TRACKING SDG7

THE ENERGY PROGRESS REPORT 2021

A joint report of the custodian agencies

iea International Energy Agency

IRENA International Renewable Energy Agency

United Nations Statistics Division

THE WORLD BANK IBRD • IDA | WORLD BANK GROUP

World Health Organization

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CHAPTER 4

ENERGY EFFICIENCY

MAIN MESSAGES

- **Global trend:** The rate of global primary energy intensity improvement—defined as the percentage decrease in the ratio of global total energy supply per unit of gross domestic product—has slowed in recent years. Global primary energy intensity was 4.75 megajoules (MJ) per U.S. dollar[42] in 2018, a 1.1 percent improvement from 2017. This was the lowest annual rate of improvement[43] since 2010.
- **2030 target:** Energy intensity improvements are moving further away from the target set under the United Nations' Sustainable Development Goals (SDGs) for 2030. Between 2010 and 2018 the average annual rate of improvement in global primary energy intensity was 2 percent. Although better than the rate of 1.2 percent between 1990 and 2010, this is well below the 2.6 percent set in SDG target 7.3.[44] Annual improvement until 2030 will now need to average 3 percent to meet the SDG target. While 2019 saw a slight rebound, with an estimated improvement rate of 2 percent, early estimates for 2020 suggested even less progress than in 2018, at only 0.8 percent, as a result of the COVID-19 crisis.
- **Regional highlights:** More robust, continuous improvements in energy intensity are seen in Asia than in any other world region. Between 2010 and 2018, primary energy intensity in Eastern Asia and South-eastern Asia improved by an annual average rate of 3.1 percent, driven by strong economic growth. Similarly, in Central Asia and Southern Asia and Oceania, the average annual improvement rate of 2.6 percent between 2010 and 2018 was above the global average (2.0 percent) and an improvement on historic trends. Rates of improvement were just below the global average in Northern America and Europe (1.9 percent), with the lowest rates of improvement in Western Asia, Northern Africa, Latin America and the Caribbean (0.8 percent), and Sub-Saharan Africa (1.4 percent). Data on absolute energy intensity reveal wide regional differences: energy intensity in Sub-Saharan Africa is almost double the level in Latin America and the Caribbean. These variations rather mirror differences in economic structure, energy supply, and access than in energy efficiency.
- **Top 20 countries in energy intensity:** Comparing the periods 2000–10 and 2010–18, the average annual rate of improvement in primary energy intensity increased in 14 of the 20 countries with the largest total energy supply in the world. However, only half of the top energy-consuming countries performed better than the global average. China continued to improve primary energy intensity at the fastest rate, at an annual average of 4.3 percent between 2010 and 2018. Other emerging economies with average energy intensity rates that are at or above that set by SDG target 7.3 include India and Indonesia. The United Kingdom, Japan, and Germany continue to improve their energy intensity at rates beyond SDG target 7.3, thanks to decades of concerted effort toward energy efficiency and a shift in their economies toward producing high-value, low-energy goods and services.
- **End-use trends:** Although global primary energy intensity improved across all sectors during the period 2010–18, the rate differed by sector. Using different intensity metrics, the rate of improvement slowed compared with the period 1990–2010 in all sectors except for transport, where fuel efficiency standards drove energy intensity improvements. The decline in the rate of improvement from one period to the other is most noticeable in services, where energy intensity has worsened since 2010, but also in agriculture and, to a lesser extent, industry. All three of these sectors were significantly influenced by emerging economies, which experienced rapid improvements in energy intensity during the period 1990–2010 as they mechanized production and shifted to higher-value goods and services.
- **Electricity supply trends:** The mounting share of renewables in electricity supply also improves the efficiency of supply by eliminating the losses that are accounted for in the conversion of primary (nonrenewable) fuels into electricity. This relationship between efficient primary renewable electricity[45] and a decrease in primary energy intensity highlights the synergies between SDG target 7.2 and SDG target 7.3. In addition, the average efficiency of fossil fuel electricity generation increased from 36 percent in 2000 to 40 percent in 2018 due to relatively more efficient gas-fired generation and the construction of more efficient coal-fired generation in China and India. Major producing countries are seeing declines in electricity transmission and distribution losses, which indicates higher rates of electrification and a modernized supply infrastructure.

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42 Based on 2017 purchasing power parity.

43 Calculated as a compound average annual growth rate.

44 Revisions of underlying statistical data and methodological improvements explain the slight changes in historical growth rates from previous editions. Yet the target of improving energy intensity by 2.6 percent per year across the period 2010–30 remains the same.

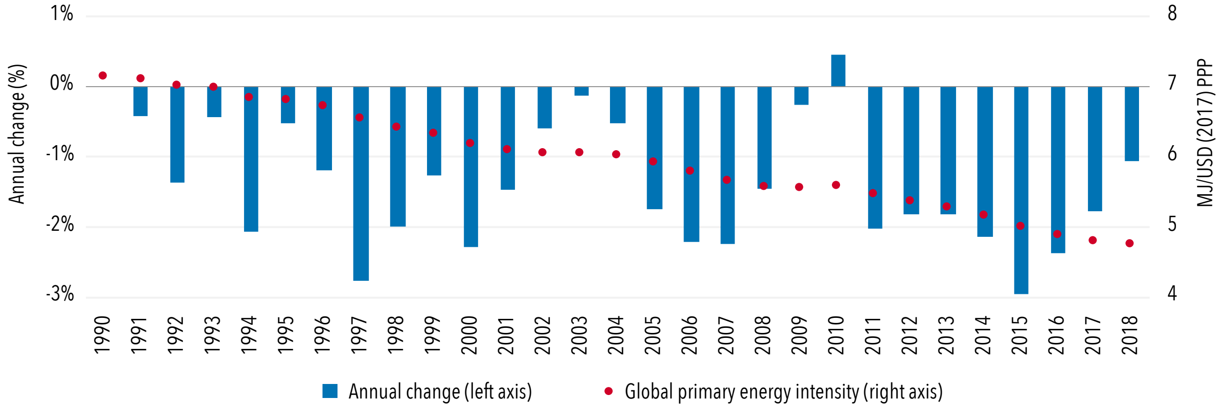
45 Primary renewable electricity such as hydropower, solar PV, wind, and ocean energy is captured directly from natural resources. Electricity from geothermal, solar thermal, and biomass sources is renewable but it is not treated as 100 percent efficient in energy statistics due to conversion losses.

ARE WE ON TRACK?

Sustainable Development Goal (SDG) 7 commits the world to ensure universal access to affordable, reliable, sustainable, and modern energy. Achieving SDG target 7.3—doubling the global rate of energy intensity improvement by 2030—is key as it also supports the other targets under SDG 7. Energy intensity is the ratio of total energy supply to the annual gross domestic product (GDP) created—in essence, the amount of energy used per unit of wealth created. By using this measure of energy intensity to understand efficiency, we can observe how energy use rises or falls while also looking for the development factors (social and economic) that may affect those rates. Energy intensity declines as energy efficiency improves.

Progress toward SDG target 7.3 is measured by tracking the year-on-year percentage change in energy intensity. Initially, an annual improvement rate of 2.6 percent per year was recommended by the United Nations to achieve the target, but since global progress has been slower than necessary in recent years, the annual average improvement rate now required to achieve SDG target 7.3 by 2030 is 3 percent (figure 4.2). Nevertheless, global primary energy intensity has shown gradual improvement since 1990[46] (figure 4.1). Recent numbers show that global primary energy intensity improved by 1.1 percent in 2018 to 4.75 MJ/U.S. dollar (2017 purchasing power parity [PPP]) (figure 4.2). This is the lowest rate of improvement since 2010, though the trend has been slowing since 2015.

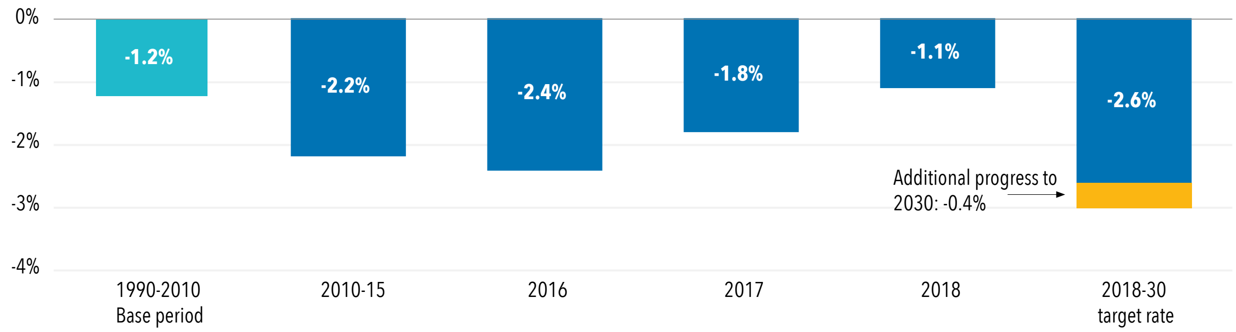
FIGURE 4.1 • Global primary energy intensity and its annual change, 1990–2018



Sources: IEA, UN, and World Bank (see footnote 46).

MJ = megajoule; PPP = purchasing power parity.

FIGURE 4.2 • Growth rate of primary energy intensity, by period and target rate, 2018–30



Source: IEA, UN, and World Bank (see footnote 46).

46 Most of the energy data in this chapter come from a joint data set built by the International Energy Agency (https://www.iea.org/data-and-statistics/) and the United Nations Statistics Division (https://unstats.un.org/unsd/energystats/). GDP data are sourced from the World Bank's World Development Indicators database (http://datatopics.worldbank.org/world-development-indicators/).

LOOKING BEYOND THE MAIN INDICATORS

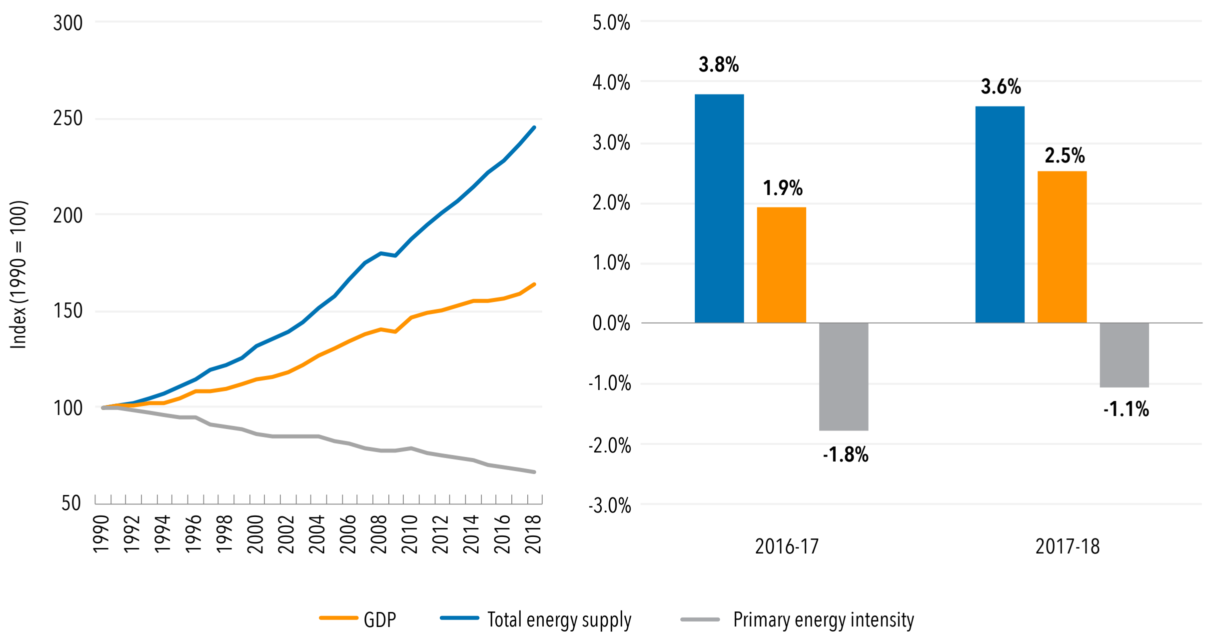
COMPONENT TRENDS

The impact of improvements in primary energy intensity (the global proxy for improvements in energy efficiency) is revealed by trends in its underlying components (figure 4.3, left). Between 1990 and 2018, global GDP increased by a factor of 2.5 while global total energy supply[47] grew by less than 65 percent. Growth in energy supply picked up in 2017, and continued to increase in 2018, growing 2.5 percent.

The difference in growth rates for global GDP and total energy supply is reflected by consistent improvements in global primary energy intensity, which fell by a third between 1990 and 2018, signaling trends in the decoupling of energy use and economic growth. In the period 2010–18, global primary energy intensity fell by nearly 15 percent, one and a half times more than the percentage fall observed between 2000 and 2010.

While GDP growth slowed slightly between 2016 and 2018, the growth rate for energy supply increased, resulting in a further slowdown in the improvement rate for energy intensity—from 1.8 percent in 2017 to 1.1 percent in 2018 (figure 4.3, right).

FIGURE 4.3 • Trends in underlying components of global primary energy intensity, 1990–2018 (left); and growth rates of GDP, total energy supply, and primary energy intensity, 2016–18 (right)



Sources: IEA, UN, and World Bank (see footnote 46).

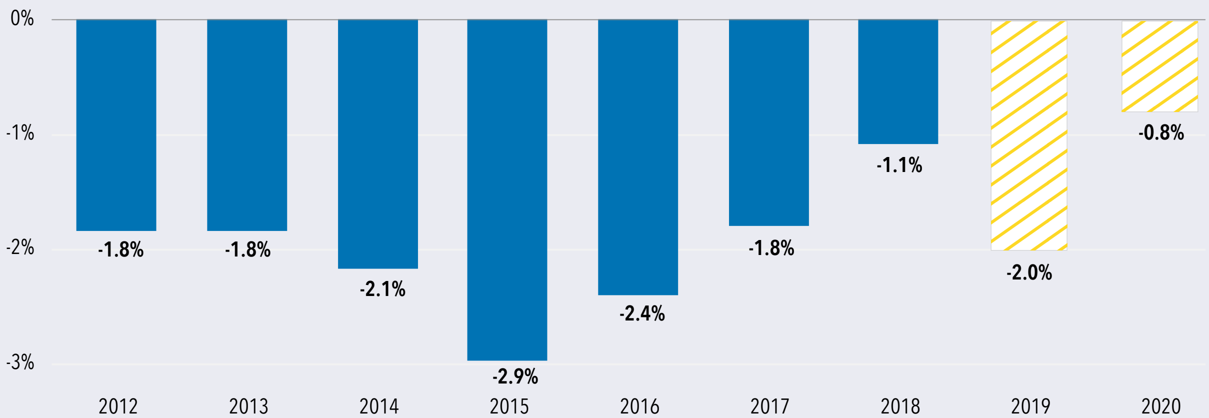
GDP = gross domestic product.

47 “Total primary energy supply” has been renamed “Total energy supply” in accordance with the International Recommendations for Energy Statistics (UN 2018).

BOX 4.1 • COVID-19 AND ENERGY EFFICIENCY

The COVID-19 crisis has had a major impact on energy intensity. Lockdowns and travel restrictions cut global economic activity dramatically, leading to an expected 4.6 percent fall in global gross domestic product and a 5.3 percent fall in global total energy supply in 2020. Consequently, primary energy intensity improved by only 0.8 percent, the lowest rate since just after the last global economic crisis in 2010 (figure B4.1.1).

FIGURE B4.1.1 • Growth rate of global primary energy intensity, 2012–20



Source: IEA 2020a.

While primary energy intensity represents a number of factors—including the effects of changes in the composition of economic activity during the COVID-19 crisis—it also includes the impact of technical energy efficiency improvements, which is likely to be weaker, due to the economic uncertainty created by the pandemic.

In the immediate term, some energy efficiency improvements are expected to have continued thanks to investments already in the pipeline. There is also evidence from some countries that lockdowns provided businesses and households with opportunities to improve the energy efficiency of commercial and residential buildings. In some cases, however, job uncertainty and lower incomes associated with extended lockdown measures have led to lower adoption of energy efficient appliances. Government support programs that subsidized household energy bills may have insulated consumers from absorbing energy costs that otherwise would have served as incentive for purchasing more energy efficient appliances. An overall decrease in travel has also had mixed outcomes for the share of energy efficient modes in transport activity. For example, the share of active modes such as walking and biking has increased, while public transport use has decreased. Efficient electric vehicles sales appear to have remained healthy, spurred partly by government support programs (IEA 2020a).

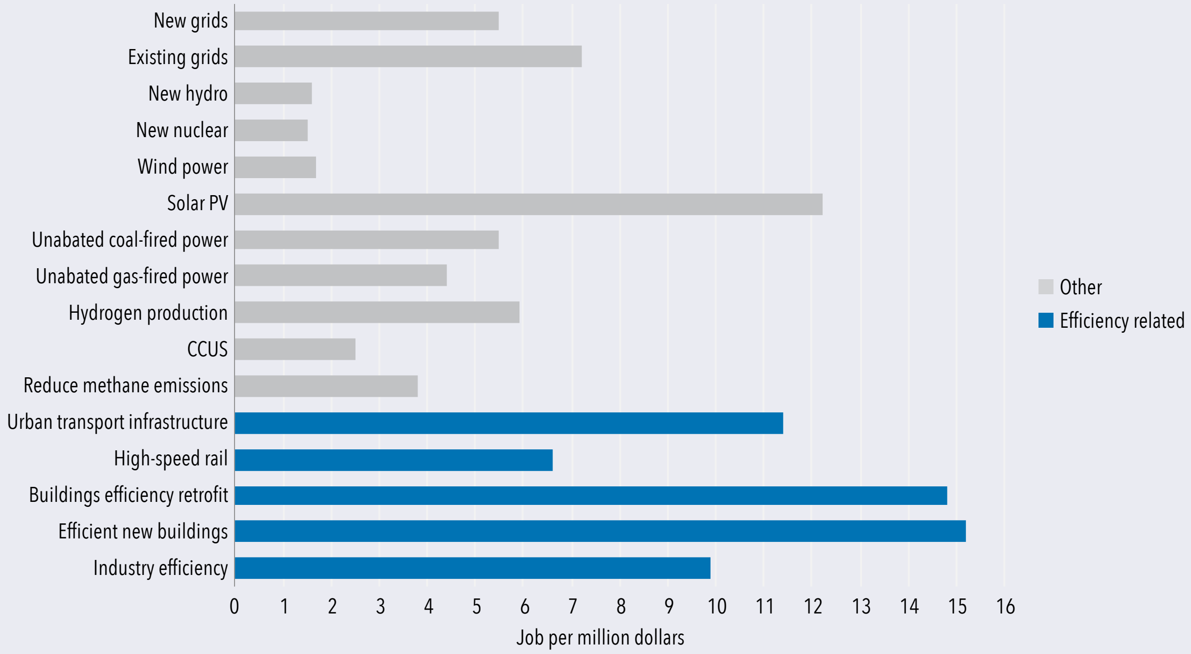
Particularly in industry, investments in new energy efficient technologies and practices are likely to have weakened, as economic uncertainty led businesses to reprioritize their investments. Overall, however, the International Energy Agency estimates energy efficiency investments remained relatively stable in 2020.

There is some evidence to suggest that following an economic crisis, a larger share of energy inefficient investments tends to flow to low-income countries, especially those dependent on foreign direct investment (Mimouni and Temimi 2018). As these countries start attracting investment to support jobs after the crisis, ideally this would not come at the expense of locking in energy-inefficient capital stock, which could ultimately cost more and lock in lower productivity in the medium to long term.

While medium- and high-income economies will have more resources available to stimulate economic growth following the crisis, they also face the challenge of ensuring stimulus investments to create jobs also support energy-efficient, rather than inefficient, technologies and practices. Therefore, strong policies for energy efficiency should be a shared goal of governments throughout the world.

Thankfully, as energy efficiency delivers a range of benefits, and supports the achievement of several SDGs beyond SDG 7 (from decent work and economic growth to sustainable cities and communities), it is an obvious choice of government support. The high labor intensity of energy efficiency makes it a particularly attractive investment during a recession. For example, International Energy Agency analysis has found that a million dollars spent on building energy efficiency can deliver around 15 jobs, one the highest factors in the energy sector (figure B4.1.2). In its post-COVID-19 recovery agenda, the International Renewable Energy Agency estimates that employment in energy efficiency would expand from just under 10 million jobs in 2017 to 29 million in 2030 (IRENA, 2020).

FIGURE B4.1.2 • Construction and manufacturing jobs created per USD 1 million of capital investment in the International Energy Agency's Sustainable Recovery Plan



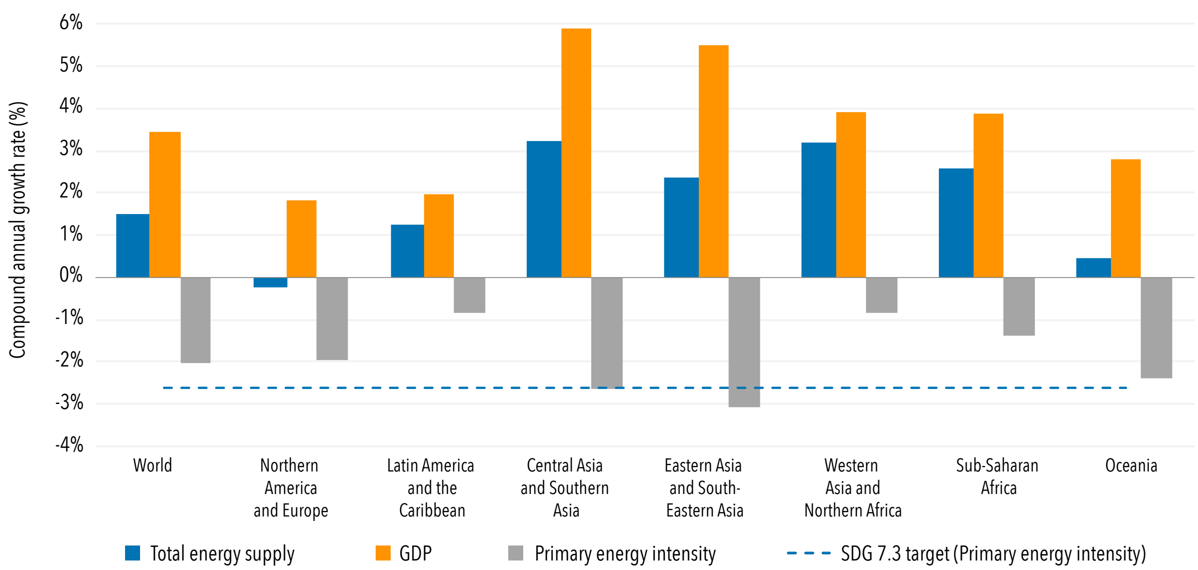
Note: Further information available from IEA (2020f); CCUS = carbon capture and storage.

REGIONAL TRENDS

Overall, since 2010, primary energy intensity has improved across the world, but significant differences in trends are observed across regions (figure 4.4). Emerging economies in Central, Southern, Eastern, and South-eastern Asia have seen a rapid increase in economic activity; however, the rise in total energy supply associated with such growth has been mitigated in part by significant improvements in energy efficiency, which have put downward pressure on the global average. Over the same period, mature economies in Northern America and Europe experienced a slight decrease in their total energy consumption, which reflects slower economic growth and a decoupling of the economy from energy usage. This last accomplishment was made possible by a continued shift toward less energy-intensive industrial activities (such as services) and improved energy efficiency one observes when mature policies are in place, particularly in buildings (Northern America) and industry (Europe). In these economies, energy intensity improved at a rate slightly below global trends, leading to an absolute level of energy intensity slightly below the global average (figure 4.5). Similar trends and absolute levels of energy intensity have been observed for Oceania, where total energy supply increased modestly, while GDP grew faster than in Northern America and Europe.

Western Asia and Northern Africa, Latin America and the Caribbean, and Sub-Saharan Africa recorded the smallest average gains in energy intensity improvement over the period 2010–18 (less than 1.4 percent per year). However, trends differed across these regions. In Latin America and the Caribbean, both growth in total energy supply and GDP were among the lowest worldwide, but it is also the least energy intensive region in the world, at 3.3 MJ/U.S. dollar (2017 PPP) (figure 4.5). In Western Asia, Northern Africa, and Sub-Saharan Africa, both growth in total energy supply and GDP were among the highest worldwide. In absolute terms, economic output in Sub-Saharan Africa is highly energy intensive, at nearly 6.5 MJ/U.S. dollar (2017 PPP), reflecting the low value of economic output and the widespread use of inefficient solid biomass for cooking in this region, compared to 4.3 MJ/U.S. dollar (2017 PPP) in Northern Africa and Western Asia (figure 4.5).

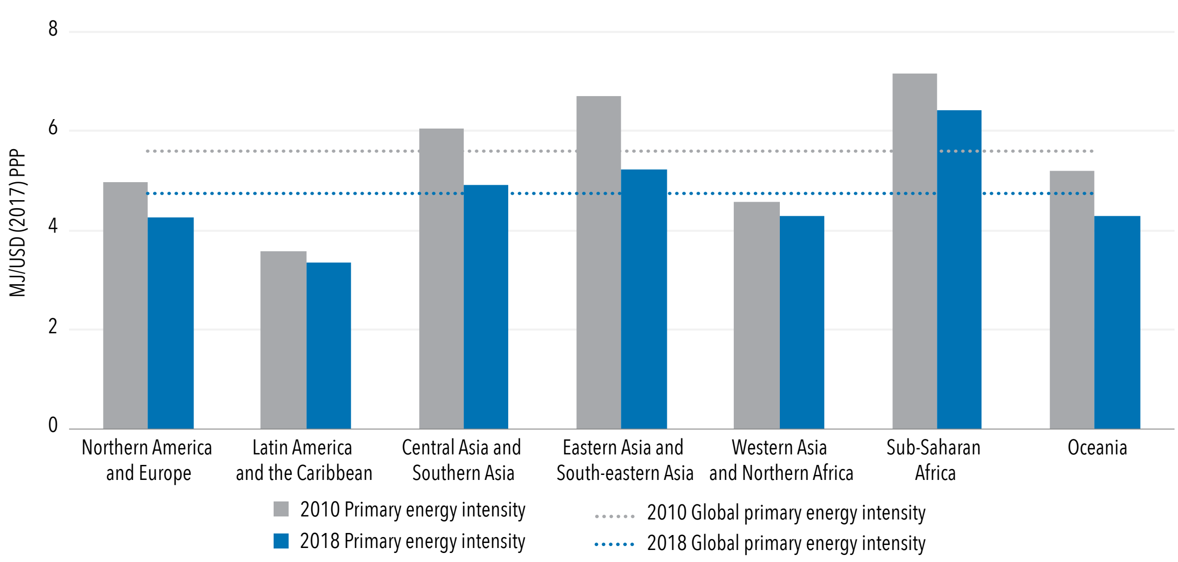
FIGURE 4.4 • Growth rate of total energy supply, GDP and primary energy intensity at a regional level, 2010–18



Sources: IEA, UN, and World Bank (see footnote 46).

GDP = gross domes6tic product.

FIGURE 4.5 • Primary energy intensity at a regional level, 2010 and 2018



Sources: IEA, UN, and World Bank (see footnote 46).

MJ = megajoule; PPP = purchasing power parity.

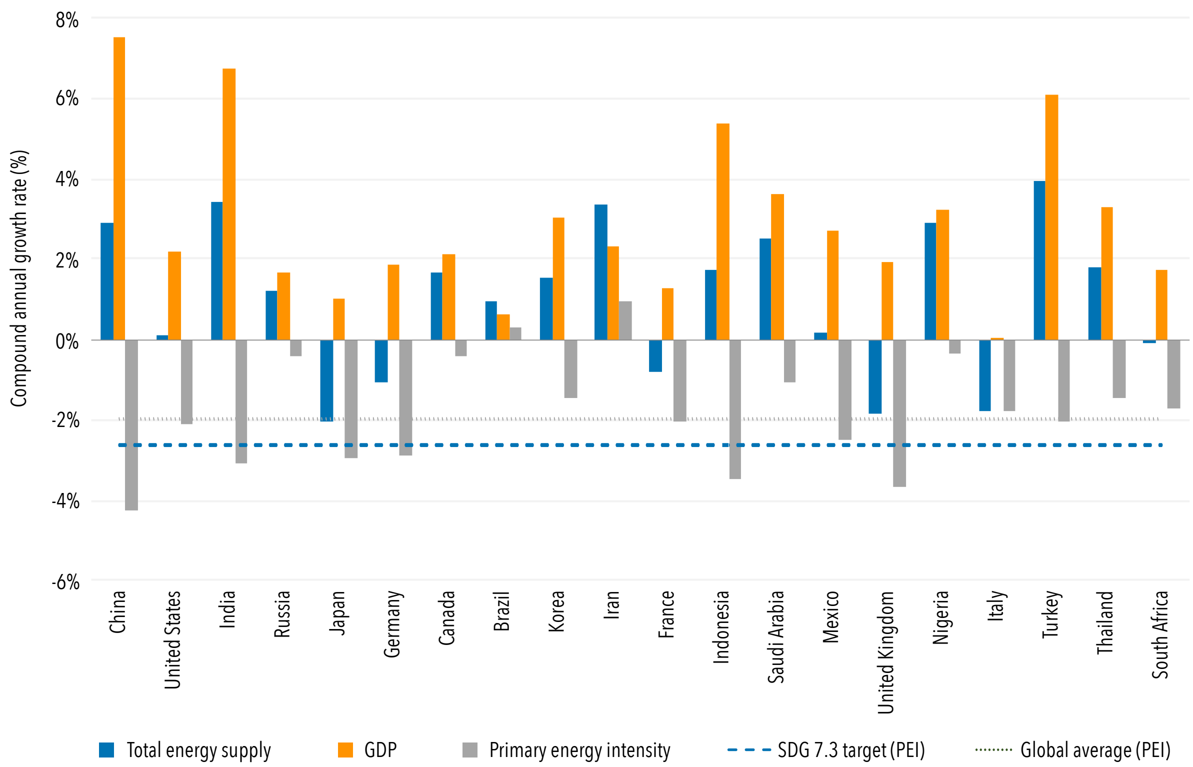
MAJOR COUNTRY TRENDS

Rates of improvement for primary energy intensity in the 20 countries with the largest total energy supply would be central to realizing SDG target 7.3, as they account for around three-quarters of global GDP and energy consumption. Over the period 2010 to 2018, 14 of these countries increased their rate of improvement, but only half of the top energy-consuming countries performed better than the global average, with six (China, United Kingdom, Indonesia, India, Japan, and Germany) exceeding the level required by SDG target 7.3 (figure 4.6).

Of these six countries, three—China, Indonesia, and India—are major emerging economies. These countries have seen rapid structural changes in their economies, changes that have moved them toward higher-value activities that create more GDP for every unit of energy consumed. In these countries—particularly China and India—concerted efforts to introduce energy efficiency policies over the period have quickened the pace of energy intensity improvements, beyond the pace set by structural economic changes alone.

The economies in the United Kingdom, Japan, Germany, and France have expanded as their energy use declined. In Italy, primary energy intensity improved as total energy supply dropped while GDP remained constant. These trends suggest that economic growth is being decoupled from energy use, as economic activity has largely shifted to high-value, service-related activities that are less energy intensive. In addition, the economies in these countries all have strong, decades-long records of policy action on energy efficiency.

FIGURE 4.6 • Growth rate of total energy supply, GDP, and intensity in the 20 countries with the largest total energy supply, 2010–18

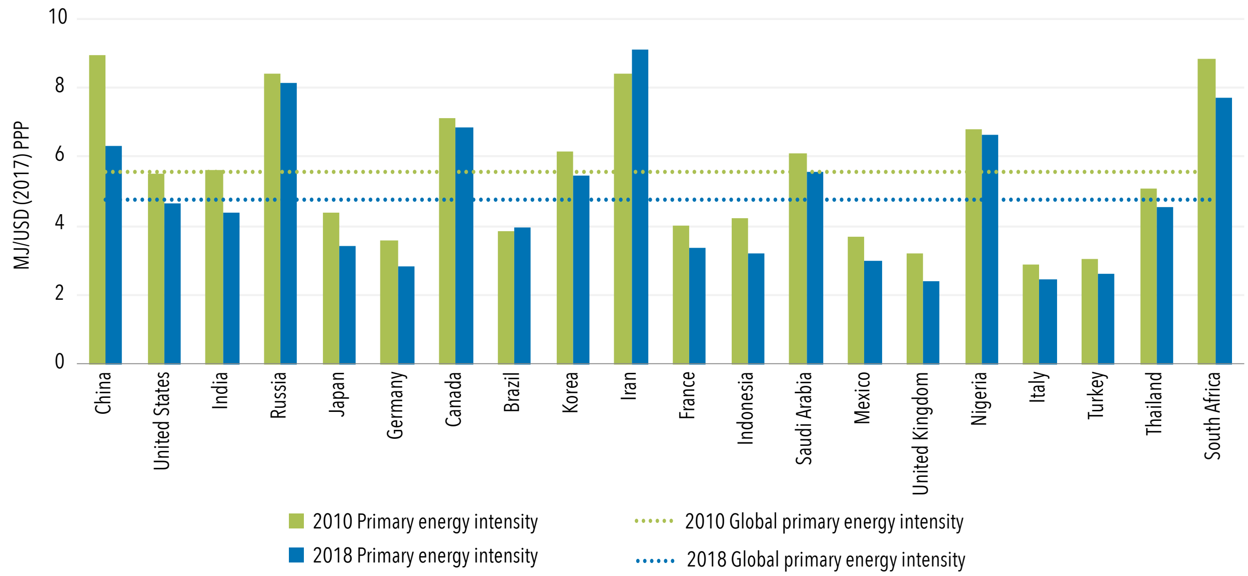


Sources: IEA, UN, and World Bank (see footnote 46).

Note: Countries along x-axis ordered by total energy supply.

GDP = gross domestic product; SDG = Sustainable Development Goal.

FIGURE 4.7 • Primary energy intensity in the 20 countries with the largest total energy supply, 2010 and 2018



Sources: IEA, UN, and World Bank (see footnote 46).

Note: Countries along x-axis ordered by total energy supply.

MJ = megajoule; PPP = purchasing power parity.

In absolute terms, the energy intensity of 8 of the top 20 energy-consuming countries remain above the global average, a minor improvement from 9 in 2010 (figure 4.7). Iran, Russia, and South Africa are the countries with the highest energy intensities and maintained levels of energy intensity exceeding global averages in 2010 and 2018. Since 2010, however, average global primary energy intensity fell by nearly USD 1/MJ (2017 PPP).

Certain countries have made progress by moving further below global average energy intensity, including India, Indonesia, Japan, the United States, and the United Kingdom. Others—such as China and South Africa—despite remaining more energy intensive than the global average, are improving and shifting toward the global average. Countries where progress has been slowest include those where energy-intensive fossil fuel extraction represents a major segment of economic activity—namely, Iran, Brazil, Nigeria, Canada, and Russia.

BOX 4.2 • DIGITALIZATION KEY TO ACCELERATING ENERGY EFFICIENCY ACROSS SECTORS AND SYSTEMS

Digitalization is transforming the energy sector, and, if harnessed, will accelerate progress toward the achievement of Sustainable Development Goal target 7.3. With the proliferation of digital devices and low-cost sensors, a wealth of granular and continuously up-to-date data is now available to optimize energy supply and use. Digitalization provides new insights to strategically direct energy efficiency measures to where they can be most impactful and have the greatest benefit.

Digitalization is a critical catalyst for decarbonization and decentralization: smart grids are vital for accommodating growing shares of variable and distributed renewables (IEA 2020j), and, together with digital platforms, allow for full, efficient utilization of a range of flexibility options, including behind-the-meter connected devices. The International Energy Agency estimates that 3,070 terawatt-hours (TWh) of current electricity consumption is technically available for digitally enabled demand response, and this is expected to almost double by 2040 to about 6,220 TWh, or around a quarter of electricity consumption worldwide (IEA 2020g).

The COVID-19 pandemic has had a major impact on energy intensity, as described in box 4.1, but it has also shown the importance of electricity systems, which have ensured continuity of critical infrastructure, enabled remote working and home-schooling (IEA 2020f), and of energy-efficient information and communication technology systems, which have allowed network electricity usage to remain flat despite a spike of 50 percent or more (GSMA 2020). Following this crisis, there is an opportunity to stimulate economic recovery based on more efficient, sustainable, and resilient electricity systems, where digitalization can play a key role.

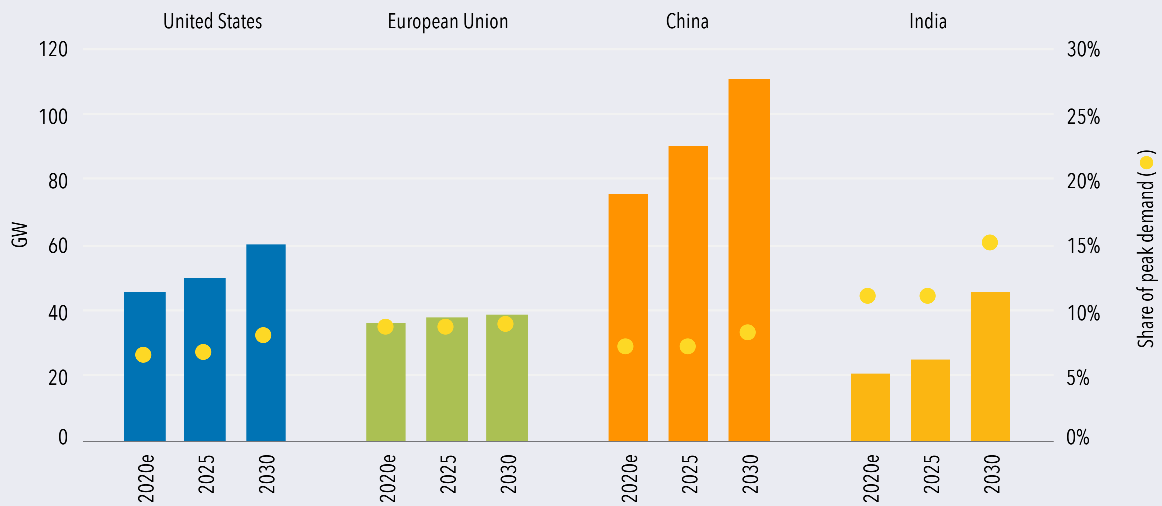
Digital technologies can help achieve significant energy efficiency outcomes across sectors. For example, in the buildings sector, digitalization could cut total energy use by 10 percent by 2040, creating cumulative energy savings of 234 exajoules—equivalent to more than half the final demand consumed globally per year (IEA 2019a).

Digitalization also offers systemwide benefits, including active participation of consumers and behavioral change, reliability and resilience, operational efficiency, cost reductions, and investment optimization. It also has the potential to produce positive economic and social outcomes. For example, the International Energy Agency estimated that projects' job creation potential is higher per unit of investment for those projects that include the modernization or digitalization of existing grids (IEA 2020f).

Cities in particular hold the key to implement many of the solutions that deeply decarbonized systems need to operate securely and efficiently. By 2040, flexibility in electricity networks will need to double to accommodate rising shares of wind, solar, and new uses of electricity like electric vehicles, or electric heating and cooling (IEA 2020j).

Deploying digitally enabled platforms in dense urban areas could unlock much of the flexibility needed. The International Energy Agency estimates that vehicle-to-grid applications during peak times could provide over 600 gigawatts of flexibility globally by 2030 across China, the United States, the European Union, and India (IEA 2020b). The vast majority of this potential—equivalent to the world's total wind power capacity in 2020 (IEA 2020e)—lays in urban and peri-urban areas, where charging of large numbers of electric vehicles in residential areas, offices, or public charging facilities could be aggregated to provide flexibility services to the grid. Four times as much potential to provide flexibility could be technically tapped in the future by smartly managing electricity equipment inside residential, commercial, and industrial buildings (IEA 2020g).

FIGURE B4.2.1 • Power system flexibility needs in selected regions in the Stated Policies Scenario, 2020–30



Source: IEA 2020j.

Note: 2020e = estimated values for 2020. Flexibility needs are represented by the average of the highest 100 hour-to-hour ramping requirements after removing wind and solar production from electricity demand.

GW = gigawatt.

END-USE TRENDS

Using different energy intensity metrics, it is possible to examine the impact across different sectors: compared with the period 1990–2010, the rate of improvement slowed across all sectors, with the exception of transport (figure 4.8).

In the industry sector, which comprises highly energy-intensive economic activities such as the production of cement, iron, and steel, the annual rate of energy intensity reductions dropped by roughly a quarter: from 3.4 percent to 2.6 percent. This slower rate of energy intensity improvement can be largely attributed to increased industrial production in China and the United States, particularly the steel and petrochemical sectors, respectively (IEA 2019a). In spite of this slowdown, industry energy intensity improved at the highest rate of all the sectors over the 2010–18 period, reflecting continued gains in productivity. This is largely driven by emerging Asian economies such as China and India through, for example, more efficient manufacturing processes for steel, cement, and chemicals (IEA 2017). The share in global cement production in China and India (where energy intensities are among the lowest in the world) rose from 42 percent to 63 percent between 2004 and 2018 (USGS 2021). Furthermore, the policy framework for industry energy efficiency tends to be more developed than for other sectors across countries worldwide (IEA 2018).

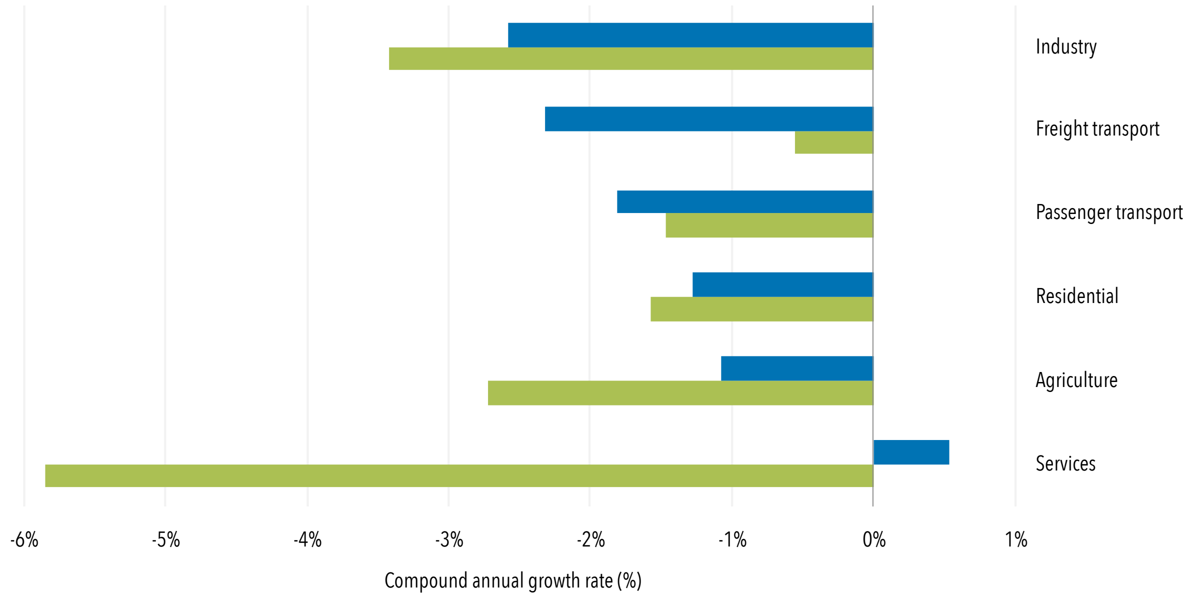
Between 2010 and 2018, the freight transport sector experienced the second-highest rate of energy intensity improvement, after the industry sector, at 2.3 percent a year. This drop in intensity is steeper than the 0.5 percent annual reduction seen in the period 1990–2010. Similarly, energy intensity for passenger transport improved at a faster rate of 1.8 percent a year compared with the previous period (1.5 percent). The transport sector is a primary source of global emissions. As people travel more frequently and over longer distances, and consume more imported goods, the sector is growing rapidly. Although stronger fuel efficiency standards in major markets are improving energy efficiency, these are offset by behavioral changes. For example, consumer demand for new and larger private road vehicles—comparatively energy-intensive forms of transport—remains strong, particularly as living standards rise in emerging economies (IEA 2019a; 2019b).

The residential sector, which is responsible for more than a quarter of electricity consumption worldwide, has seen a minor slowdown in the rate of energy intensity improvement, from 1.6 percent in the previous period to 1.3 percent annually between 2010 and 2018. Demand for new construction continues to grow alongside populations, and recent years have seen increasing demand for cooling and larger living spaces. Mitigating some of these effects would require increased ambition in the enforcement of building energy codes, especially in emerging economies, where a large share of new dwellings is being built. In addition, exceptional weather events in 2018 caused an increase in demand for heating and cooling, exacerbating the slowdown in energy intensity improvement.

Between 2010 and 2018, the services sector experienced the greatest slowdown across all sectors in the rate of energy intensity improvement. While showing the highest rate of improvement in the previous period at 5.8 percent a year, energy intensity in the sector increased over the period 2010–18 at an annual rate of 0.5 percent. There are two likely reasons for this. First, the productivity gains brought about by the widespread computerization of this sector in emerging economies had reached a saturation point. Second, services had become increasingly focused on higher-end products.

Similarly, the improvement rate for agriculture's energy intensity more than halved—from 2.7 percent a year in 1990–2010 to just 1.1 percent between 2010 and 2018. As with the services sector, this is explained by a natural slowdown in the rate of improvement in emerging economies with the advent of modern farming techniques following a period of rapid mechanization that brought large gains in output for each unit of energy consumed.

FIGURE 4.8 • Compound annual growth rate of energy intensity by sector, 1990–2010 and 2010–18



Sources: IEA, UN, and World Bank (see footnote 46).

Note: The measures for energy intensity used here differ from those applied to global primary energy intensity. Here, energy intensity for freight transport is defined as final energy use per ton-kilometer; for passenger transport it is final energy use per passenger-kilometer; for residential use it is final energy use per square meter of floor area; in the services, industry, and agriculture sectors, energy intensity is defined as final energy use per unit of gross value added (in 2017 U.S. dollar purchasing power parity). It would be desirable, over time, to develop more refined sectoral and end-use-level energy intensity indicators that make it possible to look at energy intensity by industry (e.g., cement, steel) or end use (e.g., heating, cooling). Doing so will not be possible without more disaggregated data and statistical collaboration with the relevant energy-consuming sectors.

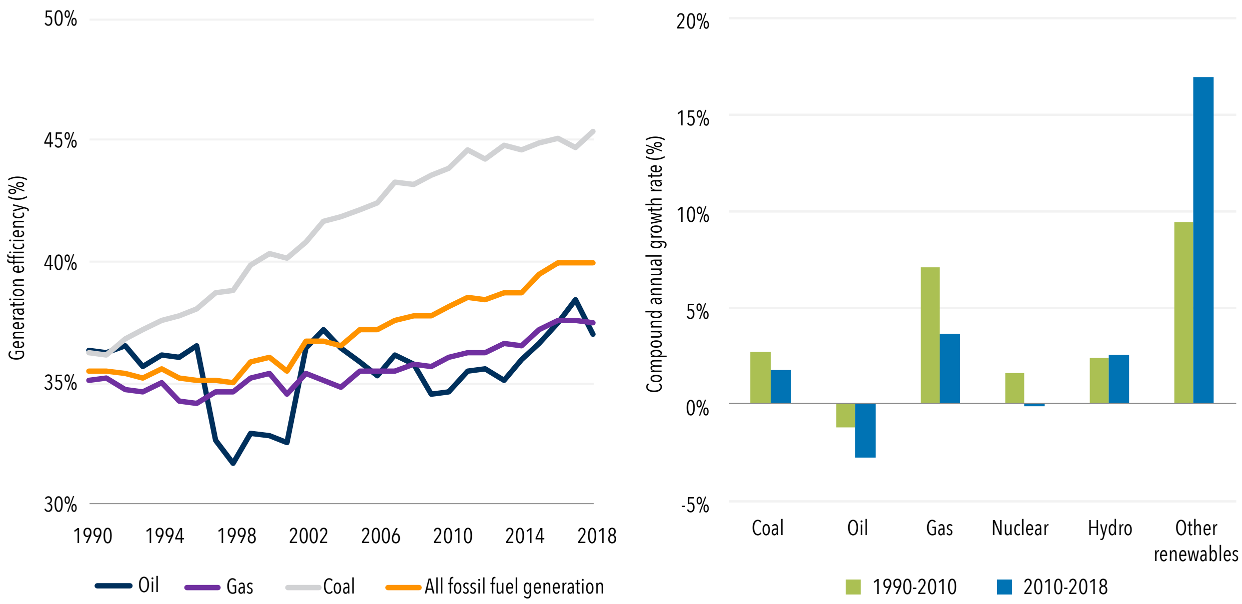
TRENDS IN ELECTRICITY SUPPLY EFFICIENCY

In addition to improvements in end-use efficiency, the rate of global primary energy intensity improvement is also influenced by changes in the efficiency of electricity supply. These include improvements in the efficiency of fossil fuel generation and reductions in transmission and distribution losses. The efficiency of fossil fuel electricity generation steadily improved from 2000, after showing flat rates of improvement during the preceding decade, to reach 40 percent in 2018 (figure 4.9).

Another factor affecting the efficiency of global electricity supply is the share of renewable energy sources in the mix. Statistically, most renewable energy technologies are treated as being 100 percent efficient because no losses are accounted for in the conversion of resources such as sunlight and wind into electricity. So, generally speaking, having more renewable energy in the mix boosts the efficiency of electricity supply.

In 2018, renewable energy comprised 29.2 percent of global electricity consumption, making a notable contribution to energy efficiency. Between 2010 and 2018, renewable electricity sources other than hydropower grew at an annual average rate of 16.9 percent, up from 9.4 percent in the period 1990–2010 (figure 4.9). Hydropower electricity also grew at a slightly faster rate than in the preceding period. Conversely, growth rates for fossil fuel generation were all lower in 2010–18 than in the 1990–2010 period. The combined effect of these growth rates has been to improve the overall efficiency of electricity supply by reducing losses experienced when converting energy supply into electricity. Trends showing that increasing the share of renewable electricity helps to reduce energy intensity point to a synergistic relationship between SDG targets 7.2 and 7.3.

FIGURE 4.9 • Trends in global fossil fuel electricity generation efficiency (left) and growth in electricity generation by fuel type (right), 1990–2018



Source: IEA 2020h.

POLICY RECOMMENDATIONS AND CONCLUSIONS

Recent shortfalls in energy intensity improvement—below rates that would meet SDG target 7.3—will require strengthened government policies on energy efficiency. Well-designed and well-implemented energy efficiency policies can deliver a range of benefits beyond energy and emissions savings.

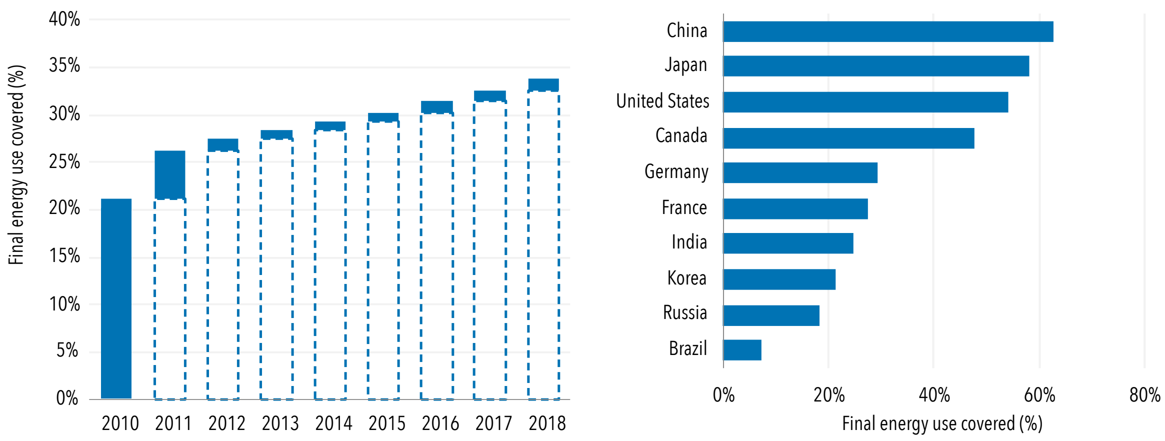
Strong policy action is also vital for signaling to investors that energy efficiency is a long-term priority, helping to create more certainty for investors and to catalyze the transformative investments needed to return the world to a path to meet SDG target 7.3.

ENERGY EFFICIENCY POLICY

Governments have several policy tools for increasing energy efficiency, including regulatory instruments that mandate minimum efficiency levels in buildings, appliances, vehicles, and industry; fiscal or financial incentives to increase the financial viability of installing energy-efficient equipment; and information programs to help energy users make informed decisions. The following section describes some options and policies.[48]

Analysis of energy use covered by regulatory instruments[49] shows that only about one-third of use is covered by measures that mandate energy savings (figure 4.10, left). Not coincidentally, policy coverage is highest in countries that have made the most progress in lessening their energy intensity since 2010, such as China, Japan, and the United States.

FIGURE 4.10 • Growth in energy use covered by mandatory efficiency policies globally, 2010–18 (left), and 2018 coverage in the 10 countries with the highest total energy supply (right)



Source: Based on analysis for IEA (2019a).

Note: Methodological improvements explain the slight changes in historical policy coverage rates from previous editions. The country with the tenth largest total energy supply is Iran. However, since there is no mandatory efficiency policy coverage indicator for Iran, the figure includes the policy coverage for France (rank 11).

48 More information and examples can be found in the IEA's Global Policies Database (https://www.iea.org/policies), the World Bank's Regulatory Indicators for Sustainable Energy (RISE) (https://www.worldbank.org/en/topic/energy/publication/rise---regulatory-indicators-for-sustainable-energy), the Global Status Report of Renewable Energy Policy Network for the 21st Century (REN21), or the recommendations of IEA's Global Commission for Urgent Action on Energy Efficiency.

49 This metric reflects: the energy use of appliances, equipment, and vehicles required to comply with minimum energy performance standards (MEPS) before being sold; the energy use of buildings that were constructed or renovated in accordance with a mandatory building energy code; and the energy use of industrial firms or sectors that are required by law to meet energy efficiency improvement targets.

Minimum energy performance standards (MEPS) are a proven tool in policy making. Introducing MEPS would be one way to expand mandatory policies covering more products in more sectors globally. Mandatory MEPS have proven to be cost-effective; evaluations show that benefits outweigh any additional costs by a factor of 3 to 1.[50] To date, nearly 100 countries have adopted MEPS, covering more than 80 different types of technologies across economic sectors; yet despite their benefits, MEPS are still absent in many jurisdictions.

Well-designed MEPS programs can include features that encourage energy efficiency well beyond the minimum standards and drive innovation among equipment manufacturers to improve the competitiveness of industries and economies.

In the European Union (EU), for example, MEPS have been introduced in an EU-wide manner since 2005 as part of the Ecodesign framework directive, which currently covers over 24 technologies, from residential equipment, such as refrigerators and heating equipment, through to nonresidential equipment, such as motors. These efficiency requirements are periodically updated according to technology developments and have expanded to address the aspect of resource efficiency in product design, central to the European Union's circular economy strategy. The Ecodesign framework directive is estimated to be delivering nearly 20 percent of EU energy savings, over 300 million tons fewer greenhouse gas emissions, and net savings of EUR 63 billion in consumer expenditure (EC, 2018).

Government actions to reduce the cost of energy-efficient equipment or retrofits include economic incentives such as grants or loans. In New Zealand, for example, a series of energy efficiency programs have combined government and third-party funding (and, in some phases, homeowner contributions) to provide insulation retrofits, and sometimes heating, in older houses. Warmer Kiwi Homes (launched in 2018) provides subsidized insulation and heating retrofits for low-income homeowners. A 2011 cost-benefit analysis of a previous iteration of the insulation grants program found that it delivered health benefits well over NZD 1 billion (USD 610 million) (Gimes et al. 2012).

Bulk procurement policies are another effective tool for easing the cost of energy efficiency investments, as governments can leverage their considerable purchasing power to procure efficiency services or products. In India, for example, more than 350 million LED lamps have been distributed though the Unnat Jyoti by Affordable LEDs for All (UJALA) program. The program's economies of scale have helped reduce the price of a LED lamp by a factor of ten (EESL 2017).

BOX 4.5 • RECOMMENDATIONS OF THE GLOBAL COMMISSION FOR URGENT ACTION ON ENERGY EFFICIENCY

In response to a global slowdown in energy efficiency improvement, the International Energy Agency's executive director convened an independent high-level commission in June 2018 to examine how progress on energy efficiency could be accelerated through new and stronger policy action. The 23-member Global Commission for Urgent Action on Energy Efficiency was composed of current and former national leaders, ministers, chief executives, and global thought leaders. Members of the commission worked together to produce a set of 10 recommendations—finalized during the COVID-19 crisis—to encourage governments to implement more ambitious energy efficiency actions (IEA 2020d). Several of the recommendations were intended to encourage governments to deploy energy efficiency measures for their short-term economic stimulus benefits and their contribution to achieving long-term clean energy transitions.

A range of governments are taking action to make policy consistent with the recommendations. Germany's stimulus policy package shows a strong focus on building renovation, expanding a preexisting mechanism—the CO_2 Building Renovation Program—by an additional EUR 1 billion. This step will help to unlock the job creation potential of energy efficiency in the buildings sector (Recommendation 2), a sector that tends to be particularly labor-intensive. Similarly, Italy has supercharged the Eco Bonus program to provide 110 percent tax incentives from July 1, 2020, to December 31, 2021, for energy efficiency building renovations, installation of rooftop solar PV, and electric vehicle charging stations.

50 As in the Technology Collaboration Programme on Energy Efficient End-Use Equipment, 4E-TCP (IEA 2016).

Spain's Law on Climate Change and the Energy Transition, approved in May 2020, sets out a long-term vision and policy framework to achieve carbon neutrality by 2050. The law puts energy efficiency at the heart of Spain's cross-governmental climate action, committing to improve efficiency and reduce primary energy consumption by at least 35 percent by 2030 (Recommendations 1 and 10). It focuses strongly on building renovation, adding to Spain's existing long-term strategy for energy rehabilitation in the buildings sector (Recommendation 2). Under the law, the national government will closely collaborate with municipalities to expand more efficient and clean modes of transport in key urban areas, including by establishing low-emission zones no later than 2023 and investing in alternative mobility infrastructure (Recommendation 7).

Canada's recent announcement that it will step up its Community Efficiency Financing Initiative creates more opportunities for municipalities and subnational partners to take stronger action toward efficiency (Recommendation 7). The new USD 300 million fund supports municipalities' financing programs for home energy performance upgrades, which have proven effective in overcoming barriers such as access to capital or uncertainty about the cost and quality of retrofits, while creating local jobs and reducing emissions.

China's new policy for supporting private energy conservation, announced in July 2020, focuses on scaling up private sector efficiency investment through a range of financial instruments (Recommendations 3 and 4). Preferential tax incentives create opportunities for more efficient use of energy and water resources among businesses, while the policy strongly encourages financial institutions to incorporate efficiency criteria in their finance services. Subnational governments play a key role in implementing and monitoring these measures (Recommendation 7).

POLICIES FOR LEVERAGING DIGITAL TECHNOLOGIES TO SCALE UP EFFICIENCY

In order to take advantage of the multiple benefits that energy efficiency and digitalization can offer, national and subnational governments need to:

- Develop strategies or roadmaps to chart steps needed to progress.
- Systematically address barriers to data access, sharing, and use and ensure robust mechanisms for data protection.
- Build capacity to enable the use of digital tools for data management and analysis.
- Take measures to enable investments and encourage the development of innovative business models.

ENERGY EFFICIENCY INVESTMENT

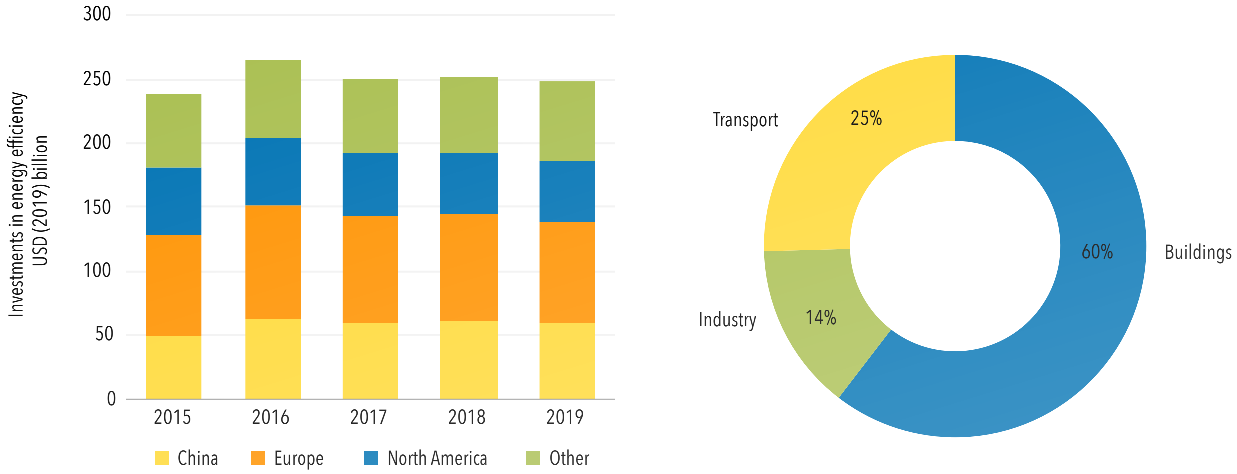
Investments in energy efficiency typically fall into one of the following four key areas:

- Incremental spending on more efficient technologies
- Project investments by energy service companies
- Green mortgages, green bonds, and property-based repayment schemes
- Climate mitigation investments by international financial institutions

Annual global investments in energy efficiency have remained largely unchanged since 2017 (figure 4.11). In 2019, incremental efficiency investments across the buildings, transport, and industry sectors stood at USD 249 billion, with the buildings sector consistently receiving the largest share of total investments—around 60 percent. Total investments declined slightly in 2019, driven by declines in industry (-6 percent) and transport (-4 percent) due to falling global car sales and the most efficient cars trailing the wider market (IEA 2020i). Global investments in the energy efficiency of buildings increased modestly, driven by strong growth in China.

Deploying readily available efficiency technologies is one of the most cost-effective means of saving energy while reducing emissions and achieving wider SDG targets. At current levels, however, the world is not investing enough in efficiency, suggesting a major missed opportunity.

FIGURE 4.11 • Energy efficiency investment by region, 2015–19 (left) and sector (right), 2019



Source: IEA 2020i.

CONCLUSIONS

The improvement rate for energy intensity has slowed over the past few years, falling well below the annual 2.6 percent initially projected as a prerequisite to reaching SDG target 7.3. The year 2018 saw a 1.1 percent improvement from 2017; this was the slowest rate of improvement seen since 2010. The average rate over that eight-year period, 2 percent, was better than the 1.2 percent annual average of the previous decade, but still low enough to require an average rate of 3 percent every year through 2030 in order to meet SDG target 7.3, doubling the global rate of energy intensity improvement by 2030. While early estimates for 2019 indicated an upward trend with an improvement rate of 2 percent, the outlook for 2020 suggests even lower levels of improvement at only 0.8 percent as a result of the COVID-19 crisis.

Nonetheless, the 3 percent target remains well within reach, provided there is significant and systematic investment in cost-effective energy efficiency improvements on a large scale. Given the multiple benefits of energy efficiency, it is an obvious choice of government support. This has been reflected in a range of recent stimulus packages throughout the world. The focus on cross-sector energy efficiency programs observed within global stimulus packages also reflects an opportunity for continued investment beyond these recovery efforts.

One of these benefits is that improved efficiency at scale would be a key factor in achieving affordable, sustainable energy access for all. The recent slowdown of intensity improvements, the significant potential opportunities for investment and economic recovery, and the pressing need for expanded access all point to the need for urgent action by governments to enact policies that would foster rapid progress toward a 3 percent annual improvement.

The decoupling of their economy from their energy use has been key to the progress some countries are making toward energy efficiency. In Japan, for example, minimally energy-intensive sectors (e.g., services) play a more prominent role in the economy than high-intensity sectors like heavy manufacturing. Still, some developing economies are seeing similar trends as their economies grow and their services and low-intensity manufacturing sectors pick up steam.

Every sector displays the trend toward slowing rates of intensity improvement, with the notable exception of transport, where efficiency rates improved faster than before. Passenger transport, for one, has seen increased demand as the world's growing middle class accelerates demand for personal vehicles and long-distance travel. This increase in demand has been offset, however, thanks to the strengthened efficiency standards many countries have implemented since 2010.

Digitalization has also been an emerging trend reshaping the energy landscape and facilitating progress toward improved energy efficiency. Wide-ranging data collection, analysis, and utilization can help to optimize demand and consumption at scale, to improve energy efficiency and to leverage flexibility opportunities at a systems level. Sector-specific digitalization solutions are also having a marked effect on energy efficiency. Some applications for the buildings sector, for example, could cut total energy use by 10 percent by 2040, creating cumulative energy savings of 234 exajoules. In addition to the opportunities to optimize efficiency, digitalization can also support deep decarbonization, particularly in cities. It would be essential for governments to seriously consider this trend when developing policies to ensure that the more optimistic scenarios end up dominating the landscape.

National and subnational governments have an array of policies to help them meet their energy efficiency goals. A number of successful, implemented policies exist in various forms around the world, including energy efficiency standards, financial incentives, market-based mechanisms, capacity-building initiatives, and regulatory changes. All of them encourage investment in efficiency measures and rebalance energy markets in favor of cleaner, more efficient operations.

The world has all of the technology and resources necessary to improve energy efficiency by 50 percent by 2030. The slowing rates of improvement and investment point to a major missed opportunity for the global community. Making energy efficiency measures a priority in policy and investment over the coming years can help the world achieve SDG target 7.3, improve economic development, and ensure universal access to clean, efficient energy.

METHODOLOGY

Total energy supply (TES) in megajoules (MJ)	This represents the amount of energy that is available in the national territory during the reference period. It is calculated as follows: Total energy supply = Primary energy production + Import of primary and secondary energy - Export of primary and secondary energy - International (aviation and marine) bunkers - Stock changes. (Definition coherent with International Recommendations for Energy Statistics). *Data sources:* Energy balances from the International Energy Agency (IEA), supplemented by the United Nations Statistics Division (UNSD) for countries not covered by IEA as of 2017.
Gross domestic product (GDP) in 2017 U.S. dollars (USD) at purchasing power parity (PPP)	Sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. GDP is measured in constant 2017 USD PPP. *Data source:* World Development Indicators (WDI database, http://datatopics.worldbank.org/world-development-indicators/).
Primary energy intensity in MJ/2017 USD PPP	$Primary\ energy\ intensity = \frac{TES\ (MJ)}{GDP\ (USD\ 2017\ PPP)}$ Ratio between TES and GDP is measured in MJ per 2017 USD PPP. Energy intensity (EI) indicates how much energy is used to produce one unit of economic output. A lower ratio indicates that less energy is used to produce one unit of economic output. Energy intensity is an imperfect indicator as changes are affected by other factors other than energy efficiency, particularly changes in the structure of economic activity.
Average annual rate of improvement in energy intensity (%)	Calculated using compound annual growth rate (CAGR): $CAGR = \left(\frac{EI_{t2}}{EI_{t1}}\right)^{\frac{1}{(t2-t1)}} - 1\ (\%)$ Where: EI_{t2} is energy intensity in year t1 EI_{t1} is energy intensity in year t2 Negative values represent decreases (or improvements) in energy intensity (less energy is used to produce one unit of economic output or per unit of activity), while positive numbers indicate increases in energy intensity (more energy is used to produce one unit of economic output or per unit of activity).
Total final energy consumption (TFEC) in MJ	Sum of energy consumption by the different end-use sectors, excluding nonenergy uses of fuels. TFEC is broken down into energy demand in the following sectors: industry, transport, residential, services, agriculture, and others. It excludes international marine and aviation bunkers, except at the world level where it is included in the transport sector. *Data sources:* Energy balances from IEA, supplemented by UNSD for countries not covered by IEA as of 2017.
Value added in 2017 USD PPP	Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The industrial origin of value added is determined by the International Standard Industrial Classification, revision 3. *Data source:* WDI database.
Industrial energy intensity in MJ/2017 USD PPP	$Industrial\ energy\ intensity = \frac{Industrial\ TFEC\ (MJ)}{Industrial\ value\ added\ (USD\ 2017\ PPP)}$ Ratio between industry TFEC and industry value added, measured in MJ per 2017 USD PPP. *Data sources:* Energy balances from IEA and value added from WDI.
Services energy intensity in MJ/2017 USD PPP	$Services\ energy\ intensity = \frac{Services\ TFEC\ (MJ)}{Services\ value\ added\ (USD\ 2017\ PPP)}$ Ratio between services TFEC and services value added measured in MJ per 2017 USD PPP. *Data sources:* Energy balances from IEA and value added from WDI.

Agriculture energy intensity in MJ/2017 USD PPP	$$Agriculture\ energy\ intensity = \frac{Agriculture\ TFEC\ (MJ)}{Agriculture\ value\ added\ (USD\ 2017\ PPP)}$$ Ratio between agriculture TFEC and agriculture value added measured in MJ per 2017 USD PPP. *Data sources:* Energy balances from IEA and value added from WDI.
Passenger transport energy intensity in MJ/ passenger-kilometer	$$Passenger\ transport\ energy\ intensity = \frac{Passenger\ transport\ TFEC\ (MJ)}{Passenger\text{-}kilometers}$$ Ratio between passenger transport final energy consumption and passenger transport activity measured in MJ per passenger-kilometers. *Data source:* IEA Mobility Model.
Freight transport energy intensity in MJ/ton-km	$$Freight\ transport\ energy\ intensity = \frac{Freight\ transport\ TFEC\ (MJ)}{Ton\text{-}kilometers}$$ Ratio between freight transport final energy consumption and activity measured in MJ per ton-kilometers. *Data source:* IEA Mobility Model.
Residential energy intensity in MJ/unit of floor area	$$Residential\ energy\ intensity = \frac{Residential\ TFEC\ (MJ)}{Residential\ floor\ area\ (m^2)}$$ Ratio between residential TFEC and square meters of residential building floor area. *Data source:* IEA Mobility Model.
Fossil fuel electricity generation efficiency (%)	$$Generation\ efficiency = \frac{Electricity\ output\ from\ coal, oil, and\ natural\ gas}{Coal, oil, and\ natural\ gas\ input}\ (\%)$$ Ratio of the electricity output from fossil fuel (coal, oil, and gas) fired power generation and the fossil fuel TES input to power generation. *Data source:* IEA Energy Balances.
Power transmission and distribution losses (%)	$$= \frac{Electricity\ losses}{(Electricity\ output\ main + Electricity\ output\ CHP + Electricity\ imports)}\ (\%)$$ Where: Electricity losses are electricity transmission and distribution losses; Electricity output main is electricity output from main activity producer electricity plants; and Electricity output CHP is electricity output from combined heat and power plants. *Data source:* IEA Energy Balances.

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