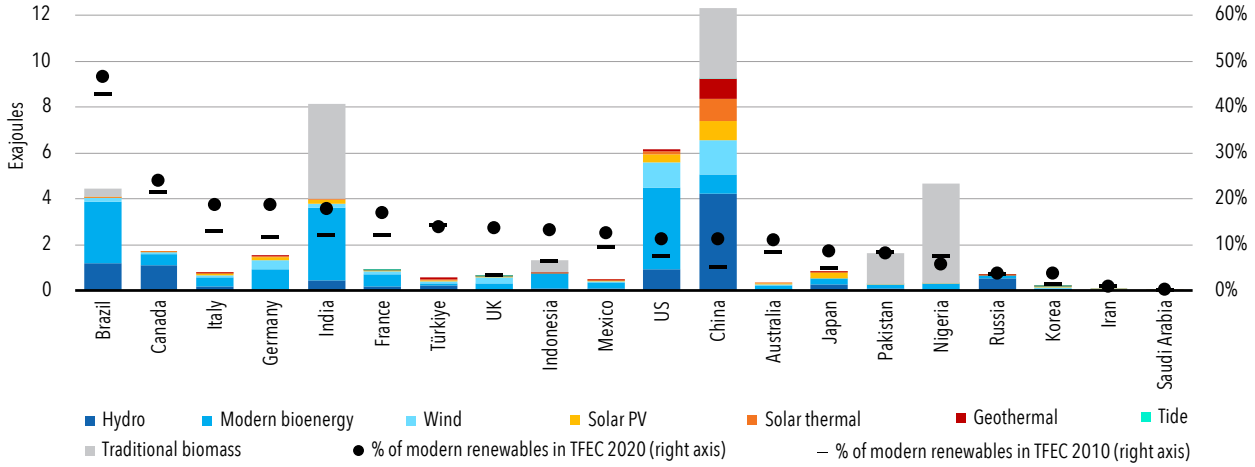


Sources: International Energy Agency and United Nations Statistics Division.
PV = photovoltaic; TFEC = total final energy consumption; TUoB = traditional use of biomass.

The share of renewable sources in national energy consumption varies widely depending on resource availability, policy support, and the total energy demand due to consumption patterns and energy efficiency performance. Among the top 20 energy-consuming countries, Brazil and Canada still had the largest shares of modern uses of renewables in 2020 (respectively 46 percent and 24 percent of TFEC), owing to heavy reliance on hydro for electricity, biofuels for transport, and biomass for heating—especially in industry (figure 3.8). China alone accounted for more than one-fifth of the global modern uses of renewable energy consumption, yet this represented just 11 percent of its TFEC.

Between 2010 and 2020, the share of modern uses of renewables in TFEC grew the fastest in the United Kingdom and Germany, due to a decline in energy demand (in part due to the impact of the COVID-19 crisis) combined with the development of wind, bioenergy, and solar PV. They were followed by Indonesia, which saw rapid deployment of biofuels, and China, which saw large hydropower developments and the growth of solar PV, geothermal, and solar thermal.

Figure 3.8 • Renewable energy consumption, 2020; and share of modern uses of renewables in TFEC, 2010 and 2020, for the top 20 energy-consuming countries



Sources: International Energy Agency and United Nations Statistics Division.
PV = photovoltaic; TFEC = total final energy consumption.

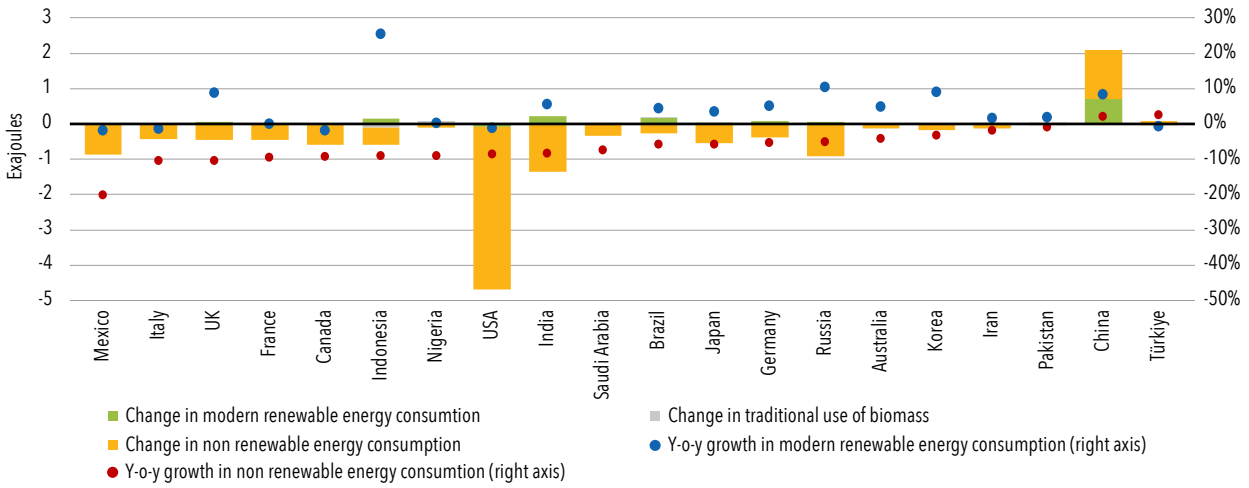
In 2020, most countries saw a declining energy demand resulting from disruption of social and economic activities due to COVID-19 policy responses. Eighteen of the top 20 energy consumers (except China and Türkiye) recorded a lower TFEC in 2020 than in 2019 (figure 3.9).

Indonesia recorded the largest year-on-year growth in the share of modern uses of renewables (+3.3 percentage points) in 2020, followed by Brazil (+2.4 percentage points), and the United Kingdom (+2.1 percentage points). This growth in Indonesia resulted from greater bioenergy consumption in transport and industry combined with a 7 percent year-on-year decline in TFEC, whereas Brazil's achievement came mostly from increased bioenergy use in industry. Growth in the United Kingdom resulted mostly from the deployment of wind power, while TFEC was down more than 8 percent year-on-year.

All top 20 energy-consuming countries (except Türkiye) had increased shares of modern uses of renewables in their TFEC in 2020. Between 2010 and 2020, this share declined in 3 of the 20 countries (Nigeria, Pakistan, and Türkiye) despite growing consumption of modern uses of renewable energy in all of them. In the same period, the consumption of nonrenewable energy increased in 11 of them. This highlights the importance of containing the overall energy consumption through both energy efficiency and sufficiency,[47] and expediting the move away from fossil fuels to achieve greater shares of renewables in the energy mix.

47 Energy sufficiency corresponds to the actions of tailoring and scaling energy-related infrastructure, technology choices, social organizations, lifestyles, and behaviors to fundamental needs, while selectively avoiding nonessential energy-intensive services and consumptions, in order to allow affordable access to energy for everyone's needs and fair access to energy wants, while keeping the impacts of energy use within environmental limits. Sufficiency is meant not only as reducing consumption (conservation) but also the operating principle of limiting damage while also supporting human and ecological well-being (Darby and Fawcett 2018; Marignac 2019). Energy efficiency and sufficiency are two complementary dimensions of energy conservation. While energy efficiency actions aim at reducing the energy consumption–energy service demand ratio, energy sufficiency aims at containing energy services demand through frugality and alternative choices of satisfiers to meet human needs.

Figure 3.9 • Annual change in renewable and nonrenewable energy consumption in the top 20 energy-consuming countries, 2020

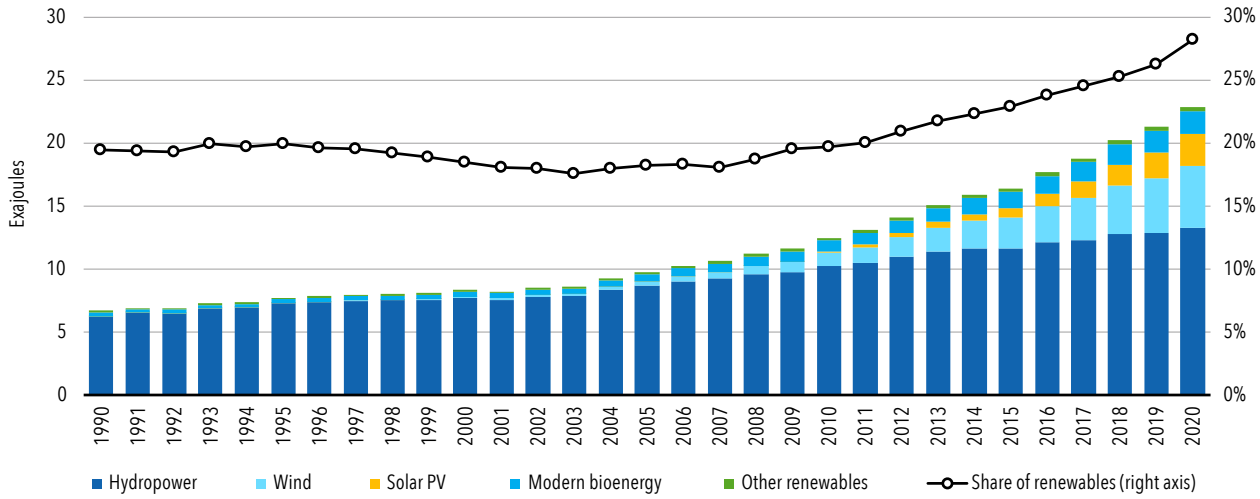


Sources: International Energy Agency and United Nations Statistics Division.
Y-o-y = year-on-year.

ELECTRICITY

Electricity accounted for 22 percent of TFEC globally in 2020 and is the fastest-growing end use. Electricity consumption doubled over the past 23 years, increasing 27 percent since 2010.[48] Yet, global annual electricity consumption remained steady at 80 EJ in 2020. Global renewable electricity consumption increased more than 7 percent (+1.5 EJ) year-on-year in 2020, whereas nonrenewable electricity consumption declined 2.8 percent (-1.6 EJ). The share of renewables in electricity generation consequently increased by 1.9 percentage points to 28.2 percent in 2020—the largest annual growth and the largest share among all end uses (figure 3.10).

Figure 3.10 • Global renewable electricity consumption by technology, 1990–2020



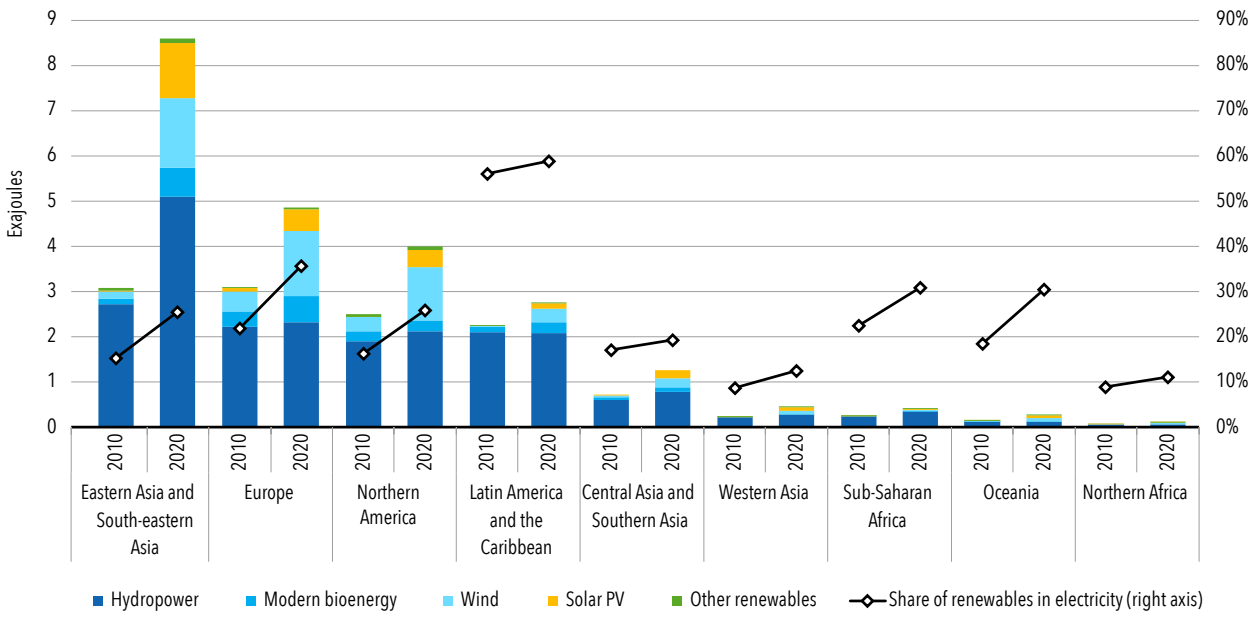
Sources: International Energy Agency and United Nations Statistics Division.
PV = photovoltaic.

48 Among the largest factors driving this trend is the rapidly growing use of electricity for space cooling, with air conditioners and electric cooling fans accounting for about 10 percent of the global electricity consumption in 2018 (IEA 2018).

Wind, solar PV, and hydropower accounted for, respectively, 36 percent, 29 percent, and 28 percent of the annual increase in renewable power generation in 2020. The majority of the remaining growth was accounted for by bioenergy. Hydropower remained the largest renewable source of electricity globally and for each region, accounting for 59 percent of renewable power generation and 17 percent of total electricity generation.

Latin America and the Caribbean had the largest share of renewable sources in power generation, with hydropower alone representing 45 percent of the regional electricity generation in 2020. That year, renewables' share of electricity generation grew the fastest in Europe, increasing by more than 4 percentage points year-on-year to account for nearly 36 percent of the total generation. This was mostly driven by favorable hydrological conditions for hydropower, rapid growth of new wind and, to a lesser extent, solar PV capacity, as well as a 3 percent decline in annual electricity demand. Thanks to rapidly declining costs and policy support, wind and solar PV together accounted for more than 60 percent of the increase in renewable electricity consumption over the past decade globally. This share exceeds 80 percent in Europe, Northern America, and Oceania (figure 3.11). However, soaring prices of energy and materials and shortages of critical minerals, semiconductors and other components are posing potential roadblocks to the scale up of renewable electricity development in the future (Box 3.1).

Figure 3.11 • Renewable electricity consumption and share of renewables in electricity by region, 2010 and 2020



Sources: International Energy Agency and United Nations Statistics Division.
PV = photovoltaic.

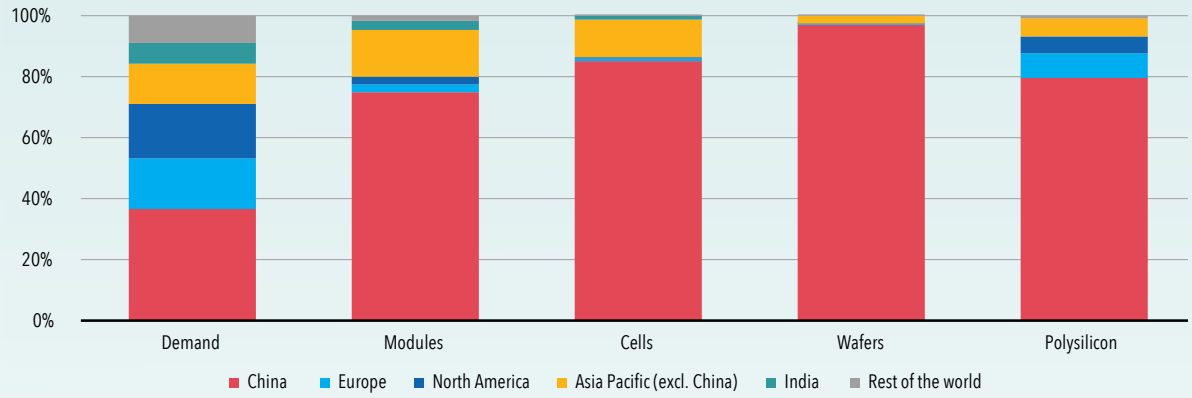
Box 3.1 • Building resilient supply chains: The case of wind and solar photovoltaic

Meeting international energy and climate goals requires solar photovoltaic (PV) and wind capacities to grow on an unprecedented scale in the coming decades. The International Energy Agency's (IEA's) Roadmap to Net Zero Emissions by 2050, for instance, depicts more than a quadrupling of global annual solar PV and wind capacity additions to, respectively, 630 gigawatts and 390 gigawatts by 2030 (IEA 2021).

Yet the economic impacts of the COVID-19 pandemic and the war in Ukraine have highlighted the vulnerability of global energy and technology supply chains. Soaring prices of energy and materials and shortages of critical minerals, semiconductors, and other components are increasing uncertainty for investors and posing potential roadblocks for the energy transition. Between the first half of 2020 and that of 2022, rising material costs contributed to a 25 percent rise on average in PV modules' prices, and up to a 20 percent increase in the prices of wind turbines outside China, after years of sustained decline (IEA 2023).

High levels of concentration make supply chains vulnerable to incidents, be they related to an individual country's policy choices, natural disasters, technical failures, or company decisions. Currently, renewable energy technology supply chains, especially those for manufacturing solar PV and wind technologies, as well as the materials they rely on, remain heavily concentrated geographically. For instance, China's share of all the manufacturing stages of solar panels (such as polysilicon, ingots, wafers, cells, and modules) exceeds 80 percent—more than double its share of global PV demand (figure B3.1.1) (IEA 2022b). Manufacturing of wind turbines is also largely concentrated geographically, with China alone accounting for 60 percent of global manufacturing capacity, and Europe having a leading role in markets outside China. The top 15 wind turbine manufacturers accounted for almost 90 percent of the total capacity deployed in 2021 (IEA 2023).

Figure B3.1.1 • Solar PV manufacturing capacity by country and region, 2021



Source: IEA 2022b.
APAC = Asia-Pacific region excluding India; NAM = North America ; RoW = rest of the world.

Strengthening and diversifying supply chains for both materials and manufacturing will be critical to reduce risk exposure and build resilience into supply chains and ensure security of supply. For many countries, diversification can also enhance local value creation and contribute to realizing the objectives under the 2030 Agenda. Industrial policies can facilitate wider job creation beyond those in installation and operation by supporting efforts to leverage and further build local capabilities across solar and wind supply chains (IRENA 2017, 2018). This is especially important for developing countries as they seek to move from being exporters of raw materials to producing higher-value products.

Governments can leverage comprehensive risk assessments of supply chains and identify competitive advantages in order to mobilize investment for key supply chain segments, for instance, through financing and fiscal incentives and derisking instruments. Furthermore, they need to support the development of workforce skills in anticipation of future needs.

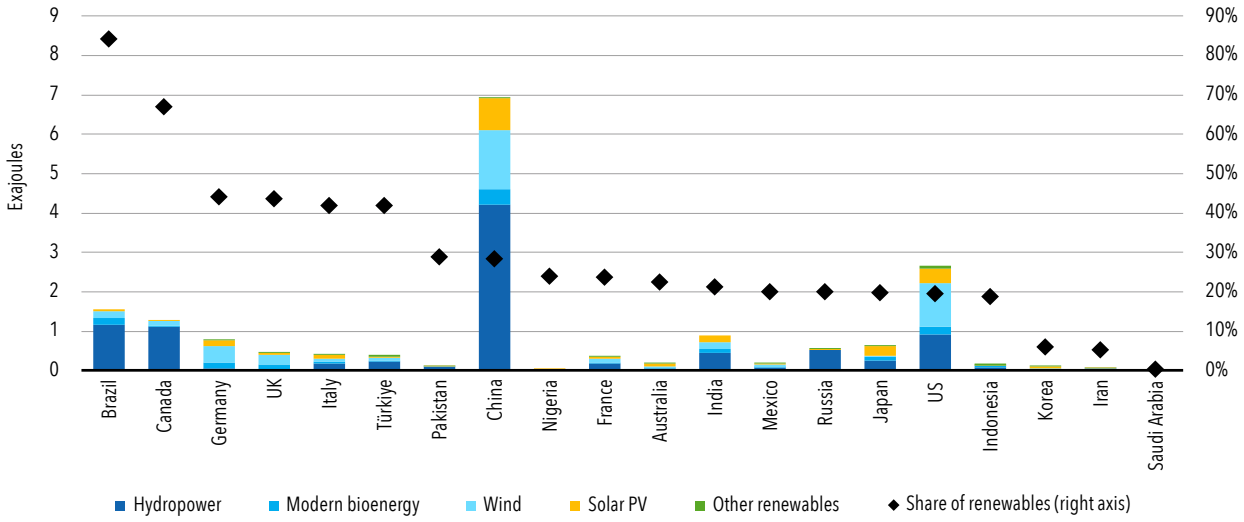
In addition, countries can support innovations in product design that reduce and diversify material inputs, especially for critical materials such as copper and silver, and make equipment more durable, reusable, and recyclable. Recycling provides an opportunity to secure a reliable secondary source of materials, while helping avoid negative environmental, social, and health impacts associated with raw material mining.

Specific attention should be paid to raw material requirements for renewable technologies. Mining projects can face lead times of more than 10 years from when their development begins to when they achieve the first production. This increases the risk of critical mineral supply becoming a major bottleneck in renewable energy supply chains. Reducing permitting time, without compromising on environmental standards, or on engagement with local communities, can help ensure that mining capacity will be scaled up in line with the requirements of the energy transition. Considering that the natural endowment for minerals differs across countries, international cooperation and strategic partnerships remain crucial.

At the same time, environmental and social risks along supply chains need to be considered and addressed. International cooperation on the development of clear and stringent environmental and social sustainability standards will be key to ensure worker protection, social inclusion, adhesion to labor rights, as well as the adoption of low-carbon and material- and energy-efficient manufacturing practices in facilities. Considering that bulk and critical material production is one of the most-emission-intensive stages of supply chains, policies should also focus on expanding lead markets for near-zero emission materials and increasing minimum recycled content requirements, traceability standards, and governance regulations.

The top 20 energy-consuming countries show contrasting trends in terms of the share of renewables in electricity generation, which varies from almost 0 percent to over 80 percent. Brazil and Canada are by far the countries with the largest shares, owing to large hydropower capacities (figure 3.12). Wind and solar PV together (i.e., nondispatchable renewables) constitute the largest renewable electricity sources in Germany, Japan, Mexico, the Republic of Korea, the United Kingdom, and the United States. Their combined share in renewable power generation ranged between 45 percent and 74 percent in these countries. The share of renewables in electricity consumption grew the fastest in the United Kingdom, Germany, Mexico, and France, with 6.4, 4.2, 4, and 3.7 percentage point increases, respectively. In each of these countries, this growth was supported by a year-on-year decline of more than 3 percent in total electricity demand.

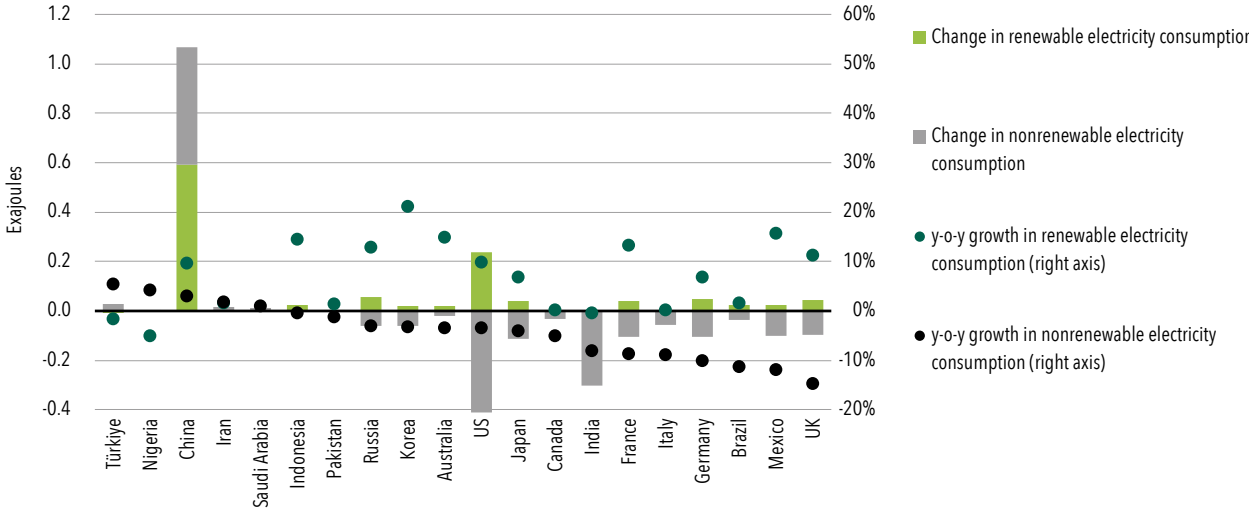
Figure 3.12 • Renewable energy consumption in electricity in the top 20 final energy consumers by source and country, 2020



Sources: International Energy Agency and United Nations Statistics Division.
PV = photovoltaic.

Between 2019 and 2020, China accounted for 39 percent of the global annual increase in renewable electricity generation, with wind and solar PV together accounting for more than half of the national growth. The United States, the Russian Federation, Germany, and the United Kingdom were the next largest contributors to this growth, together contributing one-quarter of it. In 2020, China was also responsible for the largest absolute increase in nonrenewable electricity consumption, followed by Türkiye, the Islamic Republic of Iran, Saudi Arabia, and Nigeria, while the other top 20 final energy consumer countries witnessed a decline in nonrenewable electricity consumption that year (figure 3.13).

Figure 3.13 • Year-on-year change in renewable and nonrenewable electricity consumption for the top 20 final energy users by country, 2020



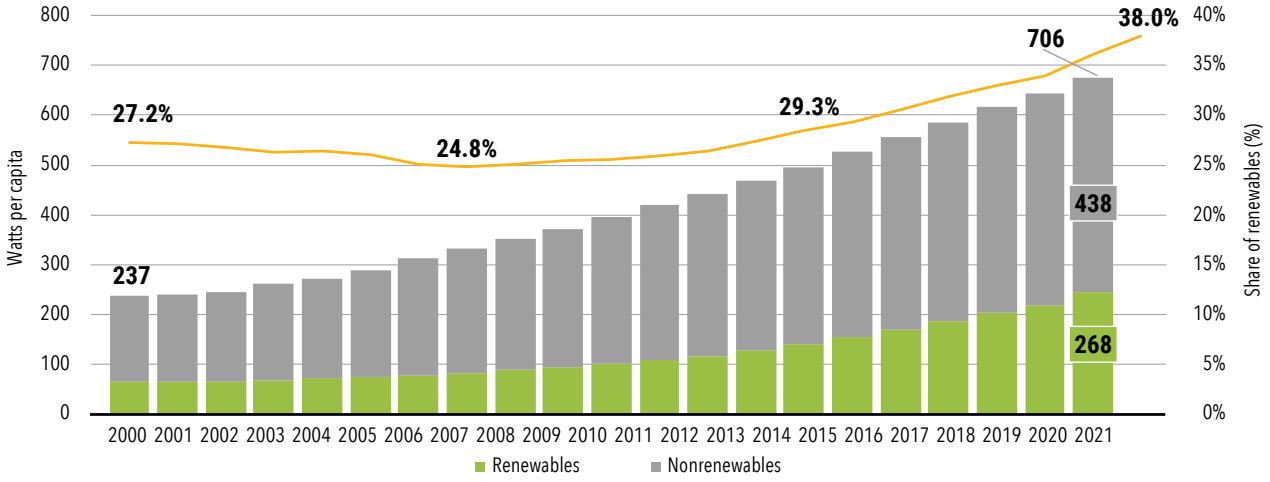
Sources: International Energy Agency and United Nations Statistics Division.
EJ = exajoule; y-o-y = year-on-year.

Installed renewable energy-generating capacity in developing countries (in watts per capita)

Renewable electricity generation is becoming increasingly important in developing countries[49] as electricity demand rises due to population growth, changing lifestyles, and development patterns. Reflecting this, SDG 7 includes a target to "expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least-developed countries, small island developing states and landlocked developing countries, in accordance with their respective programmes of support" by 2030. Progress toward SDG indicator 7.B.1, which measures the increase in renewable energy-generating capacity (in watts per capita) in developing countries, is tracked in this chapter for the third year.

The share of installed renewable energy-generating capacity in developing countries has been on the rise since 2007, when it stood at 24.8 percent. In 2021, the share of renewables reached its peak, at 38 percent, with 268 watts per capita of installed renewable capacity (see figure 3.14). This is close to the world average of 38.3 percent and the 38.8 percent of developed countries. Although 2020 saw a record for renewable energy-generating absolute capacity additions, with 186 gigawatts (GW) added in developing countries, the 174 GW of renewable power added in these countries in 2021 represents a 6 percent contraction from the previous year. This could be attributed to the severe impacts of the COVID-19 pandemic on many countries, which may have diverted public funds and attention away from renewable power installations in 2021, as well as from supply chain disruptions and financing challenges in a context of rising commodity prices. More detailed analysis would be needed to determine the specific factors behind this decline.

Figure 3.14 • Annual growth of renewable energy–generating capacity in developing countries, and share of renewables, 2000–21

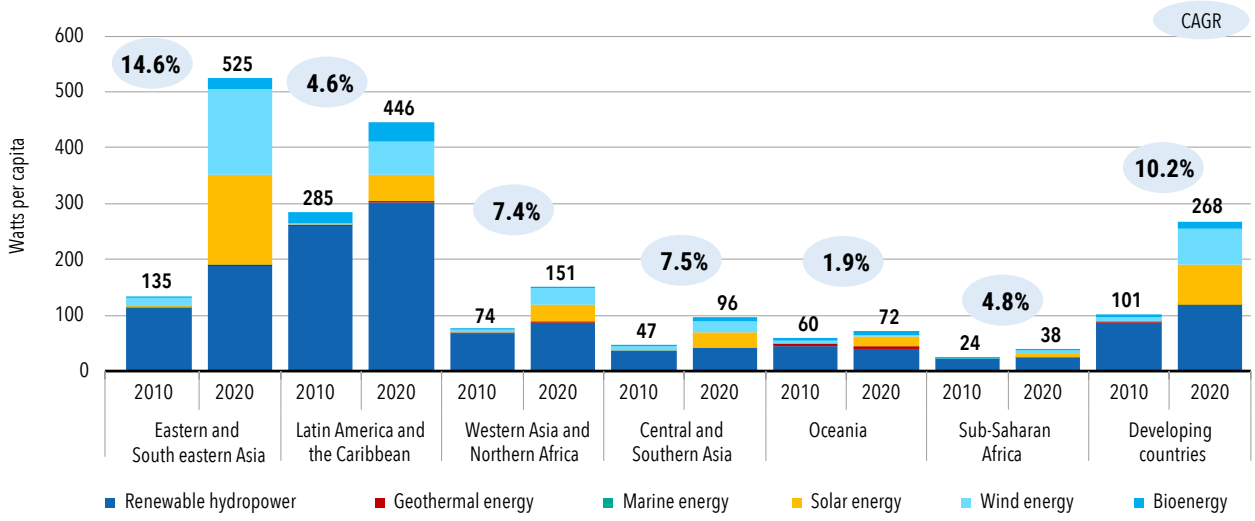


Source: International Renewable Energy Agency.

Additions to renewable energy-generating capacity have been growing at a steady pace over the past two decades and have consistently outpaced population growth in developing countries. In the first decade of the 21st century, the CAGR of renewable capacity was 4.6 percent per capita. This figure was surpassed by an 8.6 percent CAGR during 2010–15; then, in 2015–20, the CAGR increased further, to 9.6 percent. In 2021, the growth rate continued to accelerate, reaching 9.8 percent (figure 3.15), whereas addition of nonrenewable capacity decreased by 2 percent between 2020 and 2021, from 77.1 GW to 75.7 GW. This trend of decreasing nonrenewable additions began in 2016 after reaching an all-time high of 137.7 GW in 2015.

49 See chapter 7 for a list of the developing countries considered in this indicator.

Figure 3.15 • Growth in renewable energy–generating capacity per capita by technology across regions, 2010–21



Source: International Renewable Energy Agency.
CAGR = compound annual growth rate.

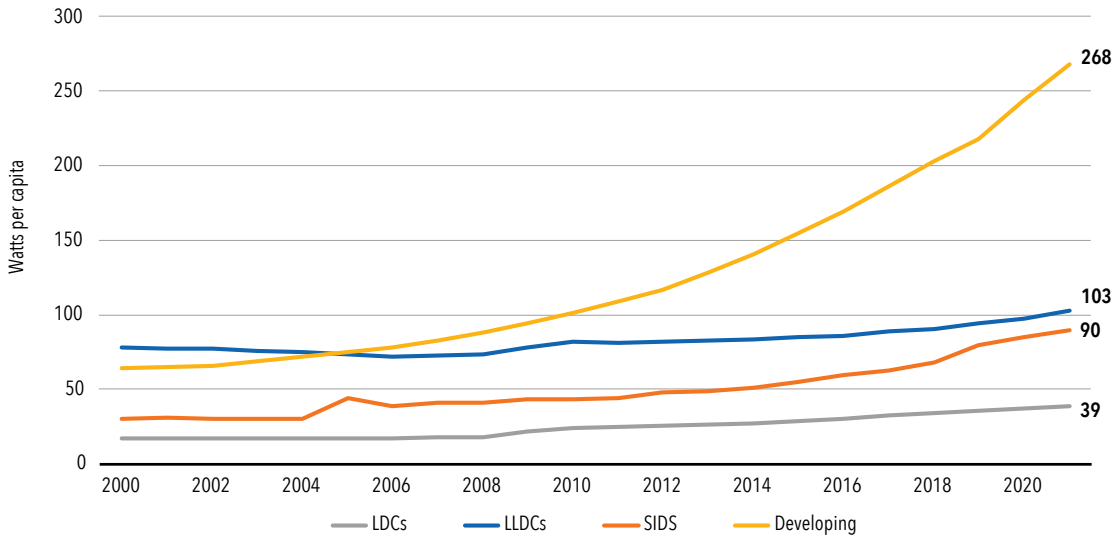
Over the past decade, growth in renewable energy–generating capacity varied across regions. The greatest capacity growth was seen in Eastern and South-eastern Asia, from 135 to 525 watts per capita between 2010 and 2021, primarily due to additions of wind and solar power. Lao PDR, China, and Korea showed the most growth in the region. In Latin America and the Caribbean, capacity increased by 57 percent, from 285 to 446 watts per capita, primarily due to wind energy (35 percent), solar energy (28 percent), and hydropower (27 percent). Uruguay, Chile, and Panama recorded the largest increase in renewables-fueled capacity per capita in this region.

Solar and wind power led to a doubling of per capita renewable energy–generating capacity in Western Asia and Northern Africa, and Central and Southern Asia in 2010–21, with Bhutan, Türkiye, and the United Arab Emirates in the lead. The lowest renewable capacity per capita was recorded in Sub-Saharan Africa, which will require specific support.

Meanwhile, growth rates across country groups reveal concerning disparities, with small island developing states (SIDS), least-developed countries (LDCs), and landlocked developing countries (LLDCs) lagging even behind other developing countries (figure 3.16). At current annual growth rates, LDCs would need almost 40 years, LLDCs would need 25 years, and SIDS would need 13 years to reach a level of deployment similar to the average levels in developing countries in 2021.

Closing the geographic gap in the deployment of renewables-based generating capacity will require tailored policies and investment measures to ensure a just and sustainable energy transition in the long term. The ambitious deployment of renewable energy–generating capacity across regions is crucial to avoid locking in unsustainable and polluting energy choices and to prevent the creation of stranded assets.

Figure 3.16 • Renewable energy–generating capacity per capita by country group, 2000–21



Source: International Renewable Energy Agency.
SIDS = small island developing state; LDC = least-developed country; LLDC = landlocked developing country.

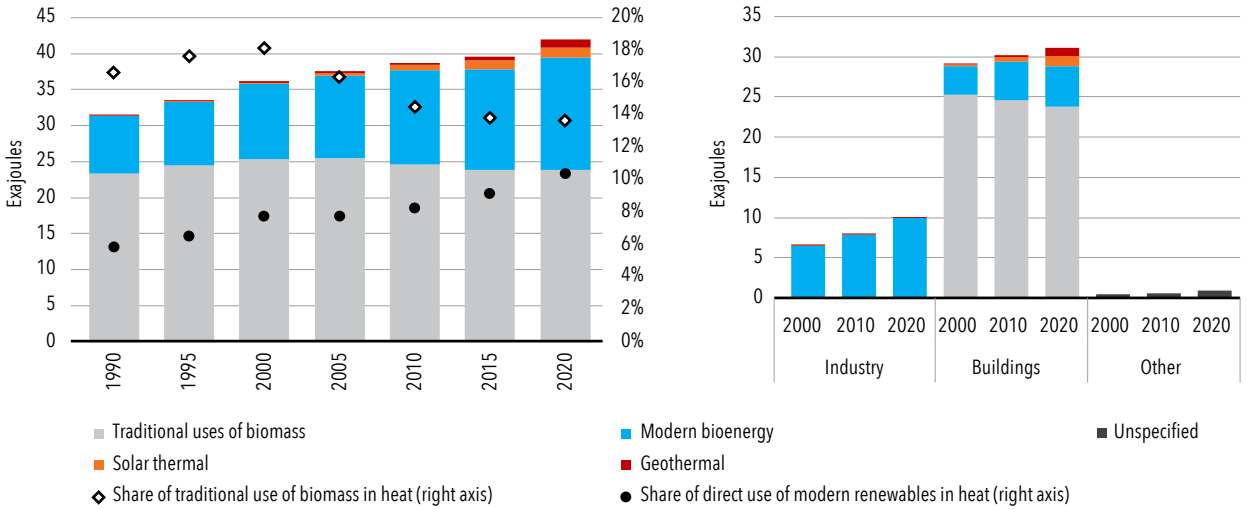
HEAT

Heat is the largest energy end use worldwide, accounting for half of global final energy consumption (175 EJ). In 2020, total energy consumption for heat declined by an estimated 0.6 percent compared with 2019. The heating sector remains heavily reliant on fossil fuels, considering three-quarters of global heat demand is met with coal, gas, and oil. Meanwhile, traditional uses of biomass grew 1 percent in 2020, accounting for almost 14 percent (24 EJ) of the global energy consumption for heat. Excluding traditional uses of biomass, as well as ambient heat harnessed by heat pumps[50] (for which data are scarce), direct renewable heat consumption increased 0.9 percent year-on-year to just over 18 EJ in 2019. This represented 10.4 percent of the total energy consumed for heat, only 2 percentage points higher than ten years earlier (figure 3.17).

Despite its dominant share in the final energy consumption, the heat sector received limited policy attention and support until recently. In 2022, renewable heat received several supporting policy updates based on energy security considerations; however, progress toward SDG target 7.1 (ensuring universal access to affordable, reliable, and modern energy services—for instance, for cooking and space and water heating) and SDG target 7.2 requires greater ambition and stronger policy support. Such support includes significant improvements in sufficiency, energy efficiency and conservation, and material efficiency (especially for energy-intensive materials, such as cement and steel, which come from hard-to-decarbonize sectors) along with rapid deployment of renewable heat technologies to transition away from fossil fuels and inefficient and unsustainable uses of biomass.

50 The rapid spread of heat pumps over the past decade is making ambient heat an increasingly important heat source, although its importance globally is difficult to estimate because data are unavailable for some markets. Because of scarce data, this report does not account for it, although ambient heat (in excess of any nonrenewable electricity used to run the pumps) can be credited as a renewable source, and electric heat pumps are expected to play a key role in decarbonizing the heat sector.

Figure 3.17 • Renewable heat consumption by source and sector, 1990–2020



Sources: International Energy Agency and United Nations Statistics Division.
Note: Indirect consumption of renewable heat through renewable electricity is not represented in this figure.

Bioenergy accounts for about 86 percent (15.6 EJ) of direct[51] modern uses of renewables for heat globally. It accounts for about one-tenth of the energy consumed for heat in industry and one-twentieth in the buildings sector. Industry is responsible for two-thirds of modern uses of bioenergy, with the majority concentrated in subsectors producing biomass residues on-site, such as wood, and pulp and paper industries, as well as the sugar and ethanol industries. In 2020, modern uses of bioenergy consumption for heat grew 1.8 percent year-on-year in industry while dropping 2.5 percent in the buildings sector. The growth in consumption was mostly due to increasing use of bioenergy in Brazil and India's sugar and ethanol industries, while the decline was due partly to mild winter conditions in large heating markets. The increased use of bioenergy requires paying specific attention to potential trade-offs and synergies amongst food-energy systems as discussed in box 3.2.

Global **solar thermal** consumption remained relatively steady in 2020 compared with 2019, accounting for 7.7 percent (1.4 EJ) of modern uses of renewables for heat; yet it still met less than 1 percent of the total final heat demand. China continued to dominate solar thermal developments, accounting for 73 percent of the global solar thermal capacity in operation and 71 percent of newly installed capacity in 2020 (IEA-SHC 2021). However, the global market for solar thermal declined further in 2020, partly due to COVID-19 lockdown measures disrupting construction and installation activities, but also due to limited policy support and the increasing interest of policy makers in end-use electrification—which meant that small-scale solar water heating systems face competition from not only heat pumps but also rooftop PV systems in some key markets (IEA-SHC 2020). From this perspective, hybrid photovoltaic-thermal (PVT) systems offer enormous potential.[52] The global market for PVTsystems grew rapidly, at 13 percent, in 2021, reaching over 0.75 GW of thermal capacity and 0.25 GW of electricity capacity (IEA-SHC 2022). Although domestic solar water

51 Renewables also contribute to heat supply indirectly through renewable electricity used for heating and district heat networks. Accounting for these indirect uses, and excluding ambient heat harnessed by air-source heat pumps, renewable electricity is actually the second-largest modern uses of renewable heat source after bioenergy, and the fastest-growing source. It accounted for almost half of the increase in the total (direct and indirect) modern uses of renewable energy consumption for heating in 2018, owing to the increase in renewables' penetration in the power sector along with heat electrification through the use of electric heat pumps and boilers. The buildings sector is responsible for the majority of electricity consumption for heating.

52 PV thermal systems combine PV cells with thermal collectors, which allow them to convert solar radiation into both usable thermal and electrical energy.

Box 3.2 • Agri-food and renewable energy: Linkages between SDG 7 and SDG 2

Energy and food systems are deeply entwined. About 30 percent of the world's energy is consumed within agri-food systems—from production to food consumption—the majority of which are fossil fuel–based (FAO 2011).[a] Energy-related greenhouse gas emissions in agri-food systems alone are estimated at 1.6 metric gigatons of carbon dioxide equivalent per year, or 12 percent of the total from the agriculture sector in 2018, and the number is growing (Tubiello and others 2021).

On-farm energy use is a significant component of agricultural productivity (Flammini and others 2022). Over the past two decades, on-farm energy consumption in Europe and the Americas remained stable, despite growth in production—thanks to increased efficiencies and agronomic progress. Meanwhile, on-farm energy use grew significantly in Asia owing to increased mechanization of agriculture with irrigation pumps, farm machinery, and inputs such as chemical fertilizers; Asia's share accounted for over half the global total in 2018. Meanwhile, the African continent, where food demand continues to grow, has seen only marginal growth of on-farm energy use, which represented about 4 percent of the global total (IRENA and FAO 2022). The disparity in energy use around the world suggests untapped potential to increase productivity, strengthen supply chains, reduce food and income losses, and improve food security.

Continuing to meet energy needs in agriculture through fossil fuels across continents poses significant challenges in terms of accessibility, affordability, lack of resilience to supply and price shocks, and environmental impacts, particularly climate change. A joint approach to the energy transition and the transformation of agri-food systems is necessary to meet current and future demand in these sectors, while advancing the Sustainable Development Goals and the Paris Agreement on Climate Change.

Renewable energy solutions can play an important role in meeting energy needs for electricity, heating, and transport in agri-food systems. From primary production to processing, storage, and consumption, various renewable energy applications are now being deployed to displace the use of fossil fuels. Solar irrigation, among the most mature applications, is being adopted to improve access to water, thus enabling multiple cropping cycles, raising incomes, and increasing resilience to changing rainfall patterns. In India, nearly half of the farmers using solar pumps reported an increase of 50 percent or more in their annual incomes compared with rain-fed irrigation (GOGLA 2019). Meanwhile, in Rwanda, smallholder farmers adopting solar irrigation pumps improved their yields by about a third (Energy4Impact 2021). The total installed capacity of solar pumps grew from 20 megawatts in 2012 to 670 megawatts in 2021. The majority of this capacity is in Asia, led by irrigation programs (IRENA 2022d).

Renewables-based agro-processing systems are offering an increasingly cost-effective alternative to fossil fuels—one that leads to cost reduction, encourages local value addition, and reduces food losses. In some regions, up to 21 percent of food is lost before reaching the market (FAO 2019). Alongside processing (e.g., drying), cold storage and refrigeration are a necessity to increase shelf life; cut losses; and maintain the quality of products from crops, livestock, and fisheries. Improving access to refrigeration could prevent the spoilage of up to a quarter of the perishable foods currently produced in countries with less-developed cold storage infrastructure (Lange and others 2016). Further, global cold chains, which involve portable or stationary cold storage from production until retail, already account for about 5 percent of food-system greenhouse gas emissions—a figure expected to rise, making a renewables-based transition a necessity (Tubiello and others 2021).

Integrated food–energy systems will be key to scale up bioenergy use while managing potential trade-offs between climate-safe energy transitions and food security. For instance, the International Renewable Energy Agency's (IRENA's) 1.5°C Pathway projects that the share of modern uses of biomass in total final energy consumption needs to increase to 18 percent (from 3 percent in 2018) to meet the demand in the transport, industry, and buildings sectors (IRENA 2022c). Feedstock production from agriculture and forestry residues, as well as organic waste, needs to be scaled to meet the bioenergy demand. Further opportunities also exist with the colocation of food and energy crops, as well

as with photovoltaics (i.e., agri-voltaics), to help reconcile potentially competing land uses as renewable energy deployment accelerates.

Increasing renewables' use in agri-food systems requires coordinated action across a range of areas, including improving the data and information base, facilitating access to financing for investors (farmers and enterprises), mainstreaming cross-sector integration and systemic thinking in policy and planning efforts, prioritizing low-risk, high-impact actions in the near term (including renewable energy applications aiming at reducing food losses), and promoting innovation in the development of technologies and energy-efficient appliances (e.g., agro-processing equipment) (IRENA and FAO 2022).

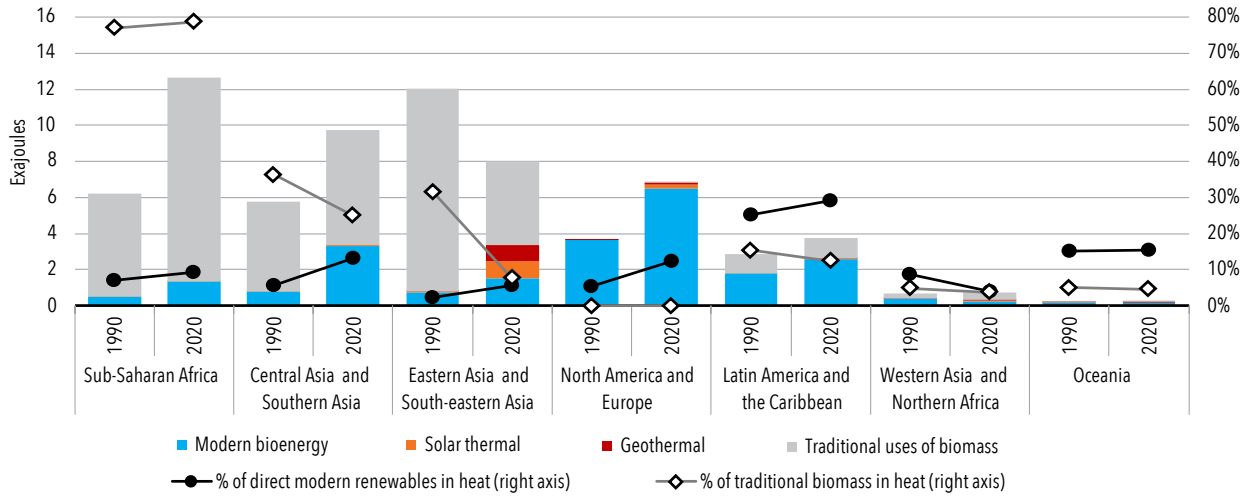
a. The energy used in agri-food systems includes direct energy for primary production as well as shares of the energy demands for fertilizer manufacturing, food processing, storage, and other inputs.

heaters still represent the large majority of installations, there is also growing interest in large-scale solar thermal systems for industrial applications or connected to district heating networks, which continue to develop as a niche market while significant potential remains untapped. Solar thermal cooling offers great potential to decarbonize space cooling, especially since the greatest demand coincides with the highest solar potential, reducing the load of electric air conditioners at peak times during summer months. However, technology deployment is currently very limited.

Global **geothermal** heat consumption grew almost 11 percent in 2020 and represented 5.9 percent (1.1 EJ) of modern uses of renewables for heat. This growth was driven almost exclusively by China. About 60 percent of geothermal heat is harnessed by ground-source heat pumps worldwide (Lund and Toth 2020). The large majority of applications concern the buildings sector, with bathing, swimming, and space heating (primarily via district heating) being the most prevalent end uses globally. China is responsible for more than four-fifths of the global geothermal heat consumption, followed by Türkiye and the United States, which together account for almost one-tenth.

Traditional uses of biomass are primarily concentrated in Sub-Saharan Africa and Asia (figure 3.18). These uses are the most common in Nigeria, followed by India, China, Ethiopia, Pakistan, the Democratic Republic of Congo, and Uganda, and, together, these countries account for two-thirds of the global consumption. Even though traditional uses of biomass showed a slightly declining trend since 2006, their levels in 2020 were still similar to those in 1990 on a global scale. Contrasted trends are observed across regions and countries over the past decade, with especially significant declines in Eastern Asia (especially in China), as well as in Indonesia and Vietnam. These declines were partly compensated by strong population-driven increases in Sub-Saharan Africa (especially in Nigeria, Ethiopia, Uganda, and the Democratic Republic of Congo) as well as in Pakistan.

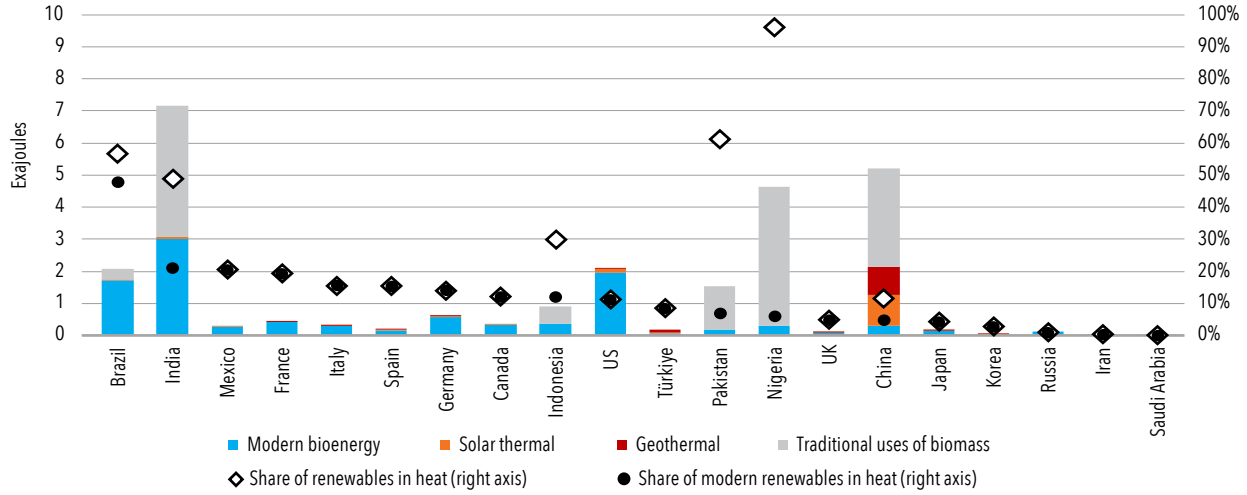
Figure 3.18 • Renewables consumption in heat by region, 1990 and 2020



Sources: International Energy Agency and United Nations Statistics Division.
Note: Indirect consumption of renewable energy through electricity for heat is not included in this figure.

Between 2010 and 2020, China and India together represented more than two-thirds of the global increase in modern uses of renewables consumed for heat. Together with the United States and Brazil, they were responsible for 45 percent of the global heat demand and accounted for half of global modern uses of renewable heat consumption in 2020 (figure 3.19). This results from large consumption of bioenergy in the "pulp and paper" industry and for residential heating in the United States, extensive use of bagasse in the Brazilian and Indian sugar and ethanol industry, and notable deployment of solar thermal water heaters and geothermal heat in China. Europe is responsible for another quarter of global modern uses of renewable heat consumption, owing to the deployment of residential wood and pellet stoves and boilers (e.g., in France, Germany, Italy) and the use of biomass in district heating (e.g., the Nordic and Baltic countries, Germany, France, Austria). Further, renewable heat consumption was supported indirectly by the growing consumption of renewable electricity through electric heaters and heat pumps, as well as the harnessing of ambient heat with heat pumps in China, the United States, and the European Union – albeit the later is not quantified in this report (IEA 2022a).

Figure 3.19 • Renewable heat consumption and share of renewables in total heat consumption among the top 20 energy-consuming countries, 2020



Sources: International Energy Agency and United Nations Statistics Division.
Note: Indirect consumption of renewable energy through electricity for heat is not included in this figure.

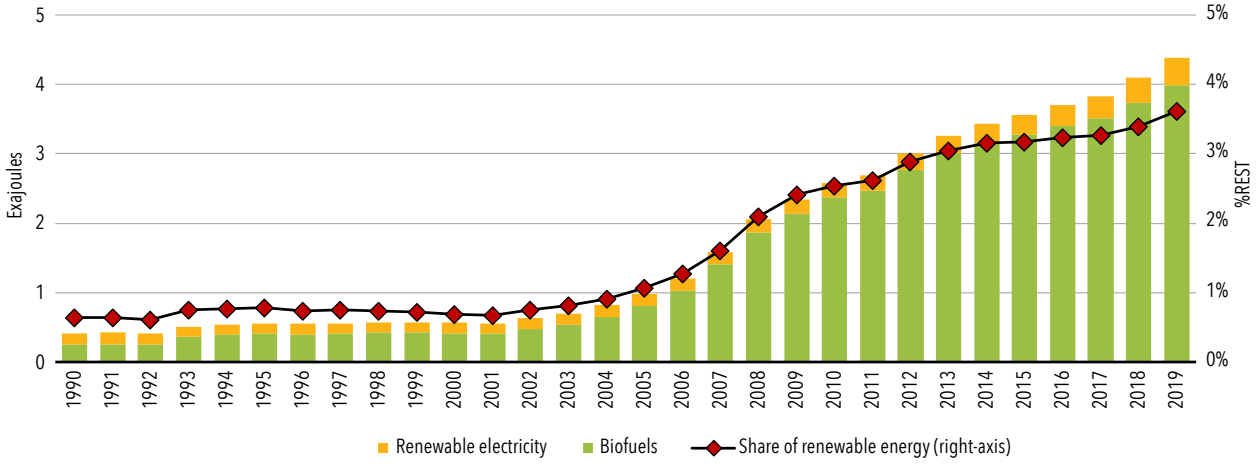
TRANSPORT

Global final energy consumed for transport declined by 14 percent(-16.6 EJ) in 2020. This resulted from COVID-19 policy responses curtailing economic activity and disrupting transport in most regions of the world. Meanwhile, biofuel demand for transport declined less severely, with an estimated 4 percent drop in consumption (-0.16 EJ) in 2020 compared with 2019. There are three reasons behind this relative resilience of biofuel demand. First, biofuels continued to meet an increasing share of the energy demand, climbing from 3.3 percent to 3.6 percent of the final energy consumed for transport. Second, in some large biofuel markets, transport demand declined less than the global average. For instance, Brazil's transport demand declined by only 7 percent, leading to a less severe percentage drop in biofuel demand. In addition, biodiesel blended with diesel fuels actually grew 6 percent globally, offsetting more severe drops in ethanol demand. Yet, 2020 saw the first reduction in annual biofuel production in two decades. The biggest year-on-year declines in output were for US and Brazilian ethanol and European biodiesel.

Still, liquid biofuels, mainly crop-based ethanol and biodiesel blended with fossil transport fuels, represented 90 percent of the renewable energy consumed for transport. The majority of the remainder came from renewable electricity used in vehicles and trains, which grew by 0.02 EJ year-on-year in 2020, the second-largest expansion since 1990. Part of this growth was due to an expanding electric vehicle fleet. The number of electric vehicles on the road grew from 7.1 million in 2019 to 11.3 million in 2020. The electricity powering these vehicles is also increasingly coming from renewable sources. Renewables' share of total electricity used for transport climbed from 20 percent in 2010 to 28 percent in 2020.

The increasing use of renewable electricity in transport combined with an overall decline in fossil fuel demand for transport led to the second-largest annual increase in the renewable fuel share in transport since 1990, reaching 4 percent in 2020, up from 3.6 percent in 2019 (figure 3.20).

Figure 3.20 • Global renewable fuel share in transport and totals for renewable electricity and biofuels, 1990–2020



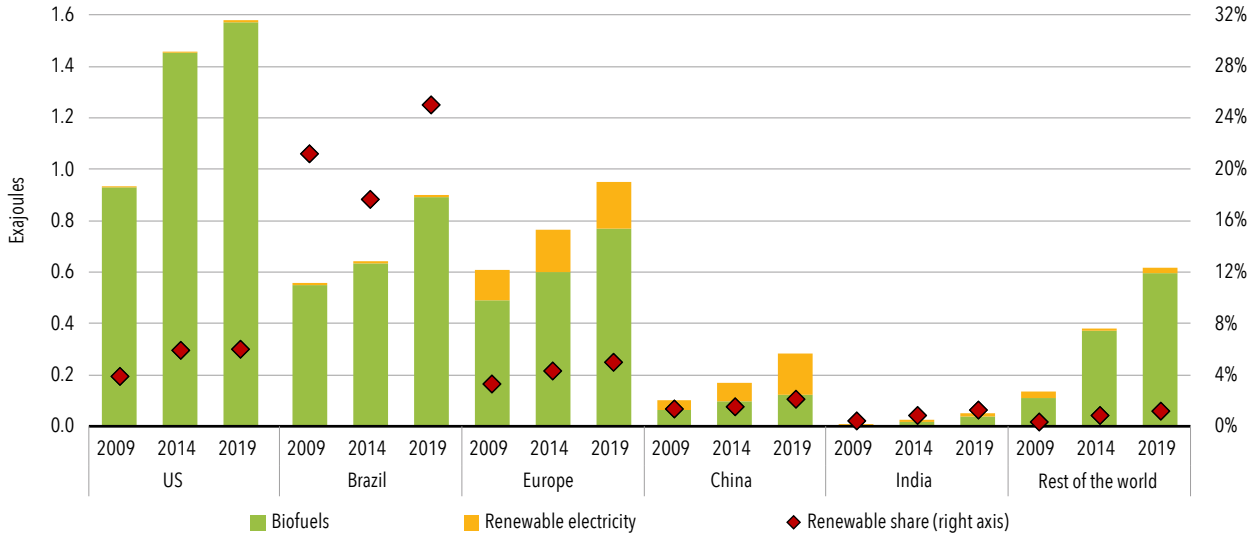
Sources: International Energy Agency and United Nations Statistics Division.
RES-T = Renewable energy used for transport .

Over the past decade, the amount of renewable energy used for transport has grown by two-thirds. The growth has been supported by country-level policies to expand biofuels, electrify transport, and increase renewable electricity generation. Biofuel policies have driven the largest growth in renewable energy, while renewable electricity has played a smaller, but growing, role. But despite many successes at the country level, these policies have only marginally kept ahead of the growing fossil fuel demand, leading to only a small increase in the renewables share (1.5 percentage points in the past ten years).

From a regional and country perspective, the United States, Brazil, and Europe account for almost 80 percent of the renewable energy used in transport. However, other regions, too, are seeing increasing shares (figure 3.21). In the United States and Brazil, biofuels—primarily crop-based ethanol and biodiesel—provide 99 percent of the renewable energy used in transport. By contrast, in Europe, renewable electricity represents 20 percent of the renewable energy consumed in transport. Meanwhile, in China, renewable energy in transport grew almost 80 percent between 2015 and 2020, with renewable electricity accounting for two-thirds of this growth. Renewable electricity represented more than half of all renewable energy used in transport in this country in 2020—thanks to increasing shares of renewables in power generation and electrification of transport efforts in parallel with only modest biofuel policy support. In 2020, China had 48 percent of the global light-duty electric vehicle fleet, aside from over 500,000 electric buses. In India, biofuel support policies have more than doubled renewable energy use in transport since 2015.

Expanding the share of renewable sources in the energy used for transport will require a combination of policies that support biofuels, while ensuring that feedstock supplies meet the most stringent sustainability criteria: transport electrification and renewable electricity generation, as well as active mobility, transit efficiency (efficiency by design), and the phaseout of fossil fuels for transport. These policies must be steadily strengthened where they are already in place and introduced where they are not yet.

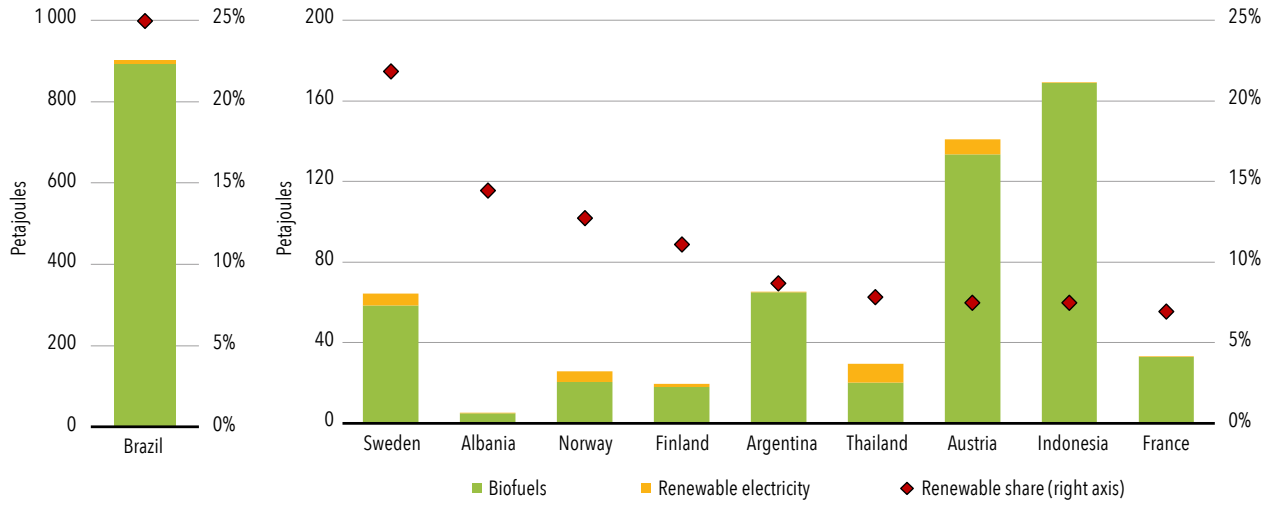
Figure 3.21 • Renewable energy share in transport and total renewable energy for selected countries, 2010, 2015, and 2020



Source: International Energy Agency and United Nations Statistics Division.

Across all countries and regions, the United States, Brazil, Europe, China, and India together constitute an 86 percent share of transport renewable energy consumption driven by policy support for biofuels and electrification. In 2020, Brazil, Sweden, Albania, Norway, Indonesia, and Finland recorded the largest shares of renewables in transport energy consumption, all above 10 percent (figure 3.22).

Figure 3.22 • Top ten countries by renewable energy share in transport, 2020



Sources: International Energy Agency and United Nations Statistics Division.

Policy Insights

Despite significant progress on SDG 7 over the past decade, the findings in this chapter underscore the need for greater ambition to achieve this goal, which in turn will enable and influence the realization of most other SDGs, including SDG 13 on climate targets, SDG 3 on health through pollution reduction, and SDG 8 on decent work and economic growth, among others. To this end, long-term commitments, supported by well-designed targets, comprehensive plans, and timelines, are needed to set clear directions and expectations for stakeholders to align their activities. The more detailed, specific, and credible a target is, the more likely it can catalyze public and private investments. Targets also need to be ambitious enough to step up from historical trends and align renewable energy deployment with SDGs and international climate ambitions. This section provides an overview of key considerations for countries as they design their renewable energy targets.[53]

Design elements of renewable energy targets. While designing renewable energy targets, decisions need to be made regarding their statistical bases; scope and coverage in terms of sectors and end uses; indicators; technology specificity; and implementation modalities (figure 3.23).

The *statistical basis* relates to whether targets are determined as a share of a mix relative to a baseline, that is, percentage-based targets (e.g., share of energy supply, electricity generation mix, percentage of vehicles) or a fixed absolute amount (e.g., capacity added, number of solar water heaters installed). Although targets expressed as a share of a mix may provide more clarity on how ambitious climate goals are, since they imply phasing out (or opting out of) fossil fuel–based energy and systems, they can be difficult to implement and monitor for multiple reasons. One such reason is that both the renewable energy deployed and the total energy demand/supply change over time. Targets expressed as absolute amounts can provide clearer commitment from policy makers and more certainty for market

53 The section is based on IRENA's report Renewable Energy Targets in 2022: A Guide to Design. For more details, please refer to the full report (IRENA 2022b).

participants and investors as they stipulate a specific quantity that must be installed or produced by a specified time. They are also easier to monitor than percentage-based targets.

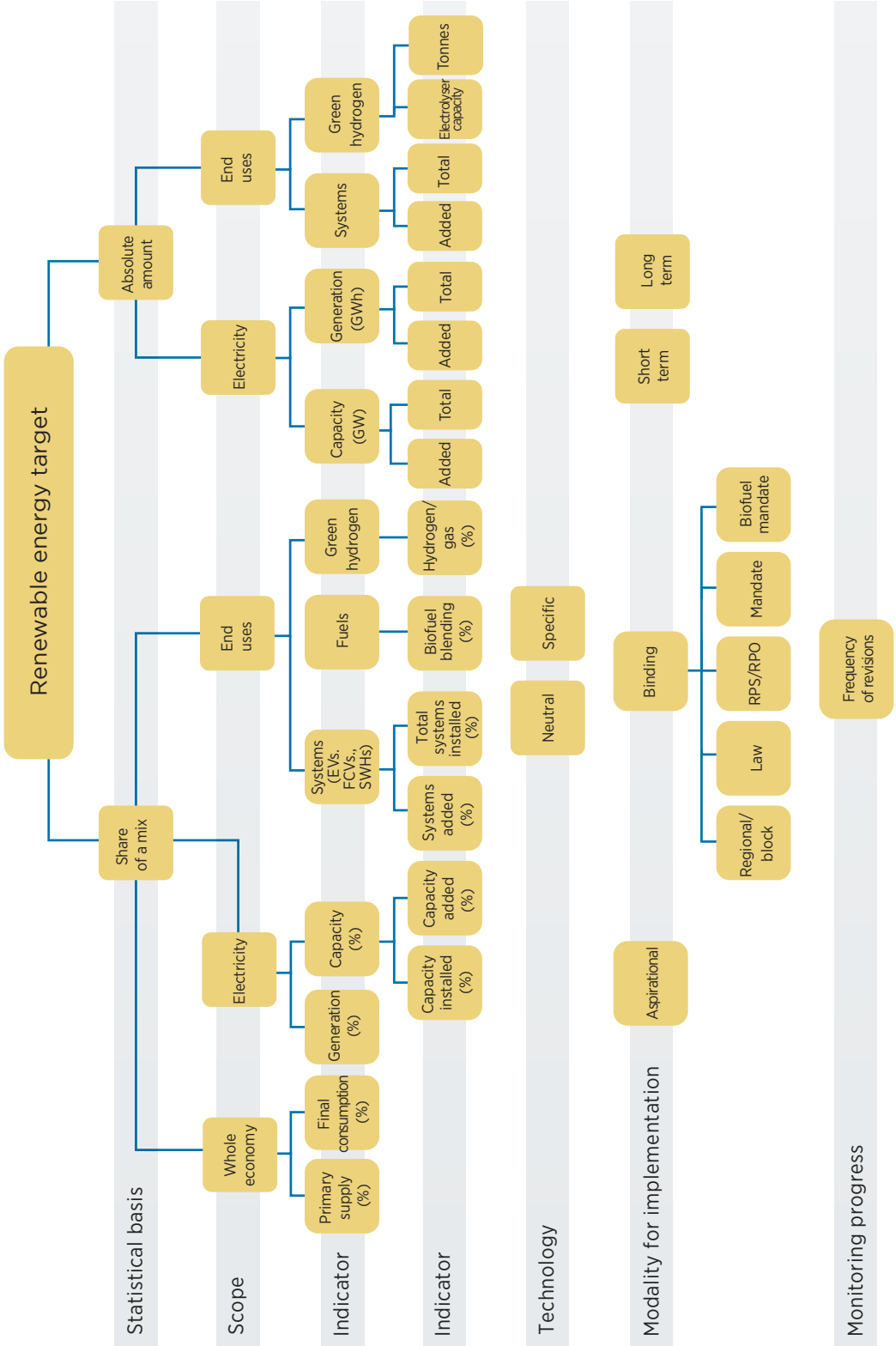
Scope and coverage relate to whether a target covers the entire energy sector or specific end uses. While the former provides a comprehensive view of the target's impact with regard to climate goals and energy security, the latter may provide a clearer signal for the development of local supply chains for specific technologies. Many countries have used a combination of both.

Targets can be set based on a range of indicators that vary in terms of scope and coverage. For percentage-based targets covering the entire energy sector, their applicability to the TFEC or total energy supply needs to be decided. For percentage-based targets in the power sector, a decision is needed on whether they represent a share of the generation or installed capacity. In end uses, a decision is needed on whether percentage-based targets represent a share of the total number of systems added by/after a given year (e.g., bans on the sales of combustion engine vehicles in the European Union and the state of California by 2035 correspond to a target of 100 percent of vehicles added after 2035 to be electric) or a share of the total in use by a given year (e.g., Paris's ban on all combustion engine vehicles by 2030 corresponds to 100 percent of vehicles on the road being electric).

Technology specificity relates to whether a target should be technology neutral or technology specific. While technology-neutral targets can be strategic in the early stages of renewable energy development, since they allow markets to identify the most cost-effective technologies, technology-specific targets can enable further diversification of the energy mix, with benefits such as resilient systems and fewer integration issues. They can also enable the development of local value chains for selected technologies. This can, for instance, help in addressing the risk that power-grid investments, including auxiliary services, storage, and flexibility measures, may not be identified early enough in current electricity markets, the importance of which is further explained in box 4.3.

Modalities for target implementation relate to whether a target is mandatory or aspirational, and short to medium term or long term. They determine the process for reviewing and revising a target.

Figure 3.23 • Key decisions for setting renewable energy targets



Source: IRENA 2022b

EV = electric vehicle; FCV = fuel cell vehicle; GWh = gigawatt-hour; SWH = solar water heater.

Target design should begin with considering how the target(s) will serve the desired policy goal(s). Possible objectives may include greenhouse gas emissions reduction in line with SDG 13 on climate; pollution reduction in line with SDG 3 on health; energy access, reliability, and affordability in line with SDG 7; job creation and economic growth in line with SDG 8; and other socioeconomic development and environmental goals set out in the UN 2030 agenda.

Reductions of emissions and energy imports. Targets may be expressed as a share of the energy mix, covering the entire energy sector, in order to address the phasing out (or opting out of) of fossil fuel–based energy and systems. This approach can provide greater clarity on the level of ambition related to the climate goals and the reduction of energy imports (for countries that are fossil fuel importers). Targets that reduce the supply of fossil fuels in their raw form (defined as a share of the primary energy supply) have greater potential to reduce energy imports and emissions across the entire process of energy conversion to consumption, including inefficiencies.

However, using primary energy as a statistical basis for setting a renewable energy target poses a problem related to the methodology used to calculate the primary energy equivalents of renewables. To overcome this, they can be translated into targets as shares in the final energy consumption. Once the overall target for the energy sector has been defined and aligned with wider emissions reduction and energy import minimization goals, a target can be broken down into the different sectors and end uses, such as the power, transport, and heating and cooling sectors, taking into account electrification plans. For example, Portugal's target of a 47 percent share of renewables in its final consumption by 2030 translates into a share of 20 percent renewables in transport, 38 percent in heating and cooling, and 80 percent in electricity. When setting such targets, energy demand must be predicted taking into consideration traditional variables that influence forecasts (e.g., population, economy, climate and weather, lifestyles and cultural choices), in addition to many components of the energy transition, such as energy efficiency targets and measures and increased electrification of end uses, among other factors.

In the power sector, targets expressed as renewables' share in electricity generation are more effective than targets expressed as renewables' share in installed capacity for achieving emissions reductions or fossil fuel savings. This is because progress monitoring excludes projects that sit idle or get curtailed.

For end uses, regarding systems such as electric vehicles or solar water heaters, for instance, targets in the form of a share of the total number of systems in use by a given year (for instance, X percent of vehicles on road must be electric vehicles) can help achieve climate and pollution goals, and energy security when fossil fuels are imported; yet targets expressed as total number of systems (e.g., Paris's ban on all combustion-engine cars by 2030) can be more effective, since they can require the phaseout of fossil fuel alternatives (e.g., all combustion-engine cars).

Universal energy access and clean cooking. Access targets expressed as percentages of population with access to electricity and clean cooking are independent of demographic changes. Additionally, separate targets specific to electrification and clean cooking are required, which have to be translated into an absolute capacity or absolute number of systems to deploy. Electricity access targets expressed as installed renewable capacity (including off-grid technologies) are easier to plan, monitor, and achieve. However, it is difficult to assess how effective these targets are in determining whether systems are being used and maintained. Output-based targets (e.g., renewables-based gigawatt-hours of electricity representing a percentage of the total electricity generation) focus on production and technology utilization. For renewables-based clean cooking, targets framed as the total number of systems to deploy (e.g., total number of biodigesters introduced) by a given deadline are easier to define, monitor, and implement than percentage-based targets.

Development of local industries for energy transition–related technologies. Translating percentage-based targets into absolute-amount targets can provide further clarity to market participants and investors and plays a role in the development of local industries for these technologies. Examples of such targets include specific capacities that must be installed (e.g., megawatts of power or number of solar water heaters) or produced (e.g., megawatt-hours generated). In particular, technology-specific targets can be instrumental in developing or enhancing local value chains for these technologies as well as leveraging local capacities. This was evident in countries that pursued technology-specific targets, such as Morocco and South Africa, where, further bolstered by policies to aid local industries, the solar and wind sectors flourished across different parts of the value chain, leading to an increase in jobs and income.

Overall, when setting national climate targets, policy makers must account for the following considerations.

- First, a balanced combination of long-term targets, further segmented into a series of short- to medium-term targets, is ideal for achieving a combination of policy objectives (in the presence of a robust policy framework to support the targets). Long-term targets provide an indication of a country's overall commitments and provide a key signal to developers, investors, service providers, and manufacturers regarding the long-term trajectory in a market. Short- to medium-term targets provide additional credibility as well as a pathway to achieving long-term objectives. They also create a sense of urgency and motivate stakeholders to act. They enable more effective implementation and rapid learning from the policy process and can coincide with investment and electoral cycles. In the case of five-year plans (e.g., China's), their periodic nature provides a high level of flexibility and adjustment. Setting short- to medium-term targets by backcasting a long-term trajectory can reconcile short-term goals with long-term objectives.
- Second, for these targets to be effective, they should be implemented together with policy instruments that are incorporated into legislation and/or institutional mandates for government agencies, corporate institutions, and other stakeholders.
- Finally, a key principle for effective renewable energy targets is to link them closely to the regular monitoring of market conditions so as to make them more ambitious in line with changes in policy objectives and priorities that call for greater ambition, market dynamics, lower renewable energy costs, and learning curves.

Methodological Notes

DEFINITIONS

Renewable energy sources. 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 along with the amount of electricity and heat consumption estimated from renewable energy sources. Ambient heat harnessed by heat pumps is not accounted for in this report, due to limited data availability.

Direct renewables. Bioenergy, and direct uses of solar thermal and geothermal energy.

Total final energy consumption. The sum of the final energy consumption in the transport, industry, and other sectors (equivalent to the total final consumption minus nonenergy use). Total final consumption excludes energy transformed into other forms of energy (e.g., natural gas used to generate electricity), as well as energy used by energy industries.

Traditional uses of biomass. Biomass uses are considered traditional when biomass is consumed in the residential sector in countries outside the Organisation for Economic Co-operation and Development. International Energy Agency statistics divide traditional uses of biomass into primary solid biomass, charcoal and unspecified primary biomass, and waste.

Traditional consumption/use of biomass is a "conventional proxy" because it is estimated rather than measured directly.

Modern uses of renewable energy consumption. Total renewable energy consumption minus traditional consumption/use of biomass.

METHODOLOGY FOR THE MAIN INDICATOR

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

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

The variables are derived from energy balance flows: TFEC is total final energy consumption as defined in table 3.1, ELE is gross electricity production, and HEAT is gross heat production, while the subscript RES indicates renewable energy sources.

The denominator is the TFEC of all energy products (as defined in table 3.1). The numerator, renewable final energy consumption, is a series of calculations showing the sum of the direct consumption of renewable energy sources and the final consumption of electricity and heat estimated to have come from renewable sources. To determine final renewable energy consumption, the consumption of electricity and heat deemed to come from renewable sources is assigned based on renewables' share in gross production.

METHODOLOGY FOR ADDITIONAL METRICS BEYOND THE MAIN INDICATOR

Renewable energy is consumed in mainly three sectors: electricity, heat, and transport. Consumption is calculated based on the energy balance and defined as follows:

Electricity refers to the amount of electricity consumed by end users. Electricity used in transport is excluded from this aggregation. Electricity used to produce heat is also excluded, because official data at the final energy service level are unavailable.

Heat refers to the amount of energy consumed for heating in industry and other sectors, as well as other uses not in electricity and transport, such as fuel used to pump water. Electricity used for heat is not included in this aggregate, due to the scarcity of official data at the final energy service level. The heat category here 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," heat does not refer to the same quantity as the energy product, "heat," in the energy balance used in the above formula.

Transport refers to the amount of energy consumed in the transport sector. The majority of the electricity used in transport is consumed in the rail and road sectors, and, in some cases, in pipeline transport. The renewable electricity consumed in the transport sector is estimated by multiplying the annual shares of renewable sources in gross national electricity production by the amount of electricity used nationally in the sector.

METHODOLOGY FOR INDICATOR SDG 7.B.1

Indicator 7.B.1 measures the installed renewable energy–generating capacity in developing countries (in watts per capita). It is computed by dividing the maximum year-end installed capacity of renewable electricity–generating power plants by the country's midyear population. Data from the International Renewable Energy Agency (IRENA) are used to calculate this indicator.

IRENA's electricity capacity database contains information on installed electricity-generating capacity, measured in megawatts. The data set covers all countries and areas from the year 2000, records whether capacity is on-grid or off-grid, and is divided into 36 renewable energy types, which together constitute the six main sources of renewable electricity. For the population part of this indicator, IRENA uses population data from the United Nations World Population Prospects (UN 2021).

More details on the methodology used in this chapter can be found in the SDG indicators metadata repository (https://unstats.un.org/sdgs/metadata/files/Metadata-07-0b-01.pdf).

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