CHAPTER 4 –
RENEWABLE ENERGY

Photo: Aldio Dwi Perkasa – Geothermal Resources Council

MAIN MESSAGES

- **Global trend:** Under Sustainable Development Goal (SDG) 7.2, global progress on renewable energy is measured by its share in total final energy consumption (TFEC). The global share of renewable energy in TFEC reached 17.5% in 2015, up only slightly from of 17.3% in 2014 and less than one percentage point higher than where it stood back in 2010 (16.7%). Even though the absolute level of renewable energy consumption has grown by more than 18% since 2010, only since 2012 has the growth of renewables outpaced the growth of total energy consumption. It is important to note that the renewable energy share includes traditional uses of biomass and is subject to significant yearly variations due to weather, in particular, to the availability of hydro resources, and to demand for renewable heating in a given year.

- **2030 target:** On current trends the world will not achieve the SDG 7.2 target of a substantial increase in world renewable energy share in TFEC by 2030. The average annual progress from 2010 to 2015 has been only 0.09 percentage points and has been slowing down each year since 2012.

- **Baseline share revised down after major data revision:** The renewable energy data underlying this report has changed significantly relative to previous years because of revised data for traditional uses of biomass in China. According to the revised data, the global share of renewable energy in TFEC in 2010, the baseline year, is now 0.6 percentage points lower than before the revision. This revision is a step in the right direction toward data harmonization. It underlines the importance of sound and methodologically consistent energy balances and data collection capacity at the global level across all energy sources, including the complex field of bioenergy.

- **Renewable electricity:** The share of renewable energy in electricity continued to climb to reach an all-time high of 22.8% in 2015. This increase was largely driven by new additions of wind energy, which accounted for approximately half of the growth in renewable electricity consumption in 2014–15.

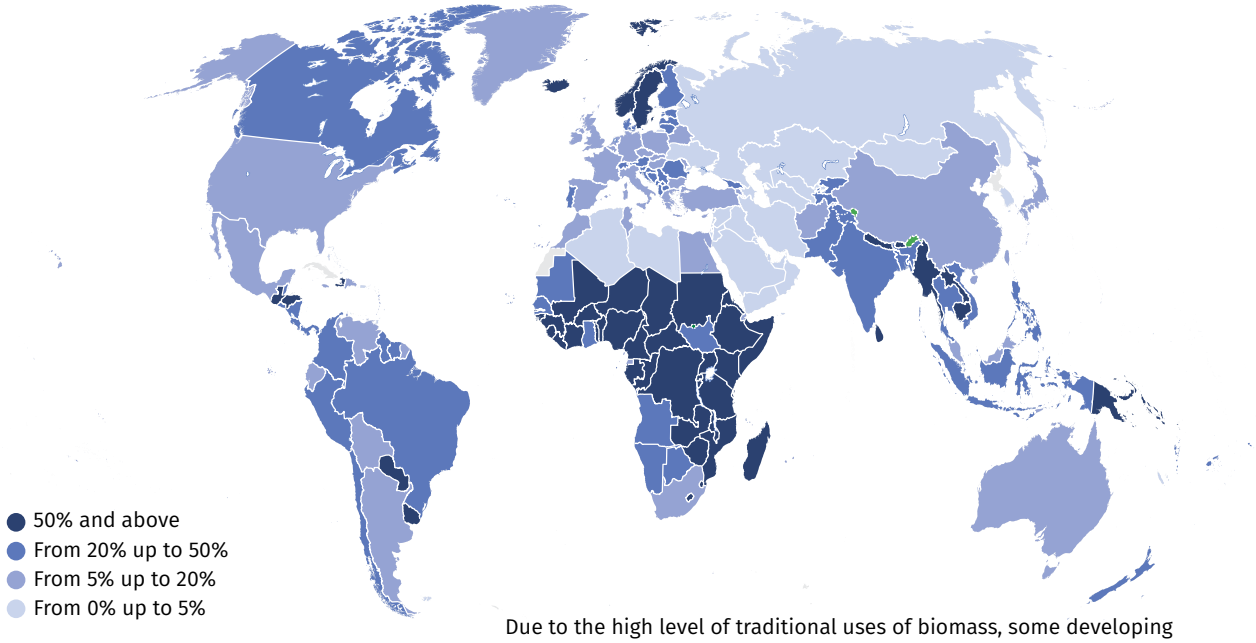
- **Renewable heat:** Although heat accounts for the largest share of TFEC, current efforts to promote renewable heat have been insufficient to achieve the pace needed to reach SDG 7. The share of renewable energy in heat consumption, dominated by 65% of traditional use of biomass, reached 24.8% in 2015, a modest improvement of less than one percentage point since 2010. The slow growth highlights the fact that more policy attention is needed to remove barriers to deployment and increase the role modern renewables play in meeting heat demand. In 2015 the traditional use of biomass was only 3% higher than in 2010, whereas the use of renewables in district heating and modern noncommercial uses of renewable heat grew by 24% and 8%, respectively, over the same period.

- **Renewable transport:** Renewable energy consumption in transport reached 2.8% globally in 2015. The consumption of renewable energy in transportation has proportionally increased faster than in either electricity or heat, but from a very low base. The greatest areas of concern remain in aviation, rail, and maritime transport, where penetration rates of biofuels are negligible at the present time.

- **Regions and income groups:** The economies of high-income countries in North America and Europe are still heavily dependent on fossil fuels. Although their share of renewables in TFEC is the lowest of any region (11.8% in 2015), these countries did achieve the most rapid increase of any region since 1990, principally because their TFEC growth has been very slow (and declining or flat across Europe). By contrast upper-middle-income countries in Asia have seen their RE share in TFEC decline, as the region undergoes economic development and shifts away from traditional uses of biomass. Low-income countries have a large share of renewables because of both a high level of traditional biomass and a significant amount of hydroelectricity production.

- **Top 20 countries:** The top 20 countries, ranked by their TFEC, together account for 65% of TFEC. In 2015 these countries had an average renewable energy share in TFEC of 18%, which is higher than the global average. Overall, they outperformed the global share of renewable energy for transportation and underperformed the global renewable energy share for heat and electricity.

FIGURE 4.1 • Renewable energy share in total final energy consumption by country, 2015



Due to the high level of traditional uses of biomass, some developing countries have the highest overall renewable energy share

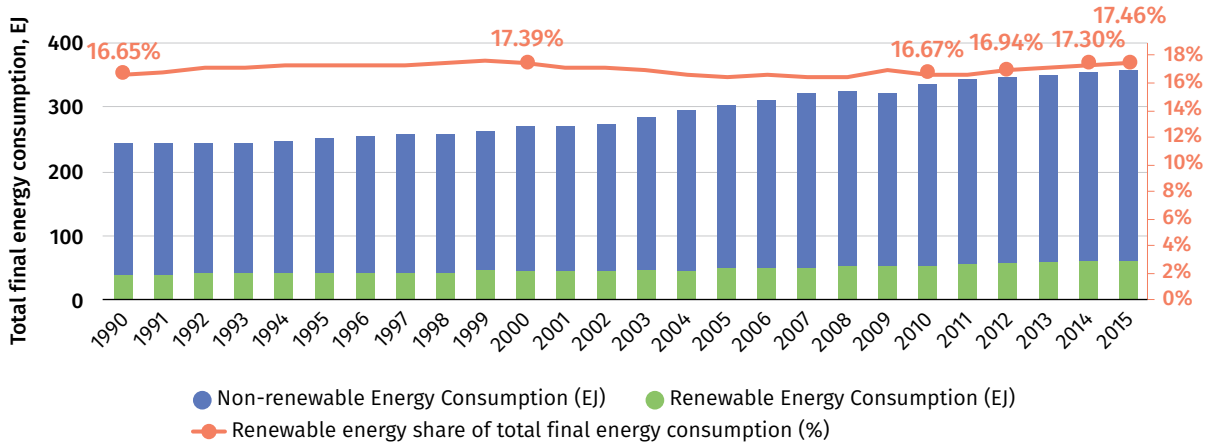
Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

THE STORY IN PICTURES

GLOBAL TRENDS

The global share of renewable energy in total final energy consumption has just increased by about one percentage point since 1990

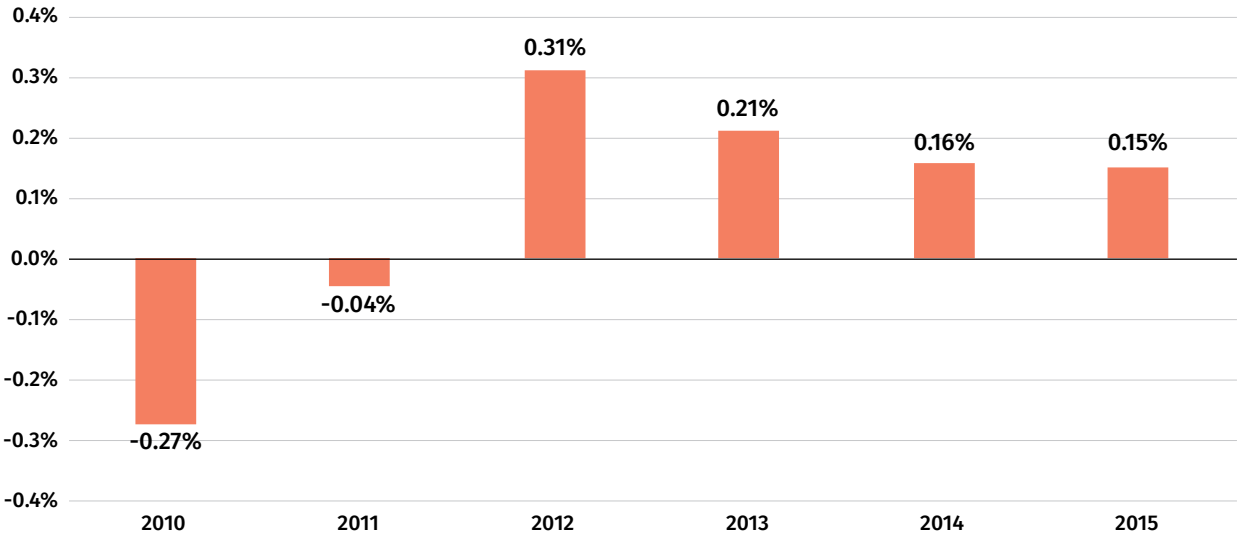
FIGURE 4.2 • Renewable energy share in total final energy consumption, 1990 - 2015



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

The speed at which the renewable energy share is growing has continued to slow in recent years

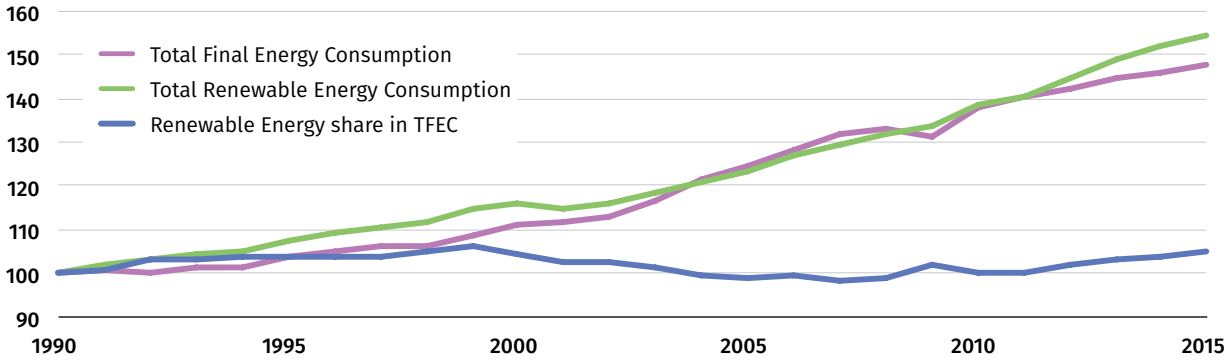
FIGURE 4.3 • Annual percentage point increase in the share of renewable energy in total final energy consumption, 2010 - 2015



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

Renewable energy share has been mostly stagnant since the world's total final energy consumption has grown almost as fast as its renewable energy consumption

FIGURE 4.4 • Growth in renewable energy consumption and total final energy consumption indexed, 1990-2015 (1990 base)

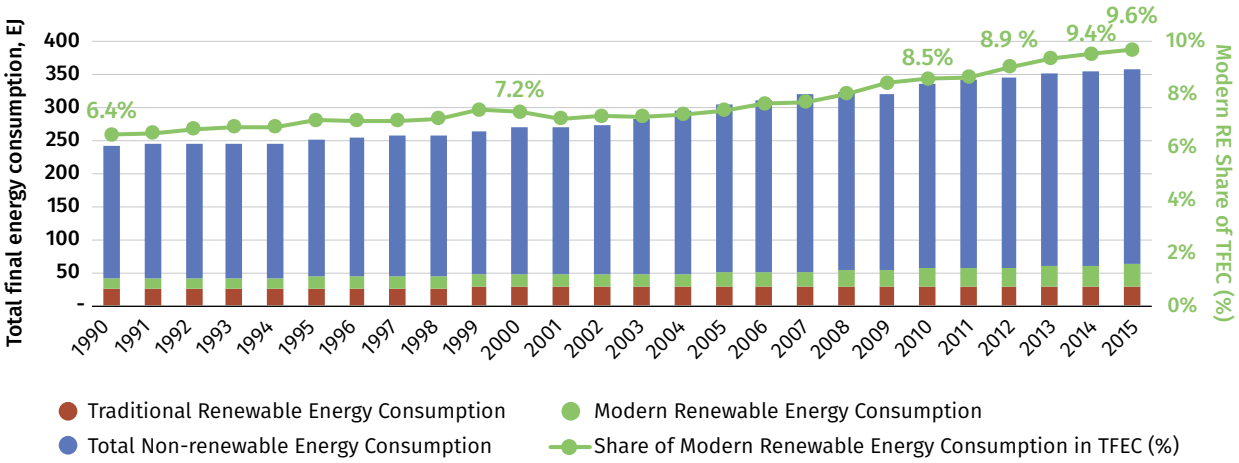


Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

TECHNOLOGY TRENDS

The share of modern renewable energy in total final energy consumption expanded much faster than the share of renewable energy overall

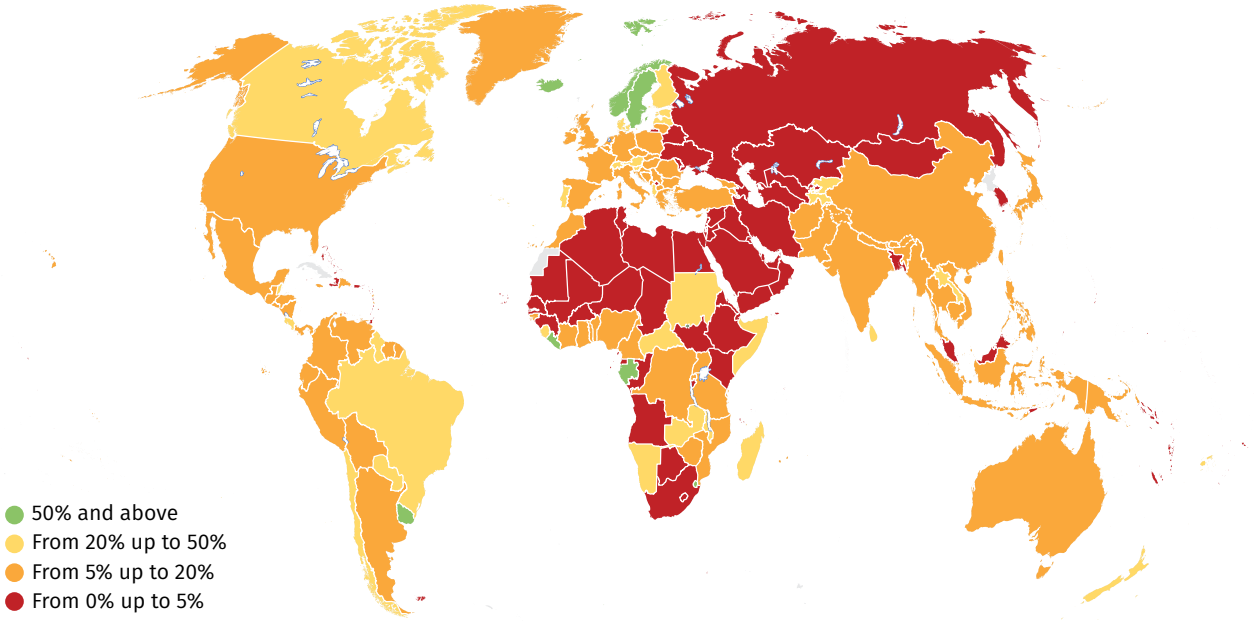
FIGURE 4.5 • Renewable Energy in total final energy consumption, disaggregated by modern vs traditional uses from 1990 to 2015



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

Countries with the highest *modern* renewable energy shares overall are typically those able to achieve significant penetrations of renewables in heat.

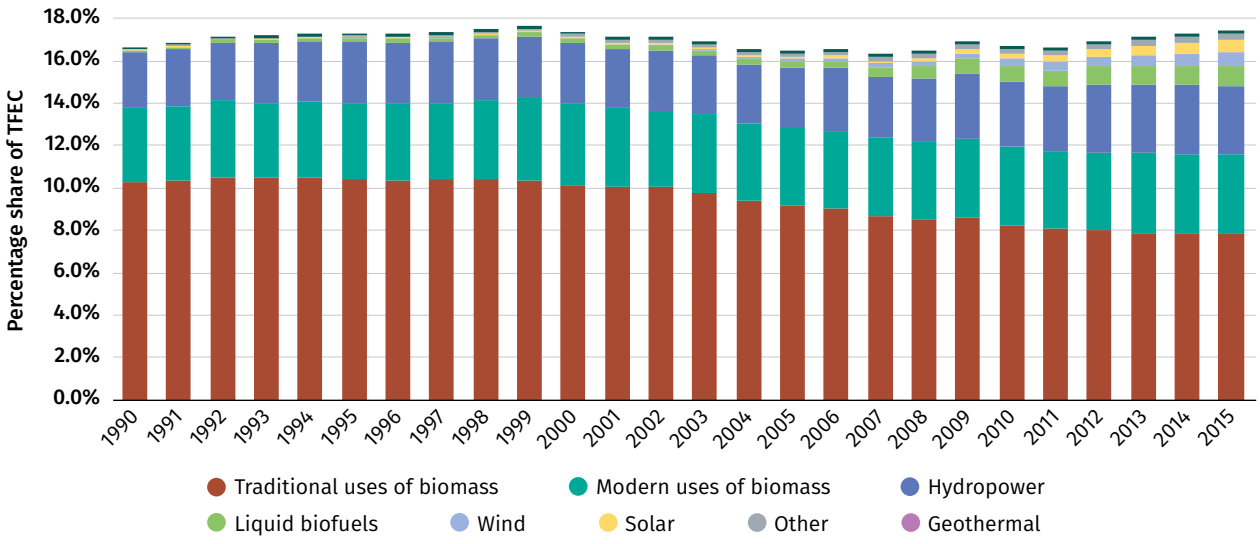
FIGURE 4.6 • Heat map of modern renewable energy share in TFEC, 2015



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

Biomass and hydropower remain the main sources of renewable energy, but wind and solar are emerging rapidly

FIGURE 4.7 • Share of individual renewable energy sources in global total final energy consumption, 1990 – 2015

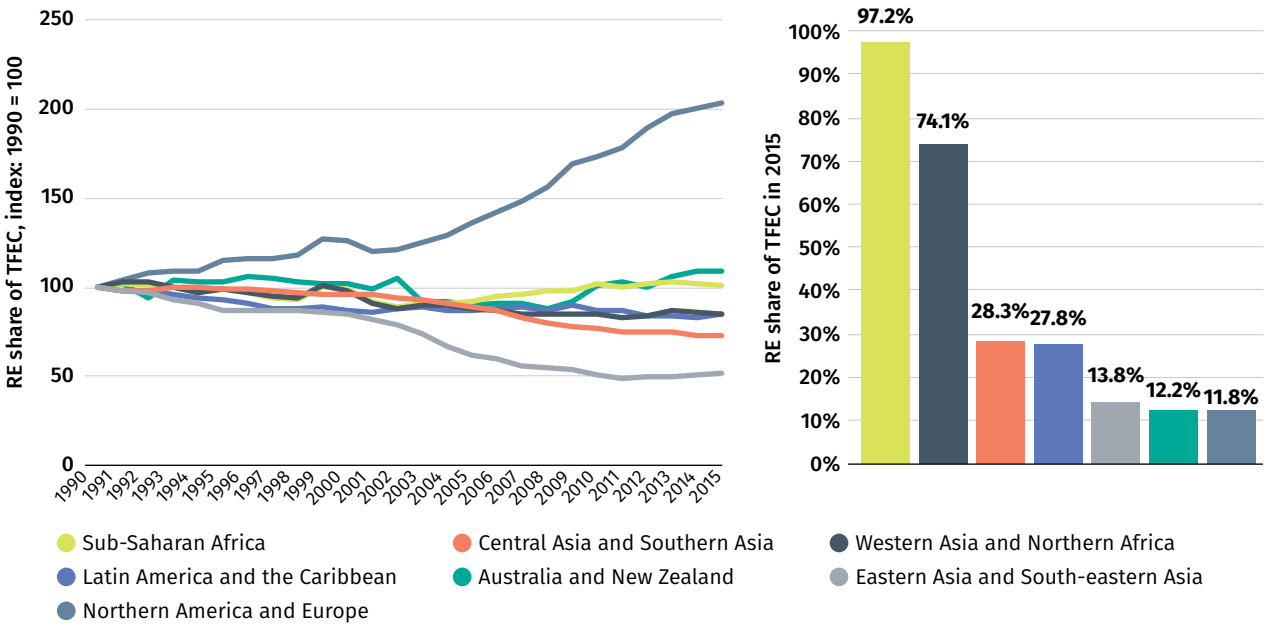


Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

REGIONS AND INCOME GROUPS

Europe and North America started from a low base to double their renewable energy share since 1990, while across the developing world renewable energy shares are high but falling

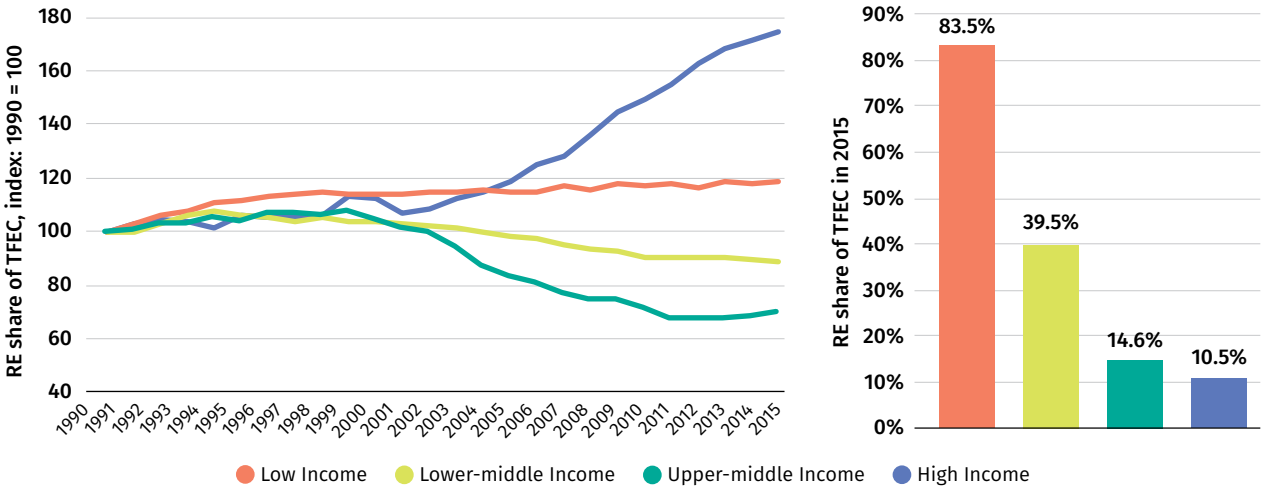
FIGURE 4.8 • Regional share of renewable energy in total final energy consumption indexed from 1990 to 2015



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

Upper middle income countries are seeing their renewable energy shares decline particularly steeply with renewable energy shares approaching those of top 20 countries

FIGURE 4.9 • Indexed growth of renewable energy share in TFEC in countries grouped by income and their growth of renewable energy as a share of TFEC from 1990 to 2015

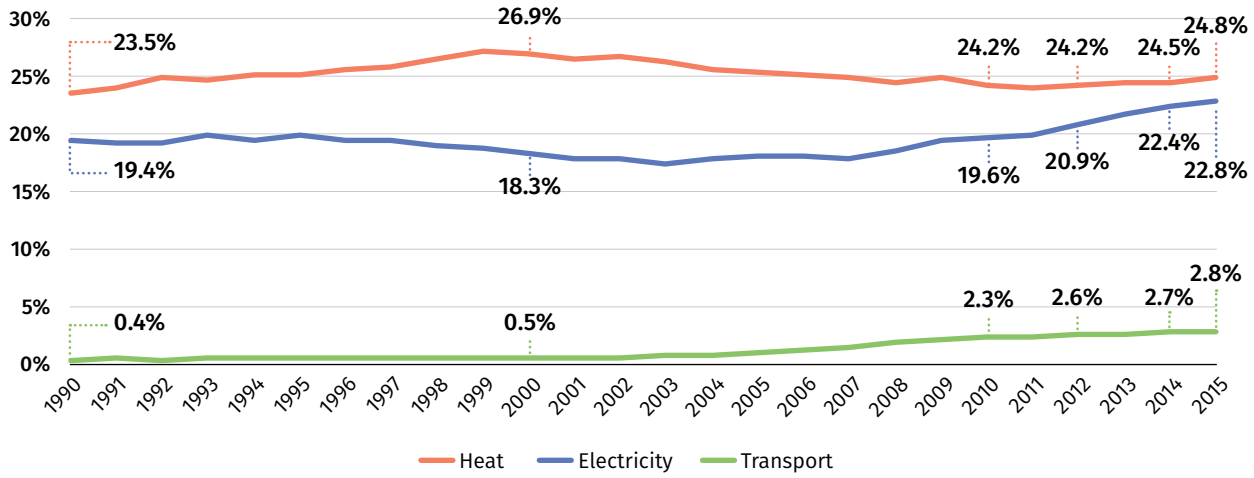


Source: International Energy Agency (IEA) and United Nations Statistics

END USE SECTORS

Since 2000, the renewable energy share of energy consumption in electricity and transport has grown significantly

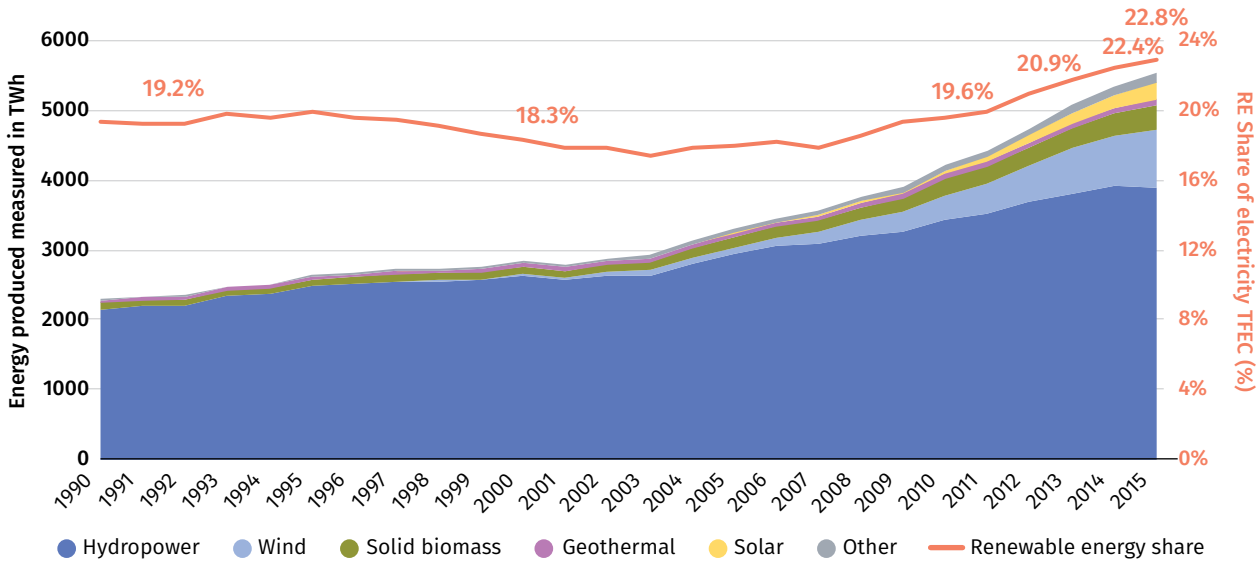
FIGURE 4.10 • The evolution of the renewable energy share in total final energy consumption by end-use sector, 1990-2015



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

While hydropower remains the dominant source of renewable electricity, wind power grew most rapidly during the period 2010-2015

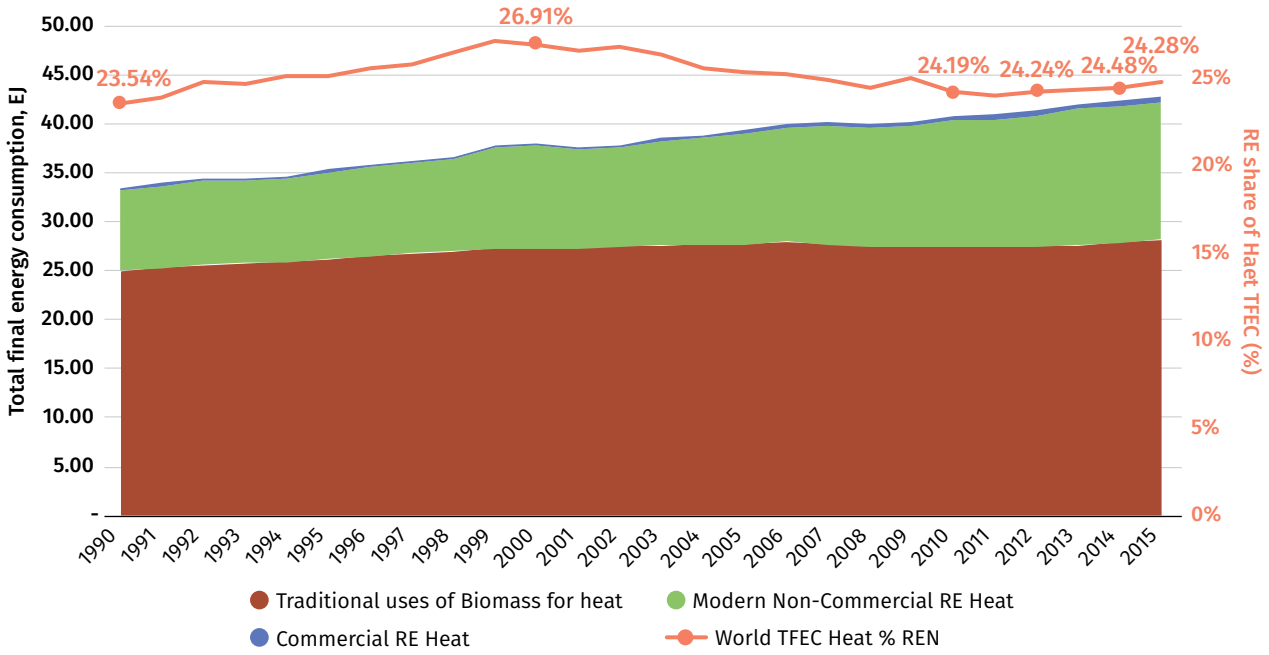
FIGURE 4.11 • Breakdown of global renewable electricity consumption by type of generation technology, 1990-2015



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

Traditional uses of biomass are the dominant source of renewable energy consumption in the heat end-uses

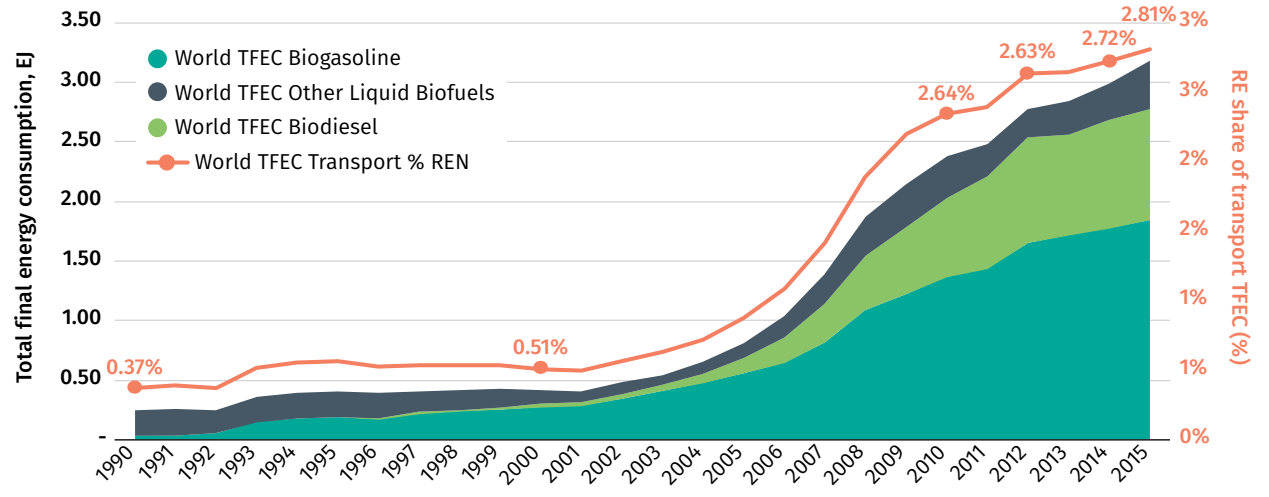
FIGURE 4.12 • Breakdown of global renewable energy consumption for heating by fuel source, 1990-2015



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

Bio-gasoline remains the major renewable fuel in transport, and bio-diesel is also growing rapidly

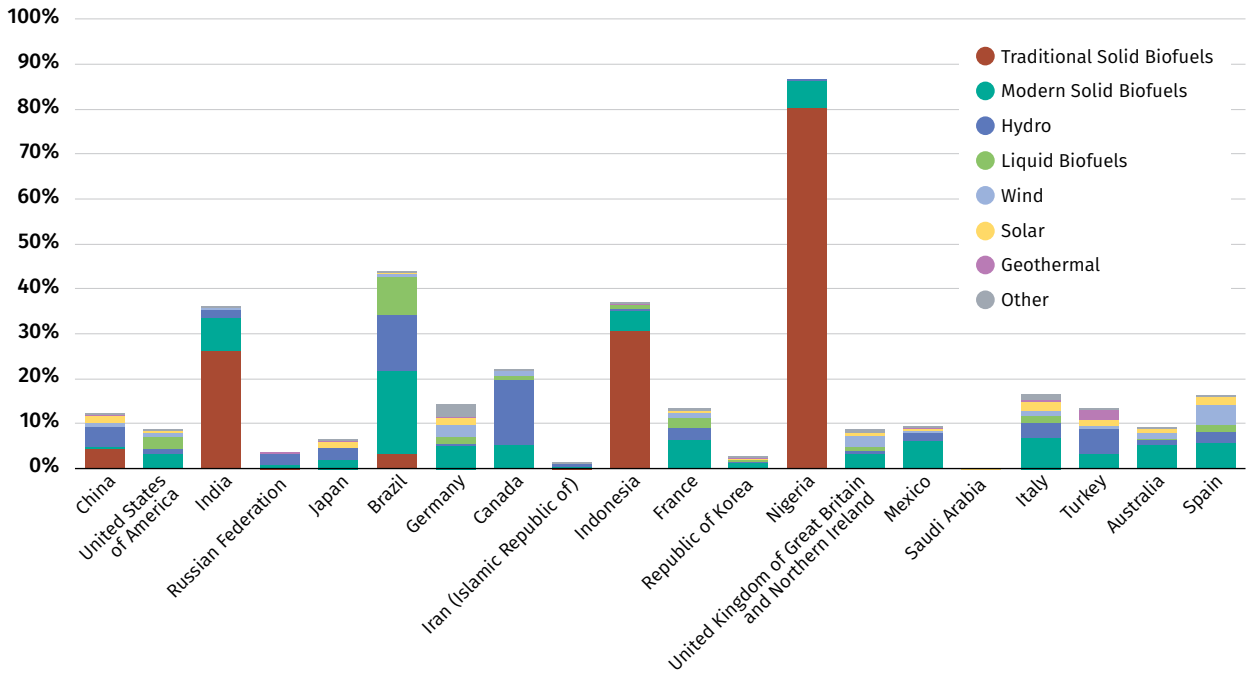
FIGURE 4.13 • Breakdown of global renewable energy consumption for transportation by type of biofuel, 1990 – 2015



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

Among the top 20 countries, traditional and modern uses of solid biomass remain the largest sources of renewable energy consumption

FIGURE 4.14 • Renewable energy share in TFEC by technology, 2015

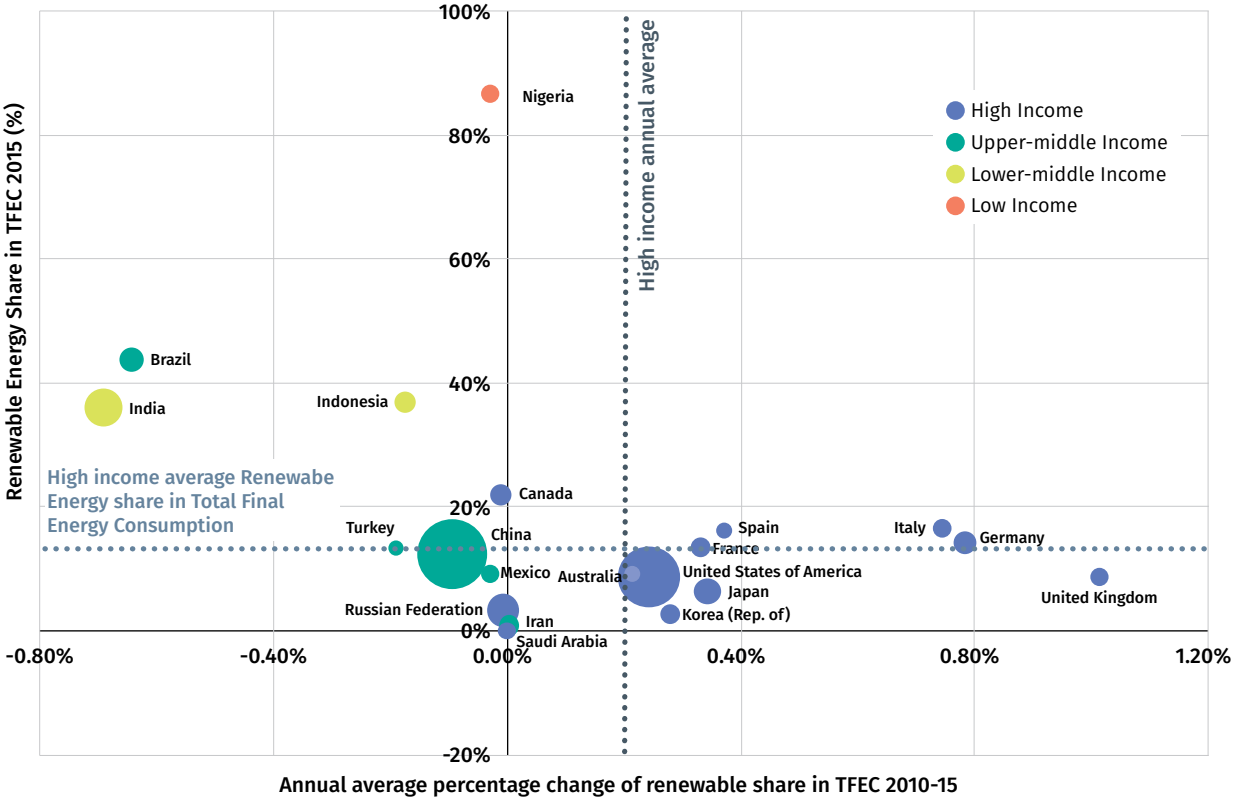


Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

COUNTRY TRENDS

Nine of the 20 largest energy consuming countries have seen their renewable energy shares decline during the period of 2010-2015

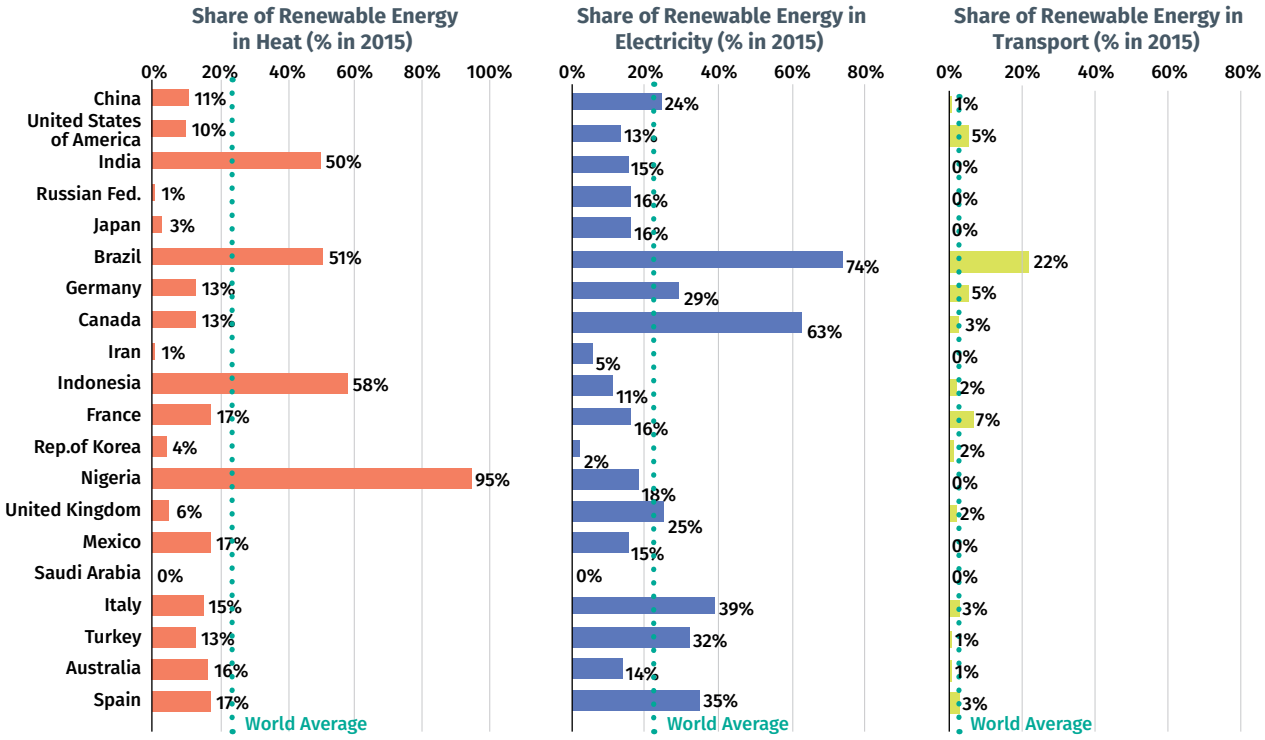
FIGURE 4.15 • Top 20 countries plotting renewable energy share in TFEC (2015) against annual average percentage change in renewable energy share in TFEC (2010-2015), with bubbles scaled according to TFEC size



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

Brazil stands out as the only one from the top 20 countries to have achieved renewable energy shares substantially above the global average for all uses: electricity, heat and transport

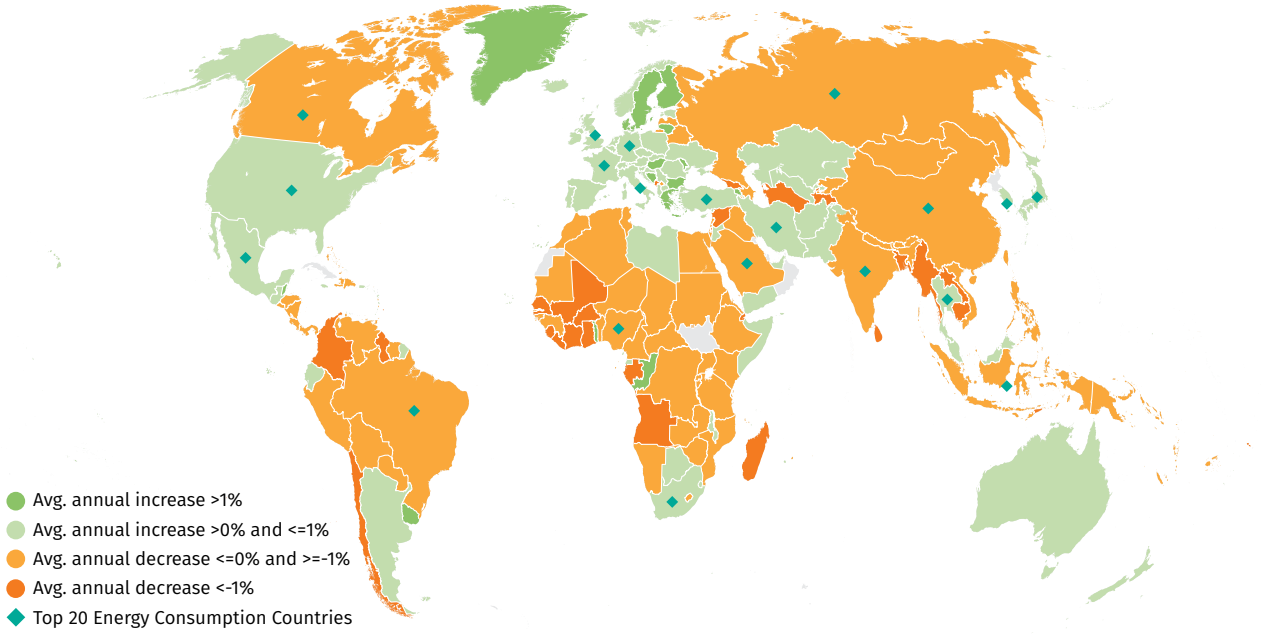
FIGURE 4.16 • Share of renewable energy in heat, electricity and transport in top 20 countries in 2015



Source: International Energy Agency (IEA), United Nations Statistics Division (UNSD) and World Development Indicators (WDI) data

Northern European nations such as Denmark and Sweden experienced the fastest growth in their share of renewable energy consumption during the period 2010-2015

FIGURE 4.17 • Heat map of changes in annual average growth of renewable energy share in TFEC, 2010-2015



Source: International Energy Agency (IEA) and United Nations Statistics Division (UNSD) data

POLICY IMPLICATIONS

Without significant additional effort to deploy renewable energy beyond the electricity sector, the world is unlikely to achieve the goal of substantially increasing the share of renewable energy in global TFEC by 2030 as foreseen under the United Nations SDG 7 commitment.

Although renewable energy's share did outpace total TFEC growth in 2015, the fact that it did so at a slower pace than before is a concern. The slower total renewable energy growth pace was influenced, in part, by declines in global hydropower. However, as 50% of the growth in renewable energy consumption came from bioenergy, of which the majority was driven by traditional uses of biomass, the actual growth rate of modern renewable energy was lower than the headline numbers. This growth is still too low for the world to achieve the SDG 7 target.

Latest results show that the global share of renewable energy in TFEC has barely risen, up by 0.8 of a percentage point between 2010 and 2015, and increased only marginally by 0.15 percentage points since 2014 to reach 17.5% in 2015. In fact, the pace at which the renewable energy share of TFEC is expanding has slowed since 2012. During the 2014–15 period, the share of renewable energy in TFEC actually declined in 114 countries[1]—that is, over half. In 68 of these 114 countries, renewable energy consumption even fell in *absolute* terms. The explanations underlying these trends relate to TFEC growth, traditional use of biomass, and climate fluctuations.

A major reason for the slow increase in the renewable energy share is the continuing steady growth of global TFEC, reinforcing the need for greater progress on energy efficiency and for tighter integration of energy efficiency and renewable energy goals. In 164 countries, an absolute increase in TFEC during 2014–2015 makes it significantly harder to increase the renewable energy share in total TFEC. This helps to explain why the renewable energy share has increased only slowly, despite a major expansion in the world's absolute consumption of renewable energy. During the period 2014–15 the world's renewable energy consumption grew by 1.16 exajoules (EJ)—comparable to the current energy consumption of Bangladesh—despite significant declines in consumption of major fuels such as coal in China, Europe, and the United States in 2015. The second part of the challenge is that renewable energy consumption can sometimes decrease, whether for structural or meteorological reasons.

In structural terms, assessing the overall progress toward SDG 7 can be complicated if the magnitude of traditional biomass uses in a country is large. For example, China's share of renewable energy in TFEC fell from 30% in 2000 to 12% in 2015 because traditional biomass uses decreased; at the same time modern renewable energy in TFEC rose from 2.5% in 2000 to 7.6% in 2015. However, because the magnitude of traditional biomass uses was larger, the overall share of renewables appeared to decline; even though the underlying performance can be considered to represent positive progress toward SDG 7.

Challenges exist also in recording certain energy sources precisely, affecting the accuracy of calculations of the share of renewables (box 5.1). Solid data collection across all energy sources, including diverse bioenergy sources and off-grid renewables, are necessary to develop an accurate national energy balance.[2] In China, efforts to more accurately record traditional uses of biomass led to the significant revision of the 2015 dataset. This change follows an extensive methodological review conducted by the International Energy Agency (IEA) and institutions in China, which has resulted in a notable decrease in Chinese renewable energy consumption. On average, the

[1] IEA/UNSD Data – Renewable energy share in TFEC for 2015 minus renewable energy share in TFEC for 2014. Include all countries where the change was lower than "-0.0000000000001"

[2] Ideally, national energy balances should be consistent with the internationally agreed methodologies of International Recommendations for Energy Statistics (IRES). See https://unstats.un.org/unsd/energy/ires/.

data revision has reduced Chinese traditional uses of biomass by 2.5% per annum from 1990 to the end of 2014. The total difference is a 33.01 EJ decline in traditional use of biomass from 1990 to 2014, which materially affects the entire global renewable energy series since 1990.

Additionally, renewable energy production is sensitive to the consumption levels of biomass for traditional uses in heat, as well as to climatic conditions that can fluctuate year on year. Most notably, hydropower output is strongly affected by precipitation levels, which can be above or below typical levels in any given year. Globally, hydropower production declined by 0.5% in 2015, in part due to droughts caused by the El Niño phenomenon in certain regions. In fact, in 2015, the National Oceanic and Atmospheric Administration (NOAA) reported "a near-record area of global land surfaces in some state of drought," with 14% of land on earth experiencing "Severe Drought" in 2015.[3] However, this decline in hydropower was offset by increases in bioenergy consumption (both in modern and traditional uses), wind, and solar.

Against the backdrop of declining hydro output in 2015 is the significant fact that 70% of new renewable energy consumption in 2014–15 came from non-hydro renewable energy sources, overwhelmingly driven by progress in China, Europe, and North America.

Finally, sector-level analysis shows that, although the expansion of renewable electricity is progressing well, the main bottlenecks to global growth of renewable energy share in TFEC are in the transport and heat end-uses. In 2015, similar to previous years, electricity accounts for only 20% of global TFEC. This illustrates the importance of greater attention by policy makers to the deployment of renewable energy in heat and transport..

BOX 4.1 • IMPROVING RENEWABLE ENERGY DATA CAPACITY

Careful data monitoring is essential for policy makers as a basis for their interventions to address the ways to achieve all the targets of SDG 7. For the renewables target, calculating the share of renewables in total energy consumption requires robust data collection processes across all energy sources to develop a solid national energy balance, which in turn leads to well-measured SDG 7 renewables indicators. In this regard, greater resources to enhance renewable energy data collection capacity, in particular for biomass uses and off-grid applications, which are the most difficult to trace, are highly desirable.

One area where statistical approaches could be enhanced is through greater use of surveys—potentially conducted jointly by statistical offices and energy ministries or governmental agencies with specialized knowledge of renewables and off-grid sector—so as to guarantee proper survey design. Given the significant role of solid biomass in renewables consumption and the expanding role of off-grid renewable solutions, and the relation of both of these to energy access (both in electrification and clean cooking), enhanced data collection methods will be essential to strengthen the accuracy of SDG 7 reporting, and toshape future energy policy.

[3] Emily Greenhalgh, 2016, NOAA, "2015 State of the Climate: Drought", https://www.climate.gov/news-features/featured-images/2015-state-climate-drought

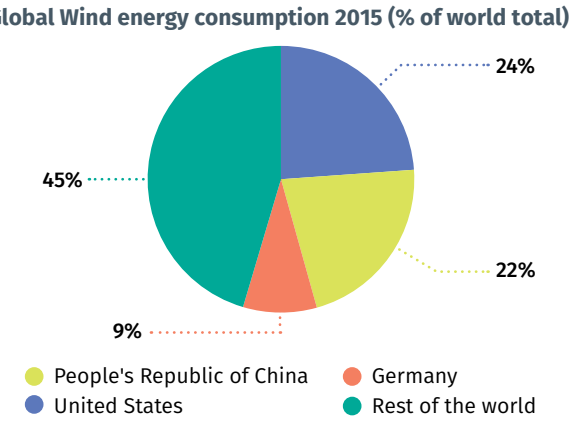
REGIONAL AND INCOME GROUP TRENDS

Improvements in energy efficiency make it easier for renewables to reach a target share of TFEC because greater efficiency lowers the energy demand. Overall, developed economies have a slow average growth of TFEC at 0.7% per annum, and as many as 30 developed economies were consuming less energy in 2015 than in 2010. Under these circumstances, expansion of renewable energy can have a discernible impact on a country's renewable energy share, highlighting the links between SDG targets 7.2 and 7.3. By contrast, developing economies have a much faster growth of TFEC at 3.3% that makes it more difficult to grow their renewable energy share, even where significant efforts are made to promote renewable energy uptake. As of 2015, there were 95 countries experiencing TFEC growth that outpaced their growth in renewable energy. However, China and Brazil had the opposite experience thanks to their significant investments in modern renewable energy, coupled with a simultaneous decrease in fossil fuel consumption.

In structural terms, low-income economies are heavily dependent on traditional uses of biomass for cooking and heating applications. As a result, many countries source as much as 82%[4] of their energy consumption from biomass, of which a significant proportion is neither collected nor consumed in a sustainable manner. As they move into the middle-income bracket, these economies shift toward more modern sources of household energy, often substituting fossil fuels for traditional uses of biomass. This is particularly clear in cooking end uses, where the SDG 7.1.2 indicator emphasizes the importance of clean fuels and technologies for cooking, often achieved by substituting renewable biomass with liquefied petroleum gas (LPG), at the expense of a country's renewable energy share as captured by the SDG 7.2 target.

This also implies that expansion of modern renewable uses in these countries needs to offset reductions in the traditional biomass uses and simultaneously outpace the expansion of TFEC. For example, traditional uses of biomass account for about half of renewable energy consumption in a number of top 20 energy-consuming countries from the developing world, including India, Indonesia, and Nigeria (see Figure 4.17). Moreover, a number of countries experienced a reduction in dependence on traditional uses of biomass between 2014 and 2015. Brazil, China, Indonesia, and Thailand all reduced their consumption of traditional uses of biomass in 2015 compared to their 2014 consumption. Notably, Thailand's reduction in traditional uses of biomass between 2014 and 2015 was greater than its entire consumption of hydroelectric power for 2015.[5].

FIGURE 4.18 • Global wind energy consumption remains concentrated



[4] IEA/UNSD data for Low-Income Group data; see [[AQ: add links here]]. Traditional uses of biomass 2015 data divided by TFEC 2015 data: average for 2015 was 82% from 14 countries.

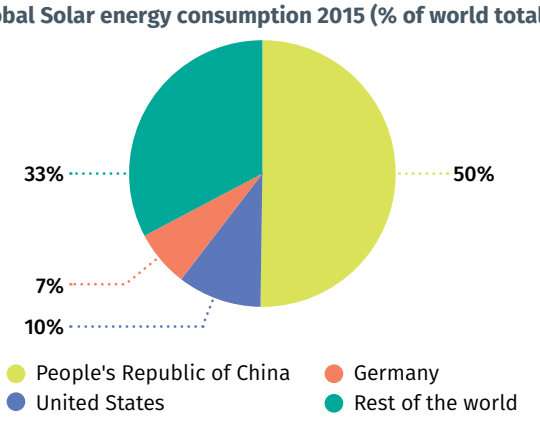
[5] Thailand consumed 600 PJ of biomass in traditional uses in 2015, against 619PJ in 2014. Thailand's total hydro consumption for 2015 was 16.7 PJ.

RENEWABLE ELECTRICITY

The most encouraging area of progress during 2014–15 has been the continued rapid expansion of the renewable energy share in the electricity sector. Although hydropower remained the dominant source of renewable electricity (accounting for 70% of total renewable electricity consumption), the percentage share of renewable energy in TFEC increased from 22.4% to 22.8% over 2014–15, thanks to wind and solar (see figures 5.18 and 5.19). Combined, these two technologies accounted for 70% of the expansion in renewable electricity. However, the growth has not been equally distributed, with the bulk of global wind and solar electricity growth driven by China, Germany, and the United States.

Thanks to technological improvements and falling costs, wind and solar are now becoming cost-comparable with conventional generation sources in an increasing number of markets. According to the International Renewable Energy Agency (IRENA), the levelized cost of energy for solar photovoltaic (PV) fell 69% between 2010 and 2016, with new solar PV now cheaper than nuclear in developed economies (IRENA 2018). This is also the consequence of the increased role of competitively set remuneration mechanisms, such as auctions. According to the World Bank's RISE data, Chile and South Africa held several renewable energy auctions between 2012 and 2014, which cumulatively secured over 3.5 gigawatts (GW) of capacity. This capacity contributed to growth during 2014–15, with wind consumption increasing by 40% in Chile and 160% in South Africa, and solar consumption increasing by 84% in Chile and 50% in South Africa.[6]

FIGURE 4.19 • Global solar energy consumption is driven by China



However, despite the growth of market-driven capacity additions, the bulk of modern renewable electricity growth in 2015 was due to the existence of alternative financial incentives including tax credits and feed-in tariffs. These incentives accounted for over 70% of new capacity installed in 2016, according to the International Energy Agency (IEA) (IEA 2017a, 142).

The immediate future for Renewable electricity is that growth is expected to continue. IEA's Renewables 2017 report forecasts that over 920 GW of renewable energy will be added to global power systems between 2016 and 2022, with wind and solar accounting for over 80% of new additions (IEA 2017a). A number of new geothermal projects being considered globally may materialize in the coming years, alongside major expansions of new hydro projects and bioenergy solutions.

One previous limitation to the deployment of variable generation technologies, such as wind and solar PV, has been integrating the variable output of these technologies into the grid. As IEA noted in its Renewables 2017 report, "Without a simultaneous increase in system flexibility (grid reinforcement and interconnections, storage, demand-side response, and other flexible supply), variable renewables are more exposed to the risk of losing system value at increasing shares of market penetration" (IEA 2017a). However, in some European countries such as Denmark, Germany, Ireland, and the United Kingdom, grid operators have been able to manage the loads across networks (IEA 2017a). Because of its connection with other Nordic countries, Denmark now generates 44% of its electricity from variable renewable sources (IEA 2017a).

[6] Both sets of auction data are drawn from the World Bank RISE website. http://rise.esmap.org/country/south-africa and http://rise.esmap.org/country/chile

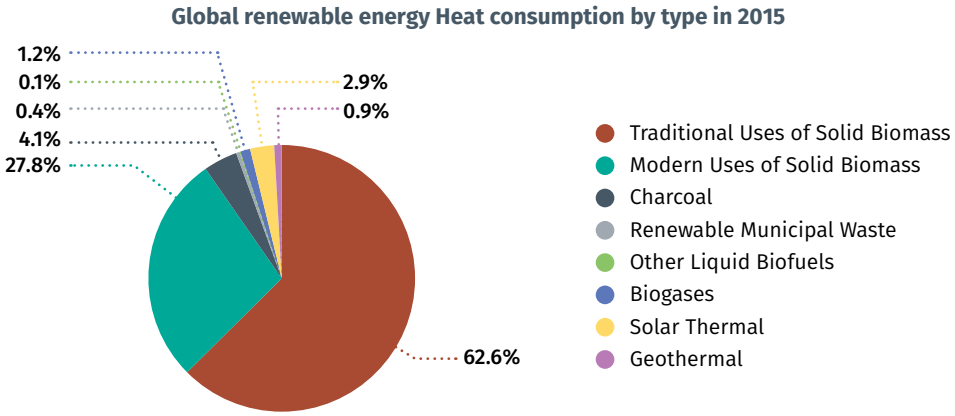
RENEWABLE HEAT

In 2015 heat demand accounted for 48% of global TFEC, and the share of renewable heat reached 25% in 2015, up from 24% in 2014.

Renewable heat[7] can come from either traditional uses of biomass or modern forms of renewable heat, which include modern uses of biomass such as high-efficiency boilers. Within modern renewable heat, renewable energy for heat can be further classified as used for either district heating or direct uses. In 2015, 66.1% of renewable heat came from traditional uses of biomass (Figure 4.20), whereas modern uses represented 1.4% in district heating and 32.5% in direct use.

Traditional uses of biomass accounted for 75% of the absolute increase between 2014 and 2015, and the fastest growth came from modern renewable energy in district heating, which increased by 3.4% over 2014–2015. The renewable energy share also increased because of a small decline in TFEC between 2014 and 2015..

FIGURE 4.20 • Global renewable energy in heat is dominated by traditional uses of biomass.



What constitutes traditional uses of biomass? Traditional uses of biomass include the use of solid biomass for cooking and heating, such as use of wood or animal waste in an open fire, with fuel that is often informally harvested. By contrast, modern renewable heat is produced from bioenergy, solar thermal, or geothermal energy. Most of it is consumed directly in the residential sector or in industry. This can include bioenergy technologies (biomass, biogas), but it may also include other technologies such as solar water heaters and direct use of geothermal heat in industry or district heating. Additionally, a small amount of renewable heat is formally sold as an energy commodity. The most common example is the use of different types of solid biomass for local district heating schemes, notably the use of woodchips or wood pellets.

Because of the significant role of traditional uses of biomass in the heat end uses in developing economies, the world's top 20 countries ranked by total final renewable heat consumption in 2015, were almost exclusively developing economies in Sub-Saharan Africa, with the exceptions of Cambodia, Guatemala, Haiti, and Paraguay.

Since renewable heat comes predominantly from traditional uses of biomass, it is particularly affected by structural trends whereby developing economies are substituting traditional uses of biomass with modern forms

[7] In this report renewable heat refers to the use of biomass, solar thermal, or geothermal energy for heat end uses (space and water heating, cooking, process heat) in the buildings, industry, and agriculture sectors. This can be either through individual applications or in district heating.

of energy, often fossil fuels. In fact, the global growth rate of traditional uses of biomass in the heat end use has fallen from 4% per annum during 1990–2014, to 1% per annum during 2014–15.

BOX 4.2 • IMPROVEMENTS IN CHINA'S BIOMASS STATISTICS

Since 2016, IEA has been working with the Institute of Built Environment of Tsinghua University, Beijing, to improve its understanding and hence data on solid biomass consumption in the residential sector in China. Tsinghua University implemented an initial residential survey in 2006–07, and data were updated thanks to a new survey conducted in 2015.[a]

As a result of these findings and from discussion with staff involved in the surveys, IEA's solid biomass figures for China have therefore been revised in the 2017 edition back to the year 1997 to reflect a decreasing trend in the last decade that was not apparent in previous editions.

The resulting residential consumption of solid biomass is lower than in previous editions for the most recent years. For example, 2014 levels are 56% lower for solid biomass consumption in residential, 26% lower for total energy consumption in residential, and 44% lower for the overall share of renewable energy in total final consumption.

IEA is now working even more closely with its main data provider, the National Bureau of Statistics, and with a wider range of organizations with an aim of improving data for the country. As a result, revisions may occur as the work to improve and understand national energy statistics is further enhanced.

[a] *Short descriptions of the surveys are available at http:*//www.iea.org/eeindicatorsmanual/rsu06.php; http://www.iea.org/eeindicatorsmanual/rsu07.php. More information on the urban survey is available in BERC 2017.

Footnote 1: Short descriptions of the surveys are available at: http://www.iea.org/eeindicatorsmanual/rsu06.php; http://www.iea.org/eeindicatorsmanual/rsu07.php. More information on the urban survey is available in "China Building Energy Use 2017, Building Energy Research Center of Tsinghua University".

Several large developing economies have begun the transition toward modern sources of energy for heat. In 2015, traditional uses of biomass have declined in 33 developing countries compared to their consumption in 2010. Some countries have had significant success in converting their biomass to modern uses[8]: for example, in Brazil, as of 2015, 43% of renewable heat consumption was modern and only 8% based on traditional uses of biomass. Others have taken longer, such as China where 7.8% of renewable heat consumption in 2015 still came from traditional uses and only 3.3% of heat consumption was modern. Importantly though, among the top 20 largest consumers of biomass for traditional uses in 2015, only China, Indonesia and Thailand saw their demand fall between 2014 and 2015.

Although the absolute growth rate of modern renewable energy in heat appears to have slowed during 2014–15, this is largely attributed to the weather (IEA 2017a). The annual average global growth rate of direct renewable energy consumption for heat was 1% during 1990–2014, but this rate fell to 0.96% over 2014–15. A similar pattern is observable for renewable energy in district heating, which grew at an annual average rate of 4.6% per annum from 1990 to the end of 2014, decelerating to 3.4% in 2014–15.

Modern renewable heat lags behind electricity in terms of growth partly because of technological barriers, but the other challenge is securing strong policy support. In developed countries only Finland, Iceland, Latvia, and Sweden had more than 50% renewable energy penetration in total final heat consumption in 2015. This

[8] According to IEA data, from 2010 to 2015, Brazil's traditional biomass consumption fell by about 13%.

was achieved thanks to a combination of strong policy push and significant favorable resource endowments (geothermal in the case of Iceland and biomass in the other countries).

Despite the growth of renewable energy in district heating, that growth remains highly concentrated in a few economies. The world's top 10 largest consumers of renewable energy in district heating are almost all European (8 of 10), and together they consume 77% of total renewable energy in district heating. The single largest consumer is Sweden, which accounts for 18% of global renewable consumption in district heating in TFEC, greater than Austria, Iceland, the Russian Federation, and the United States combined.[9]

The highest percentage levels of direct use of modern renewable heat are concentrated among European economies or emerging countries that have been able to repurpose agricultural by-products by consuming them directly on-site for heat uses—for example, bagasse use in Brazil and several other countries. In emerging countries such as Gabon, biomass can be used for industrial heat purposes: in 2015, 64% of Gabon's heat TFEC came from modern uses of biomass.[10] Other countries have been able to use non-biomass technologies, such as solar water heaters in Greece, diverse solar thermal technologies in China, or geothermal in France and Japan.

RENEWABLE ENERGY FOR TRANSPORT

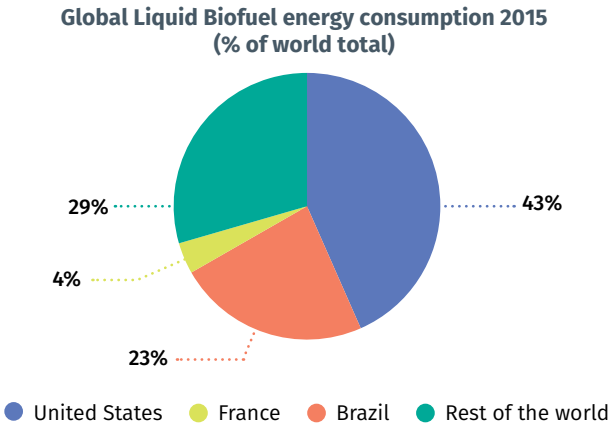
Data from the World Bank's Sustainable Mobility for All report 2017, and from IEA's *World Energy Balances 2017*, shows that transport accounts for about 30% of TFEC on a world average, but it remains the largest sector by final energy consumption for roughly 40 percent of countries worldwide (World Bank 2017; IEA 2017b).

Although the penetration of biofuels in the transport sector is growing, it is starting from a very low base (see Figure 4.12). As a result, the share of renewable energy in TFEC within the transport sector has grown from 2.34% in 2010, to 2.81% in 2015, adding less than 0.1 percentage point to the renewable energy share annually.

The largest factor driving the deployment of biofuels in vehicles has been the use of biofuel blending mandates by policy makers. Accordingly, consumption can fluctuate depending on changes to targets and government provided subsidies.

IEA reported data as of 2015 on biofuels consumption in transport for 59 countries. There were 21 among these that experienced an absolute decline in renewable energy in transport during 2014–15. The top 10 largest consumers, however, added 185 PJ of renewable consumption, which represents 96% of all new globally consumed renewable energy in transport between 2014 and 2015.

FIGURE 4.21 • The United States and Brazil are the major drivers of global renewable energy in transport..



[9] These four countries represent the world's 7th-, 8th-, 9th-, and 10th-largest consumers of renewable energy in district heating (in order: Austria, the United States, Russia, and Iceland).
[10] According to data from the IEA Energy Balances, 73% of solid biomass used for energy in Gabon is consumed by Industry.

Alongside the broad increase in consumption from the world's top 10 largest liquid biofuel consumers, there were significant achievements and setbacks in other nations. Both Iceland and Switzerland grew their share of renewable energy in transport TFEC by over 100% during 2014–15 (306% and 147% respectively),[11] whereas the United Kingdom recorded the largest absolute decline of renewable energy in transport TFEC of any country over the same period, with consumption falling by 9.8 TJ (20%).

Among the world's top 20 energy-consuming countries, consumption of biofuels in India grew by 85% in absolute terms, whereas consumption fell in China by 7% and rose in the United States by 5%, all over the same 2014–15 period.

The success of Brazil, France, Germany, and the United States in increasing their consumption of biofuels in transport has been largely due to the strength of their domestic agriculture and the provision of supportive government policy frameworks (see Figure 4.21). In the United States, the Renewable Fuel Standard set a target of 36 billion gallons of renewable fuel to be blended with transport fuel by 2022.[12] In Brazil, the government has an ethanol-blending mandate of 27%. However, most ethanol consumption is from unblended ethanol because of the country's large flexible fuel vehicle fleet. Brazil also has a 10% biodiesel blending mandate (USDA 2017).

The main sources of renewable energy in transport are bio-gasoline (fuel ethanol) and bio-diesel (biodiesel), which account for 87% of renewable transport TFEC in 2015. These are overwhelmingly consumed by light-duty vehicles in Brazil and the United States.

Although the potential impact of electric vehicles on increasing the share of renewable energy in transport is large, as of 2015 there were fewer than 1 million electric vehicles in the 1.2 billion light-duty vehicle fleet. There are also a number of issues with measuring the contribution of electric vehicles to renewable energy share in transport, which are discussed in annex 4A.

Outside of road transport, the prospect for increasing the global share of renewable energy in transport TFEC remains challenging. As IRENA (2015, 4) noted in its technology brief on shipping, the role of renewable energy will be "limited in the near and medium terms—even under optimistic scenarios." Similarly, the IRENA (2017) technology brief on aviation noted that no alternative propulsion system, other than "biojet" fuels will be able to play a meaningful role in increasing the share of renewable energy in aviation before 2050. Even here, IRENA estimates that the total operational capacity of the world's current HEFA diesel facilities would amount to less than 1.5% of the world's jet fuel requirements. In IEA's (2017c) bioenergy roadmap, biofuels start to notably penetrate the aviation sector by 2025, providing a quarter of demand in 2040, and provide over 40% of energy demand by 2050.

Thus, the current assumptions for global renewable energy in transport by 2030 are that 4.5% of renewable energy in TFEC will come from liquid biofuels and 0.6% from renewable electricity (IRENA 2016).

[11] Iceland consumed 480 TJ of additional biofuels in 2015 vs. 2014, whereas Switzerland consumed 1,124 TJ of additional biofuels over the same period.

[12] For more information on the U.S. Department of Energy's Renewable Fuel Standard program, visit https://www.epa.gov/renewable-fuel-standard-program/overview-renewable-fuel-standard

BOX 4.3 • ARE ELECTRIC VEHICLES A SILVER BULLET FOR TRANSPORTATION?

Renewables' penetration into the transport sector has been slow to date, reaching just 3% in 2015, the lowest among all sectors. Most of the renewable consumption is concentrated in road transport and is almost exclusively from biofuels. However, the rapid rise of electric vehicles (EVs), a segment of vehicles comprising electric two- and three wheelers, cars, and buses, is providing a way for renewable electricity to contribute to road transport as well.

In 2016, EVs accounted for an estimated 4% of renewable energy consumption on roads 2016[2] (IEA 2017a, figure 5.3.1). Most of this consumption was in China thanks to the substantial size of its fleet of electric two- and three wheelers coupled with the increasing share of renewables in its power mix (26% in 2016) (figure 5.3.2).

The remaining global consumption of RE electricity in transport was much smaller in comparison and occurred mostly in Europe, Japan, and the United States. Europe had the highest share of renewable EV consumption. This is due to vehicle deployment in markets with high shares of renewable generation such as Norway, Europe's largest electric car market where hydropower accounts for over 90% of total generation. Renewable electricity consumption in transport in Japan and the United States was mostly from electric cars. However, because renewables play a less prominent role in the electricity supply of both Japan and the United States (10% and 15% respectively in 2016), their contribution to the cars' total electricity demand was relatively smaller than in China or Europe.

FIGURE 4.3.1 • Renewable energy in road transport

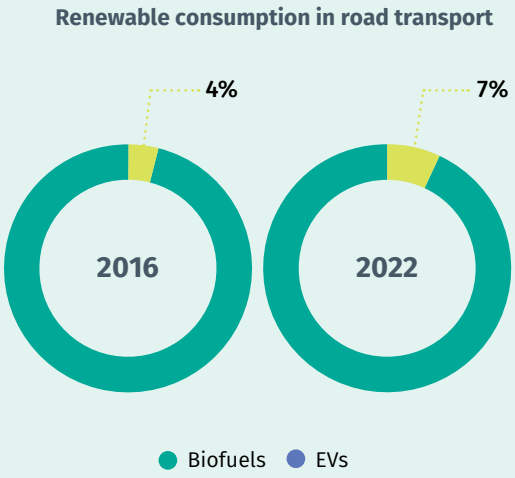
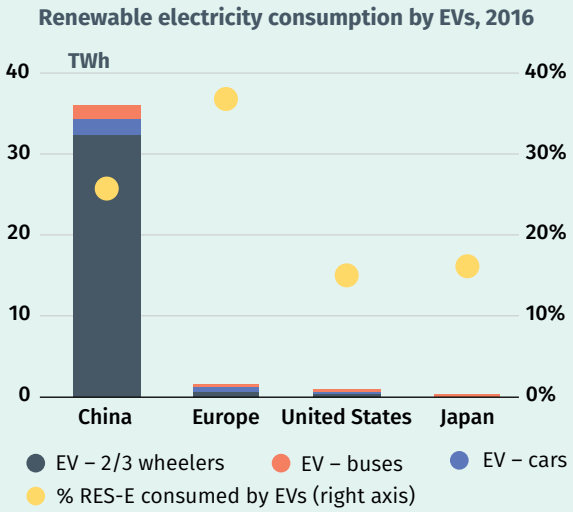


FIGURE 4.3.2 • Renewable energy consumption by EVs, 2016



Source: International Energy Agency, 2017a.

Going forward, the continuing expansion of EVs in markets with rising shares of renewable generation is expected to help renewable electricity increase its contribution to road transport. By 2022, renewable electricity could account for 7% of the renewable road consumption, compared to just 4% today (see above). System integration policies will be key to maximize renewables' contribution to fuel EVs as well as vice versa: to ensure that EVs contribute to the integration of renewables in a system friendly way.

1.This data is an estimation because real-world observed data regarding the primary energy source of electricity consumed at the point of final end user does not exist. The assumption used to account for this is based on the principle of allocating the final energy consumption of a secondary energy source (electricity) to it primary source (renewables) based on the shares in gross production. This convention is in line with the renewable energy statistical accounting frameworks established by the Sustainable Energy For All Global Tracking Framework (SE4ALL, 2013; SE4ALL, 2015) and the European Commission Renewable Energy Directive 2009/28/ED (European Commission 2009).

2.The shares of biofuels and renewable electricity are based at the end-user consumption level and do not account for the efficiencies of each motor. EVs have two to three times higher fuel economy than internal combustion engines.

CONCLUSIONS

In recent years, the world has made encouraging progress in deploying renewable energy, particularly renewable electricity, which has accounted for well over 50% of net global power capacity additions over the past five years. Yet more needs to do be done. Biomass for power, hydropower, geothermal, solar PV, and onshore wind technologies now can in many circumstances provide electricity that is competitively priced compared to fossil-based electricity generation. This development should help convince investors and utilities to expand their deployment of renewable energy generation.

Still, analysis presented in this report suggests that, without significant additional effort, the world is unlikely to achieve the goal of substantially increasing the share of renewable energy in global TFEC by 2030 as foreseen under the UN SDG 7 commitment. The needed acceleration is technically and economically feasible but requires strong and concerted policy action.

Institutional, financial, and policy measures for a sustainable energy transition need to be tailored to the different regional, national, and local contexts, so they can support socioeconomic objectives such as employment, welfare, social equity, and community cohesion. The Policy Brief #3, part of Policy Briefs in support of the first SDG7 Review at the UN High-Level Political Forum 2018, addresses priority actions that could help to achieve a substantial increase of the share of renewable energy in the global energy mix.

Although the transformation of the electricity sector is already under way, the bulk of deployment is still concentrated in a relatively small number of countries. The potential is great elsewhere but more progress is needed, particularly in many developing countries, where perceived investment risks are a barrier. Public finance can catalyze private investments, but its role extends to such important tasks as direct financing, especially in the context of expanding access to modern energy services (SDG 7.1 target) in poor rural communities, as well as providing alternative sources of funding, such as social financing.

It is important to highlight that investments are needed in both on-grid and off-grid solutions. Furthermore, national, regional, and global action plans need to strive toward more equitable access to energy and greater convergence of energy use between the rich and the poor. An emphasis on energy services for productive end uses helps achieve the transformative impacts of modern energy access on poverty alleviation and other SDGs.

Efforts of a much greater magnitude are also required in end uses such as heating/cooling and transport. With proper policy support and guidance, the use of renewable energy technologies for these purposes can indeed be stepped up significantly. An emphasis on energy services for productive end uses helps achieve the transformative impacts of modern energy access on poverty alleviation and other SDGs (IRENA 2017b).

In heating, district energy systems using biomass, geothermal, or solar thermal (often in combination with storage and excess heat use) are an option in many cities and can be pursued through public investment, changes in fiscal and financial policies (including carbon taxes, grants, and incentives), and policies such as heat zoning (IRENA 2017b). Grants and subsidies can also support the greater deployment of renewables for industrial heat applications. The deployment of solar thermal technologies and other renewable heat options for households can be facilitated though rebate programs with free or low-cost installations for low-income households, mandates and building codes, and financial incentives.

In the transport sector, phasing out fossil fuel subsidies is essential to incentivize greater use of biofuels and electric vehicles. The production, distribution, and use of biofuels can be encouraged through obligations/mandates, tax incentives, and research and development and demonstration programs. Tax incentives and purchase subsidies can support the adoption of electric vehicles, especially if paired with investments to create a dense network of charging stations and parallel investments into the rapid increase in renewable energy penetration in the electricity sector. The energy transition also depends on a rebalancing of transportation modes, including a major expansion of urban public transit systems running on renewable energy. Such choices can be reinforced by land-use policies that favor dense, mixed-use development.

Although advances in the power sector have been strong, progress has been uneven and further growth will require tailored efforts to address deployment barriers across different country contexts. In emerging renewable energy markets, access to affordable finance and predictable policy frameworks will play an important role in supporting the development of the sector. In this context, innovative public financing instruments and de-risking tools have a crucial role to play in catalyzing investments in technology innovation and deployment. In mature markets, where the share of variable renewables has reached significant levels, a focus on system integration and adaptation of market design and regulations becomes central for continuing growth of the sector and its transformation. Indeed, renewables also play a key role in expanding access to electricity in unconnected areas (linked to the SDG 7.1 target), requiring targeted efforts to support deployment.

Renewable energy and energy efficiency need to be promoted and accelerated in tandem to ensure that the transition to sustainable energy is not undermined by uncontrolled growth in TFEC. Together, renewables and efficiency will need to account for the vast majority of the decarbonization required to stay within the Paris Agreement boundaries. Tapping into synergies between them, together with the increased electrification of end-use sectors, will also permit greater overall energy system flexibility.

A final policy area concerns the socioeconomic dimension—the energy transition discourse has thus far been largely technology-oriented and disconnected from the socioeconomic aspects upon which it is built and upon which its long-term sustainability depends. To ensure that the energy transition accelerates in a just, timely, and equitable way, greater attention is needed to the transformative impacts on society, institutions, financing, ownership structures, and the wider economy. This requires not only aligning private and public-sector policies but also supporting effective participation by all stakeholders. The transformation must be aimed at enabling active social involvement in energy system planning and operation, creating new businesses and jobs, pursuing a just transition, and helping citizens and industries to flourish while respecting climate and sustainability constraints.

METHODOLOGY

Renewable Energy for Transport

Recently policy makers have asked what impact electric vehicles (EVs) may have on the transportation sector and whether EVs could significantly improve the share of renewable energy in global transport. However, the answer is complex and a significant reason for this complexity is due to energy accounting practices.

From an energy accounting perspective, EVs are treated similarly to any other electric appliance because they do not produce energy themselves, rather they consume and store energy provided from another electric source. As a result, the main effect of substituting internal combustion engine light duty vehicles for EVs would be a decline in TFEC in Transport and an increase in TFEC in electricity, though due to higher electric motor efficiencies, this will not be a "one for one" increase.

In theory it is possible to allocate electricity to transport in statistics. However, country data must be reported accurately and as of today there is also no universally agreed methodology in energy statistics to compute the percentage of renewables in sectors.

REFERENCES

BERC (Building Energy Research Center of Tsinghua University). 2017. *China Building Energy Use 2017*. Beijing: China Architecture and Building Press.

IEA (International Energy Agency). 2017a. *Renewables 2017: Analysis and Forecasts to 2022*. Market Report Series. Paris: IEA.

———. 2017b. *World Energy Balances 2017*. Paris: IEA.

———. 2017c. *Technology Roadmap: Delivering Sustainable Bioenergy*. Paris: IEA.

IRENA (International Renewable Energy Agency). 2015. *Technology Brief: Renewable Energy Options for Shipping*. Bonn: IRENA.

———. 2016. *REmap: Roadmap for a Renewable Energy Future, 2016 Edition*. Bonn: IRENA.

———. 2017a. *Technology Brief: Biofuels for Aviation*. Bonn: IRENA.

———. 2017b. *REthinking Energy: Accelerating the Global Energy Transformation*. Bonn: IRENA.

———. 2018a. *Renewable Power Generation Costs in 2017*. Bonn: IRENA.

———. 2018b. *The Energy Transition: View to 2050*. Bonn: IRENA.

USDA (U.S. Department of Agriculture). 2017. "Brazil Biofuels Annual 2017." Global Agricultural Information Network Report BR17006, USDA, Washington, DC.

Sustainable Mobility for All. *Global mobility for all 2017*, Washington, DC.