TRACKING SDG 7

THE ENERGY PROGRESS REPORT 2020

A joint report of the custodian agencies

iea International Energy Agency

IRENA International Renewable Energy Agency

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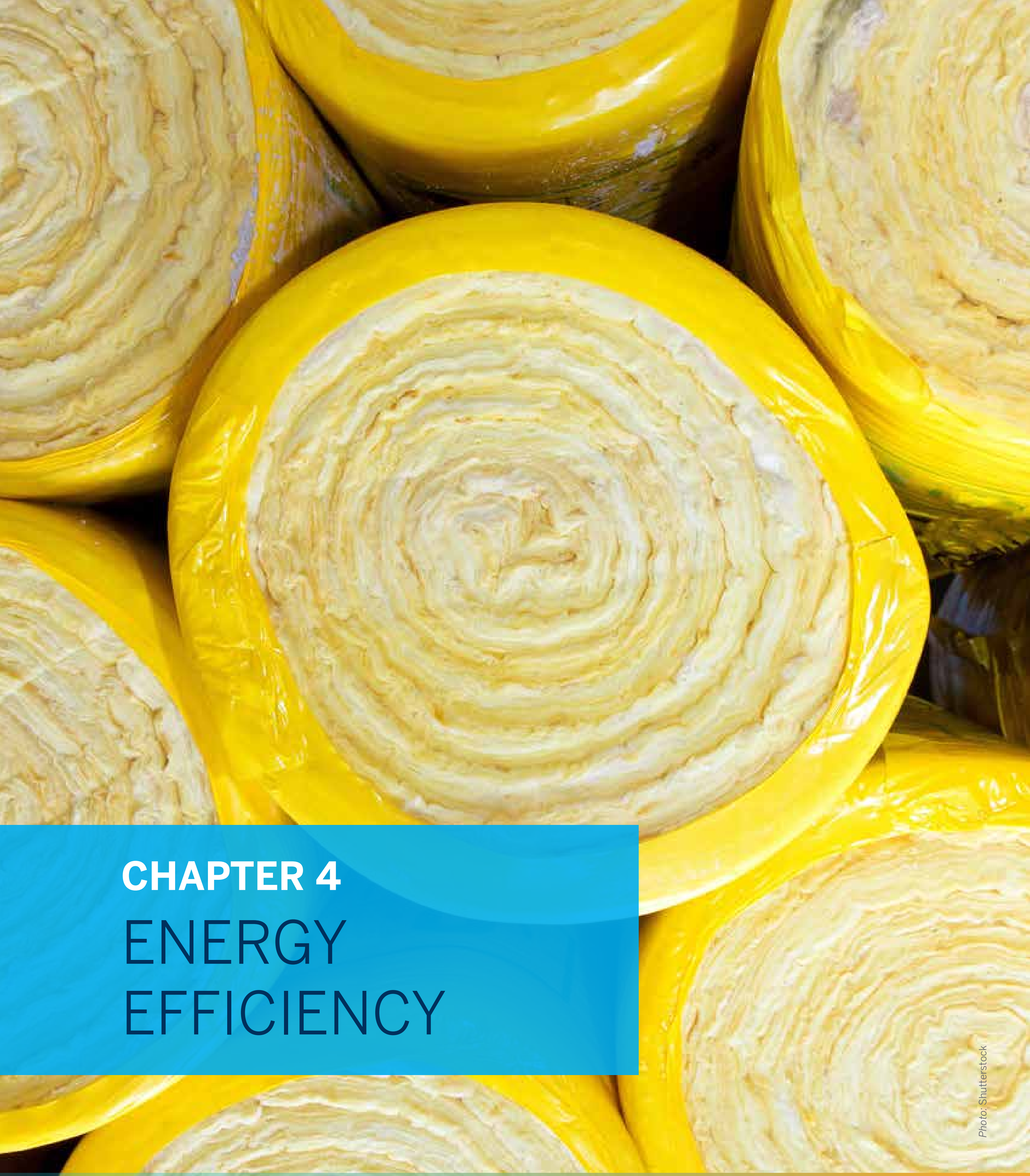

CHAPTER 4
ENERGY EFFICIENCY

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MAIN MESSAGES

- **Global trend:** After a period of relative stability, the rate of global primary energy intensity—defined as the percentage decrease in the ratio of global total primary energy supply per unit of gross domestic product (GDP)—has slowed in recent years. Global primary energy intensity was 5.01 megajoules (MJ) per U.S. dollar (2011 PPP [purchasing power parity]) in 2017, a 1.7 percent improvement from 2016. This was the lowest rate of improvement since 2010.
- **2030 target:** Energy intensity improvements are moving further away from the target set under the United Nations' Sustainable Development Goal (SDG) for 2030. Between 2010 and 2017 the average annual rate of improvement[27] in global primary energy intensity was 2.2 percent. Although better than the rate of 1.3 percent between 1990 and 2010, it is well below the SDG 7.3 target of 2.6 percent—which would have doubled the historic trend. Annual improvement until 2030 will now need to average over 3 percent to meet the target set in SDG 7.3. Even a positive rebound, as indicated by a preliminary estimate of 2 percent for 2019, remains well below the 3 percent annual increases needed to reach SDG target 7.3—or even the 2.2 percent seen between 2010 and 2017.
- **Regional highlights:** Asia is where more robust, continuous improvements are seen in energy intensity than in than any other world region. Between 2010 and 2017, primary energy intensity in Eastern Asia and South-eastern Asia improved by an annual average rate of 3.3 percent. Similarly, in Central Asia and Southern Asia and Oceania, the average annual improvement rate of 2.5 percent between 2010 and 2017 was above the global average (2.2 percent) and an improvement on historic trends. Rates of improvement were just below the global average in Northern America and Europe (2.1 percent), with the lowest rates of improvement in Sub-Saharan Africa (1.3 percent), Western Asia and Northern Africa (1 percent), and Latin America (0.9 percent). Data on absolute energy intensity reveal wide regional differences: the most energy-intensive region is Sub-Saharan Africa, and Latin America and the Caribbean the least. These variations likely mirror not energy efficiency so much as economic structure, energy supply, and access.
- **Top 20 countries in energy intensity:** Comparing the periods 2000–10 and 2010–17, the annual rate of improvement in primary energy intensity increased in 14 of the 20 countries with the largest total primary energy supply in the world. But, of these, only 8 performed better than the global average. China continues to improve primary energy intensity at the fastest rate, at an annual average of 4.5 percent between 2010 and 2017. Other emerging economies with average energy intensity rates that are at or above those aimed for in SDG target 7.3 include India, Indonesia, and Mexico. Japan and the United Kingdom 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 energy intensity improved across all sectors during the period 2010–17, the rate differs by sector. Using different intensity metrics, the rate of improvement declined compared with the period 1990–2010 in all sectors except transport, where fuel-efficiency standards drove improvements. The decline in the rate of improvement from one period to the other is most noticeable in services, agriculture, and, to a lesser extent, industry. All three of these sectors were strongly 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.

27 Calculated as a compound average annual growth rate.

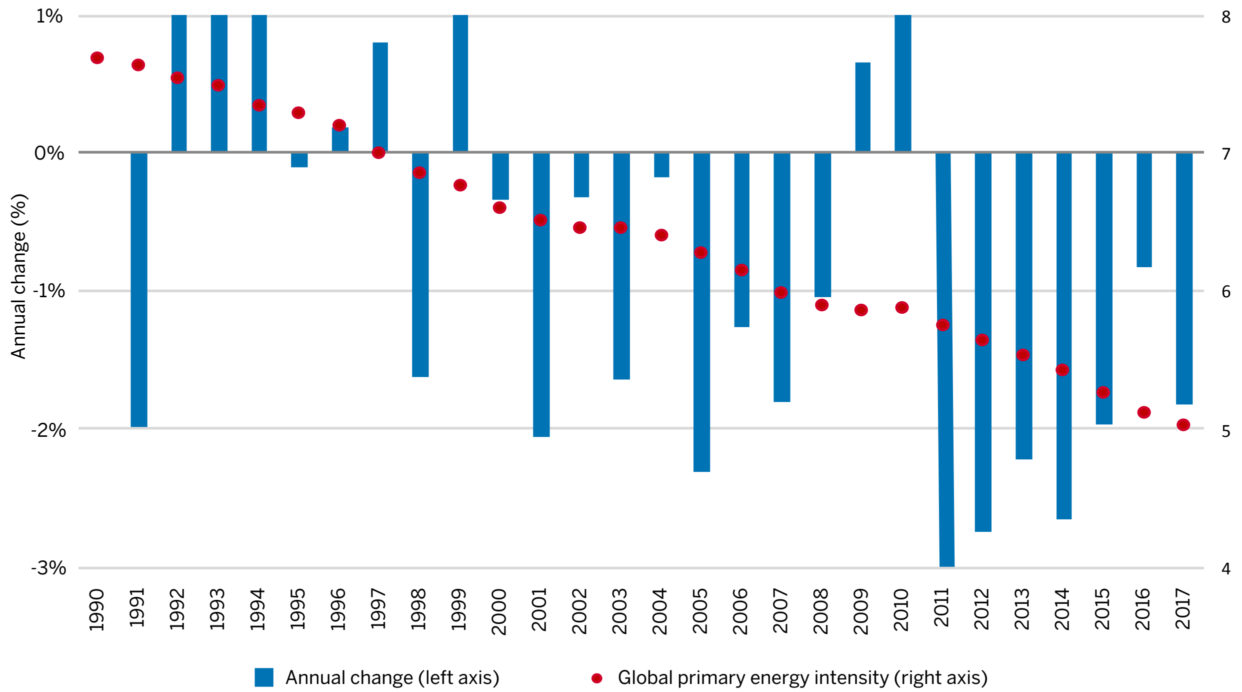
- **Electricity supply trends:** The mounting share of renewables in electricity supply also improves the supply efficiency by eliminating the losses that accompany the conversion of primary (non-renewable) fuels into electricity. This relationship between efficient renewable electricity and a decrease in primary energy intensity highlights the synergies between SDG target 7.2 and SDG target 7.3. In addition, nearly 40 percent of the average efficiency of fossil fuel electricity generation is due to relatively more efficient gas-fired generation and the construction of highly efficient coal-fired generation in China and India. Major producing countries are seeing declines in electricity transmission and distribution losses, which indicate higher rates of electrification and a modernized supply infrastructure.

ARE WE ON TRACK?

SDG 7 commits the world to ensure universal access to affordable, reliable, sustainable, and modern energy. Energy efficiency supports all of SDG 7's targets, but it is especially relevant to SDG target 7.3: doubling the current global rate of energy efficiency by 2030. Energy efficiency is most commonly measured in terms of "energy intensity," or the ratio of primary energy supply to the annual 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, the annual improvement rate now required to achieve SDG target 7.3 is at least 3 percent. Figure 4.1 illustrates global energy intensity improvements since 1990.[28] Recent numbers show that global primary energy intensity improved by 1.7 percent in 2017 to 5.01 MJ/U.S. dollar (2011 PPP).

FIGURE 4.1 • Global primary energy intensity and its annual change, 1990–2017

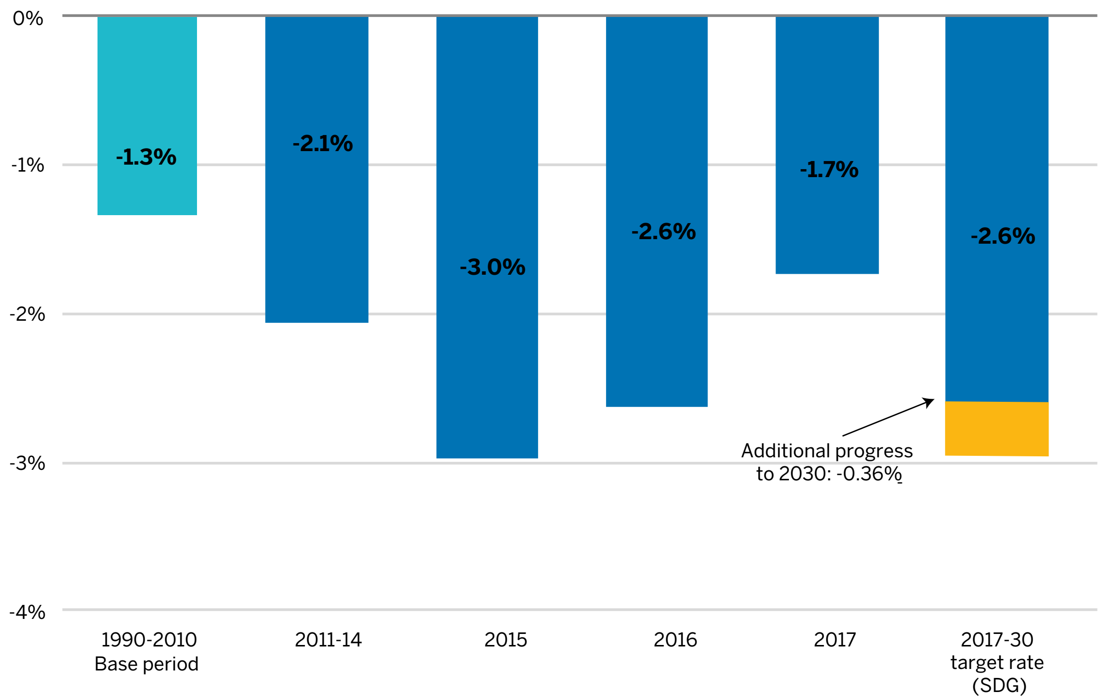


Source: IEA, UNSD, and World Bank (see footnote 2).

MJ = megajoule; PPP = purchasing power parity.

28 Most of the energy data in this chapter, including that used for many of the figures, come from the International Energy Agency's (IEA) World Energy Balances database (https://www.iea.org/data-and-statistics/) and the United Nations Statistical Division's (UNSD) Energy Balances database (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/).

FIGURE 4.2 • **Growth rate of primary energy intensity, by period and target rate, 1990-2030**



Source: IEA, UNSD, and World Bank (see footnote 2).

The 2017 rate of 1.7 percent was the lowest rate of improvement since 2010, continuing the slowing trend since 2015 (Figure 4.2). As a consequence of this slowing, the average rate of improvement needed to meet SDG target 7.3 has now increased to 3 percent per year between 2017 and 2030, a difference of 0.4 percent from the 2.6 percent initially estimated when the SDGs were enacted.

LOOKING BEYOND THE MAIN INDICATORS

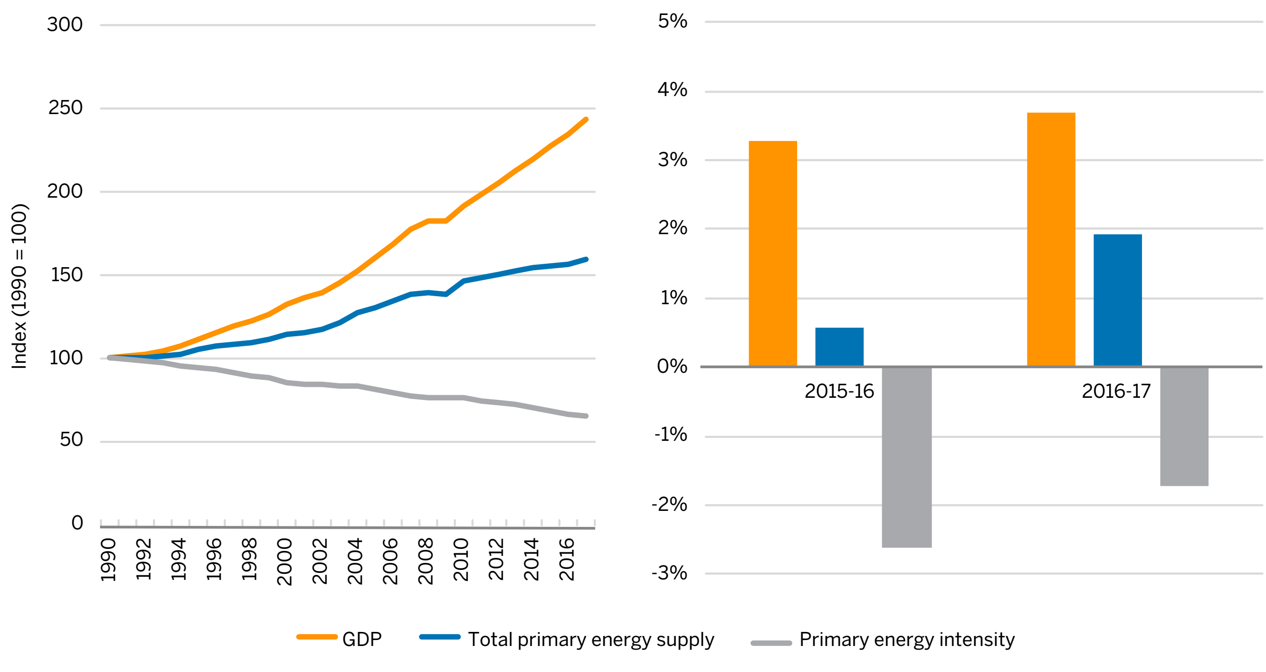
COMPONENT TRENDS

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 2017, global GDP more than doubled while global total primary energy supply increased by just over 50 percent. Although growth in primary energy supply slowed markedly in 2015 and 2016, it picked up again in 2017, growing by nearly 2 percent.

The difference in growth rates for global GDP and total primary energy supply is reflected by consistent improvements in global primary energy intensity, which fell more than 30 percent between 1990 and 2017, signaling trends in the decoupling of energy use and economic growth. In the period 2010–17, global primary energy intensity fell by 10 percent, or just slightly more than the percentage drop observed between 2000 and 2010.

The recent slowdown in the improvement rate for energy intensity—from 2.6 percent in 2016 to 1.7 percent in 2017 (Figure 4.3, right)—means that while GDP growth trended modestly upward, the growth rate for primary energy supply tripled.

FIGURE 4.3 • Trends in underlying components of global primary energy intensity, 1990–2017 (left); and growth rates of GDP, primary energy supply, and intensity, 2015–17 (right)

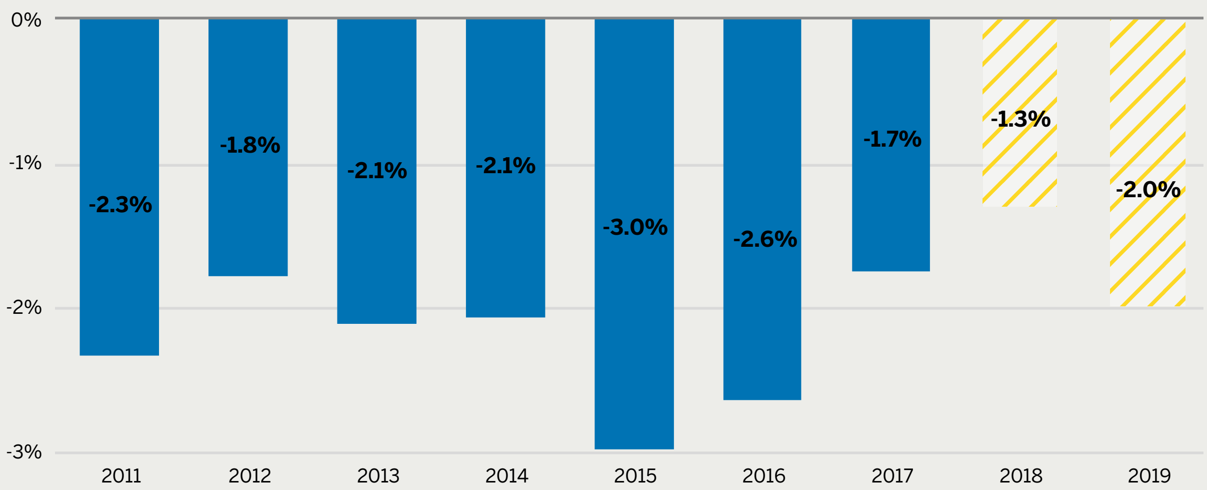


Source: IEA, UNSD, and World Bank (see footnote 2).
GDP = gross domestic product.

BOX 4.1 • ESTIMATES FOR 2018 AND 2019 INDICATE SLOWING RATES OF PRIMARY ENERGY INTENSITY IMPROVEMENT

Estimates from the International Energy *Agency's Global Energy Review: Energy and carbon emissions status report 2020* show that the rate of improvement in global primary energy intensity continued to slow in 2018 but may have improved slightly in 2019 (Figure B4.1.1). Global primary energy intensity is estimated to have improved by just 1.3 percent in 2018 and 2 percent in 2019, well below the 3 percent annual improvement target required to achieve SDG target 7.3.

FIGURE B4.1.1 • Growth rate of global primary energy intensity, 2011–19



Source: IEA 2020.

Although it is estimated that efficiency continued to improve in 2018 and 2019, its impact has been overwhelmed by factors leading to increased energy demand, such as changes in energy users' purchasing decisions and structural shifts back toward more-energy-intensive industries. These factors, linked to strong economic growth and low energy prices, have combined with a static energy efficiency policy landscape to shrink improvements in primary energy intensity. Progress in implementing new energy efficiency policies or strengthening existing policies has been slow, limiting the ability of energy efficiency gains to offset the impact of economic growth on energy demand. Slowing rates of improvement mean that additional effort will be required, on top of that already needed, to reach SDG target 7.3.

Note: Further information available from IEA (2020).

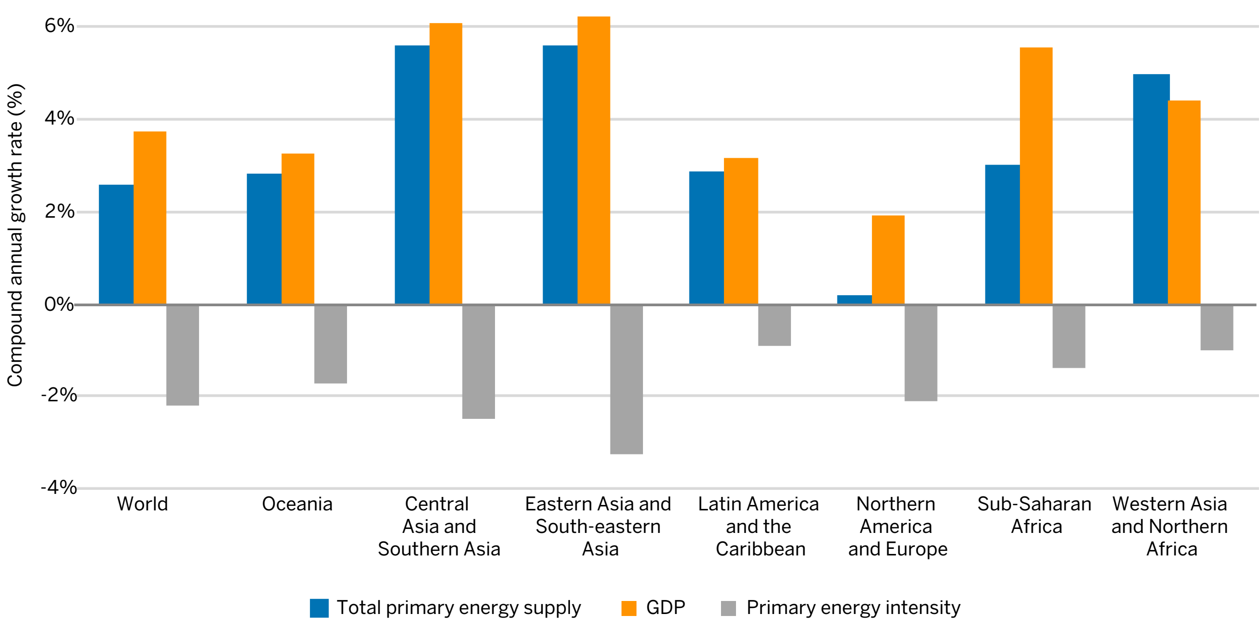
REGIONAL TRENDS

Overall, since 2010, primary energy intensity has improved across the world, but noteworthy differences in trends are observed across regions (Figure 4.4). Emerging economies in Eastern and South-eastern Asia have seen a rapid increase in economic activity; however, the rise in primary energy supply associated with such growth has been mitigated in part by substantial improvements in energy intensity, 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 primary 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 the improvements in energy efficiency observed when mature policies are in place, particularly in buildings (Northern America) and industry (Europe). In these economies, energy intensity improved at a rate just below global trends, leading to an absolute level of energy intensity just below the global average (Figure 4.5).

From 2010 to 2017, economic activity steadily increased across Northern Africa, Oceania, Sub-Saharan Africa, and Western Asia, accompanied by growth in primary energy consumption well above the global average. Improvements in energy intensity in these regions have been modest and unable to offset the effects of economic growth on demand. In absolute terms, significant differences exist between these regions, reflecting differences in their stages of development and economic output (Figure 4.5). For example, economic output in Sub-Saharan Africa is highly energy intensive, at nearly 7 MJ/U.S. dollar (2011 PPP), partly reflecting the low value of economic output in this region, compared to 4.3 MJ/U.S. dollar (2011 PPP) in Northern Africa and Western Asia (Figure 4.5).

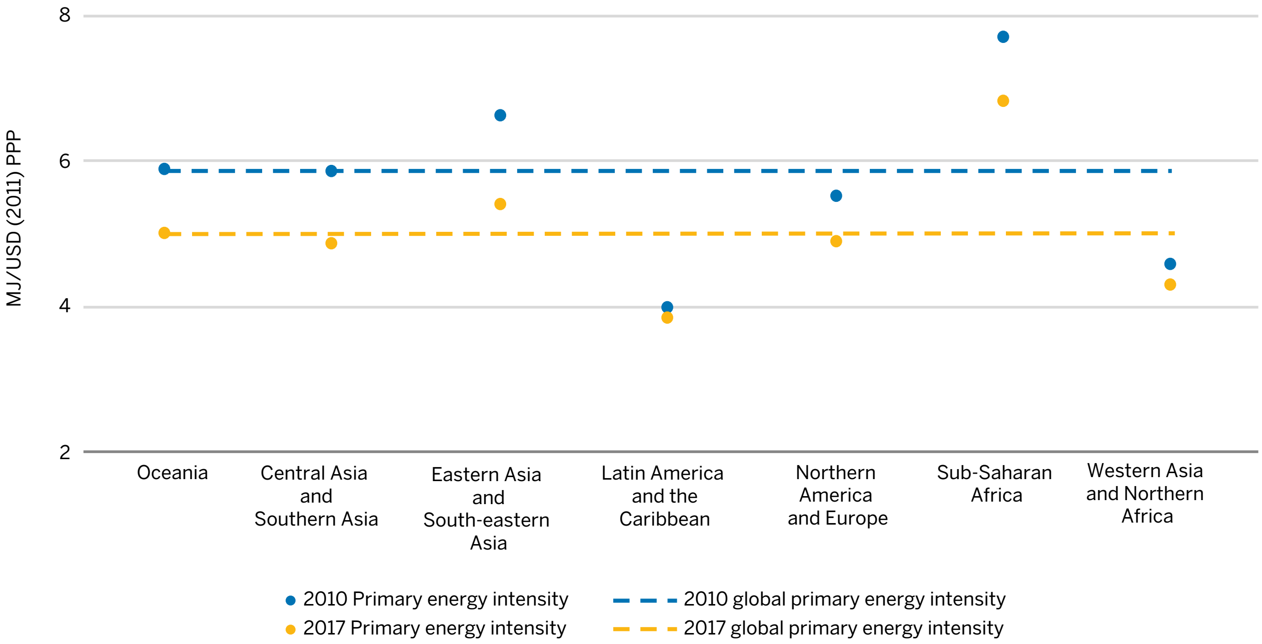
Despite continuing to record the smallest average gains in energy intensity improvement over the period 2010–17 (less than 1 percent), the Latin America and the Caribbean region experienced a year-on-year improvement in energy intensity of 2.1 percent in 2017, the largest gain there since 2011. This region is also the least energy intensive in the world, at just below 4 MJ/U.S. dollar (2011 PPP) (Figure 4.5).

FIGURE 4.4 • Growth rate of GDP, primary energy demand, and regional energy intensity, 2010–17



Source: IEA, UNSD, and World Bank (see footnote 2).
GDP = gross domestic product.

FIGURE 4.5 • **Primary energy intensity, by region, 2010 and 2017**



Source: IEA, UNSD, and World Bank (see footnote 2).
MJ = megajoule; PPP = purchasing power parity.

MAJOR COUNTRY TRENDS

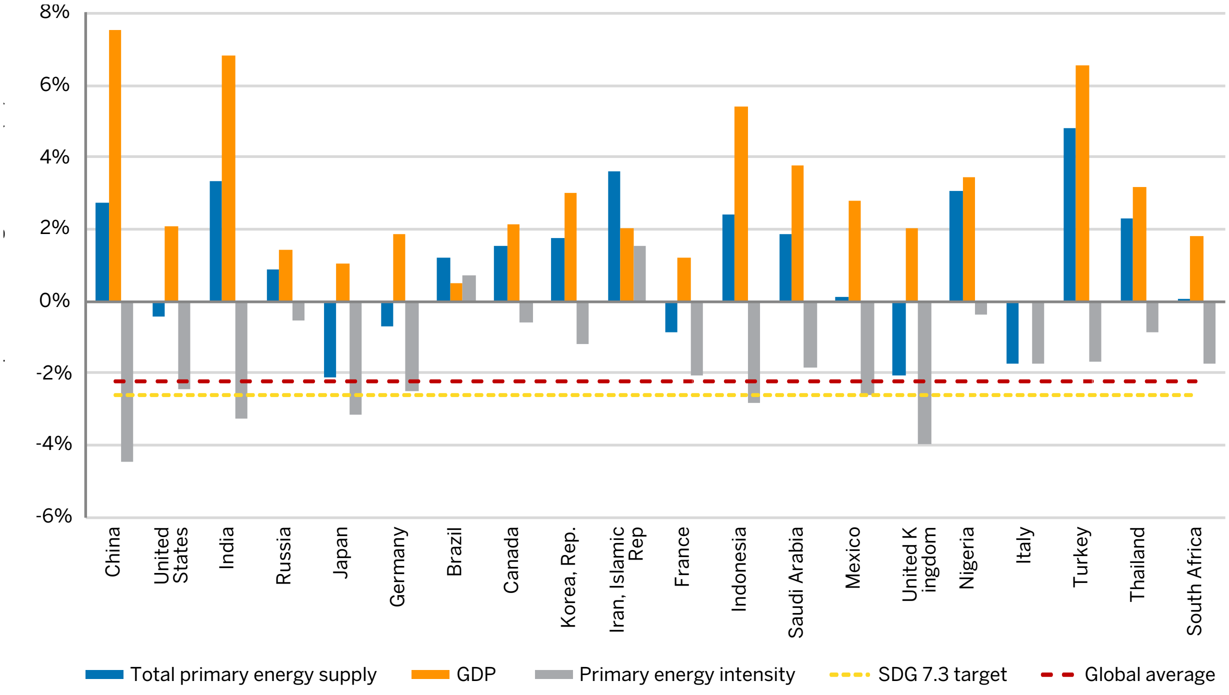
Rates of improvement for primary energy intensity in the 20 countries with the largest total primary energy supply would be central to realizing SDG 7.3. Over the period 2010 to 2017, 14 of these countries increased their rate of improvement, but only 8 performed better than the global average, with 6 (China, India, Indonesia, Japan, Mexico, and the United Kingdom) exceeding the level required by SDG target 7.3 (Figure 4.6).

Of these six countries, four—China, India, Indonesia, and Mexico—are 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 of Japan and the United Kingdom have expanded as their energy use declined. Both display energy intensity improvement rates above the global average, suggesting that economic growth is being decoupled from energy use. A similar trend is observed in France, Germany, and the United States. High-value, service-related activities are less energy intensive, and the economies in these countries all have strong, decades-long records of policy action on energy efficiency.

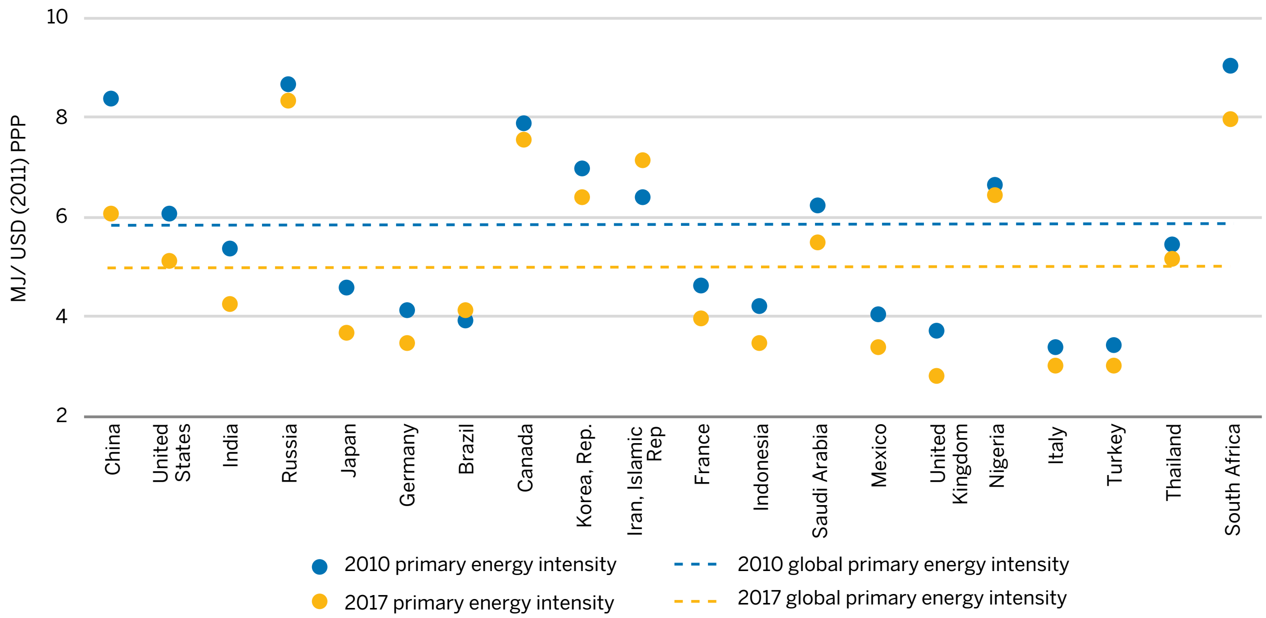
By contrast, Brazil and Iran are two major energy-consumers with worsening primary energy intensity, partly because their stagnant economic conditions inhibit greater investment in industrial efficiency. Notably, both countries have sizable energy-intensive industry sectors. In Iran, where fossil fuels are plentiful, energy efficiency has not been a priority; meanwhile, generous government subsidies of fuel prices have further entrenched inefficient energy use.

FIGURE 4.6 • Growth rate of GDP, primary energy demand, and intensity in the 20 countries with the highest total primary energy supply, 2010–17



Source: IEA, UNSD, and World Bank (see footnote 2).
Note: Countries along x-axis ordered by total primary energy supply.
GDP = gross domestic product; SDG = Sustainable Development Goal.

FIGURE 4.7 • Primary energy intensity in the 20 countries with the highest total primary energy supply, 2010 and 2017



Source: IEA, UNSD, and World Bank.
Note: Countries along x-axis ordered by total primary energy supply.
MJ = megajoule; PPP = purchasing power parity.

In absolute terms, the energy intensity of 10 of the top 20 energy-consuming countries remain above the global average, compared to 9 in 2010. For example, energy intensity in Thailand grew from being below the global average in 2010, to above it in 2017 (Figure 4.7). Since 2010, however, average global energy intensity has fallen by nearly USD 1/MJ (2011 PPP). Certain countries have made progress by moving further below global average energy intensity, including India, Japan, and the United Kingdom. Others (such as China, South Africa, and the United States), despite remaining more energy intensive than the global average, are improving and shifting toward the global average.

Countries that have made the least progress include those where energy-intensive fossil fuel extraction is a major economic activity—namely, Canada, Iran, Nigeria, and Russia.

BOX 4.2 • THE IMPACT OF PRIMARY ENERGY INTENSITY IMPROVEMENTS ON GDP GROWTH

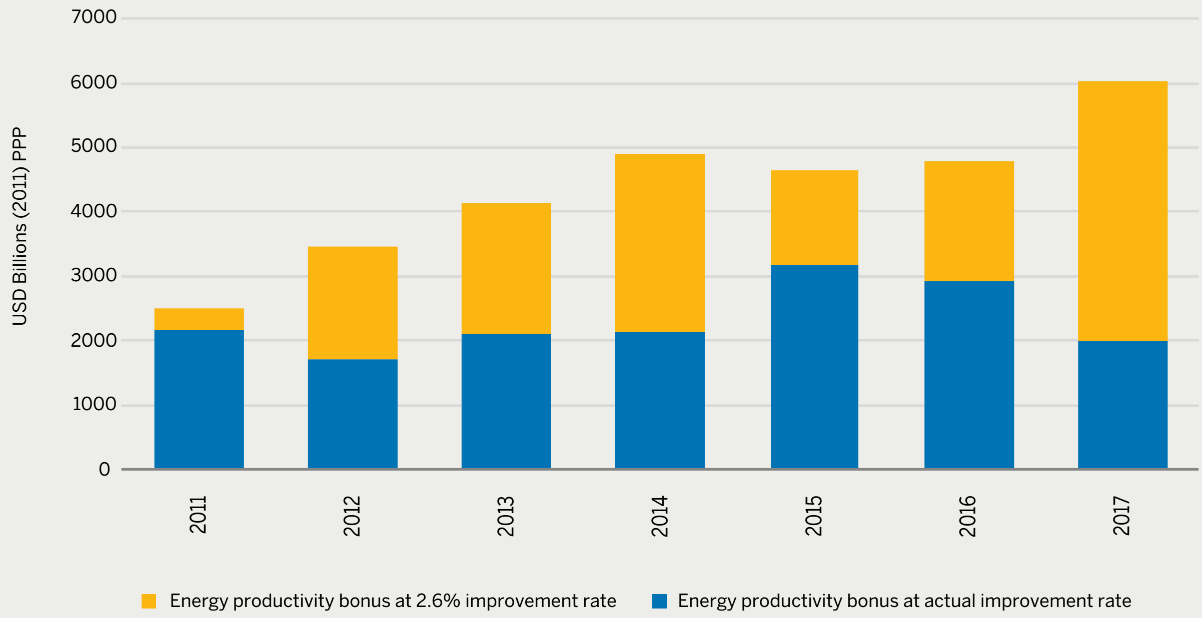
Improvements in primary energy intensity can have a marked effect on economic growth because less energy-intensive economies create more wealth for every unit of energy consumed. This additional wealth is termed the "productivity bonus"—that is, the bonus wealth created by annual energy intensity improvements. The productivity bonus can also be used to track the economic opportunities missed because rates of energy intensity improvement are slowing. By comparing the energy productivity bonus of a given year with a theoretical bonus attained through a given higher level of efficiency that year, we can assess the opportunity cost of continuing to operate in a business-as-usual manner.

Figure B4.2.1 shows the annual global productivity bonus from 2011 to 2017 and compares those improvements against the productivity bonus that could have been created had the world achieved, with respect to the energy consumed between 2011 and 2017, the 2.6 percent improvement rate in annual energy efficiency set in Sustainable Development Goal (SDG) 7. As the figure shows, the world has fallen short of this goal since it was announced, missing out on an average of USD 2 trillion per year, totaling more than USD 14 trillion over the seven-year period.

These global figures are driven by the largest economies—India, China, the European Union, and the United States. These four economies account for more than 60 percent of global gross domestic product, so as their contributions to global growth increase and decrease in scale, so, too, do their energy intensity rates affect the global efficiency measures. For example, in 2017, the global productivity bonus dropped by about 33 percent, from approximately USD 3 trillion in 2016 to approximately USD 2 trillion in 2017. China's 2016 productivity bonus, which was larger than all other countries combined, dropped by 42 percent in 2017 after its energy intensity improvement rate more than halved from 6.9 percent in 2016 to 3.4 percent in 2017. The year-on-year change in China's intensity contributed significantly to the loss of global productivity bonus, comprising 77 percent of the total loss. With the European Union and India responsible for 8 percent and 11 percent of the total loss, respectively, and the United States contributing an 11 percent gain, only 15 percent of the total effect is attributable all other countries (IEA 2018). This comparison underscores the heavy hand these four economies have over global efficiency and its impact on potential benefits brought with improvements.

Because of its capacity to increase economic productivity, energy efficiency can support not only SDG 7 but also the world in its progress toward SDG 8, which calls for greater economic growth and productivity.

FIGURE B4.2.1 • Energy productivity bonus, 2011–17



Source: IEA 2019a.
PPP = purchasing power parity.

END-USE TRENDS

Overall, during the period 2010–17, energy intensity improved in all sectors. Using different energy intensity metrics, it is possible to examine the impact across 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 the most-energy-intensive economic activities, the annual rate of energy intensity reductions dropped by roughly a third: from 3.7 percent to 2.5 percent. In spite of this slowdown, industry energy intensity improved at the highest rate of all the sectors over the seven-year 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 production of cement production in China and India (where energy intensities are among the lowest in the world) rose from 42 percent to 65 percent between 2004 and 2017. Furthermore, the policy framework for industry energy efficiency tends to be more developed than for other sectors across countries worldwide (IEA 2018).

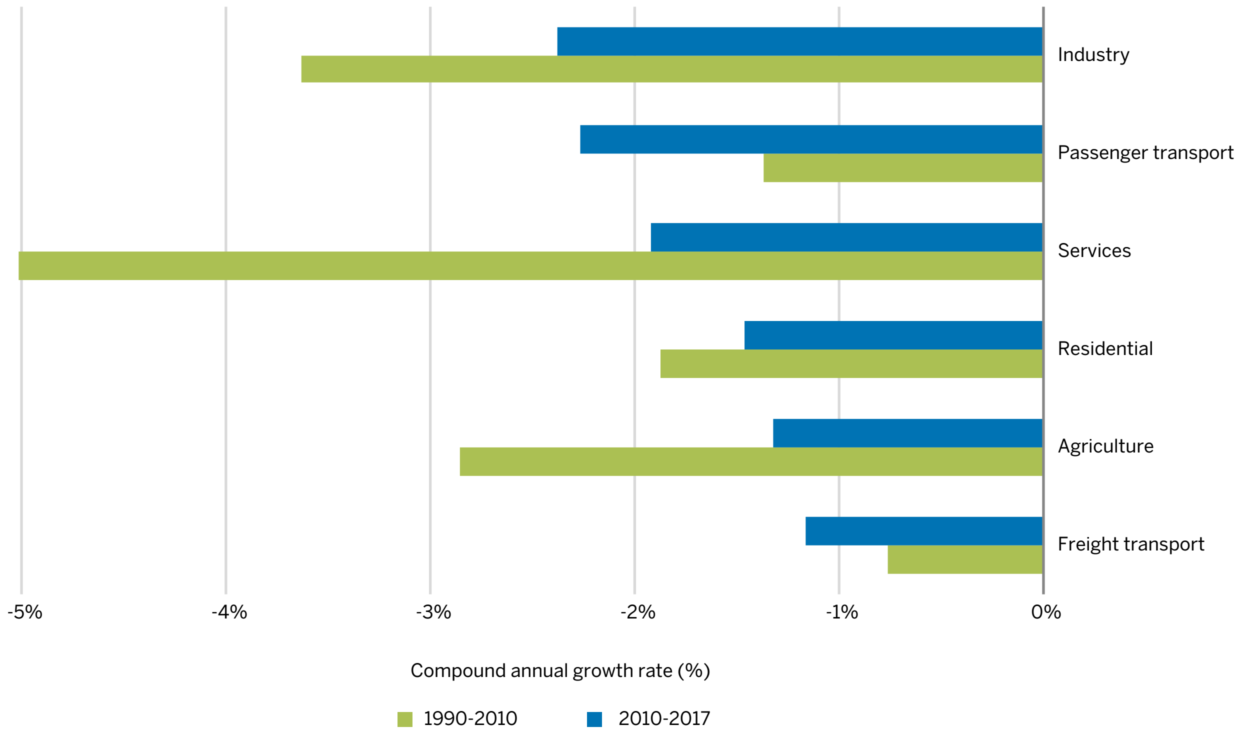
Between 2010 and 2017, the passenger transport sector experienced the second-highest rate of energy intensity improvement, after the industry sector, at 2.3 percent. This increase is higher than the growth rate of 1.4 percent seen in the period 1990–2010. Similarly, energy intensity for freight transport improved at a faster rate compared with the previous period. Nevertheless, its gains remained the lowest across all sectors, at only 1.3 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 transport behavior and consumer preferences. 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 roughly 27 percent of electricity consumption worldwide, has seen a minor slowdown in the rate of energy intensity improvement, from 1.9 percent to 1.5 percent. Demand for new construction continues to swell with population growth, and recent years have seen rising demand for cooling and larger living spaces. Mitigating some of these effects would require greater ambition in the enforcement of buildings' energy codes, especially in emerging economies, where a large share of new dwellings is being built.

Between 2010 and 2017, the service sector's rate of energy intensity improvement slowed more starkly than that of any other sector, falling from 5 percent in the previous period (1990–2010) to just 1.9 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, which tend to be more energy intensive to produce.

Similarly, the improvement rate for agriculture's energy intensity more than halved—from nearly 3 percent in 1990–2010 to just 1.3 percent between 2010 and 2017. 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 • Growth rate of energy intensity by sector, 1990–2010 and 2010–17



Source: IEA, UNSD, and World Bank (see footnote 2).

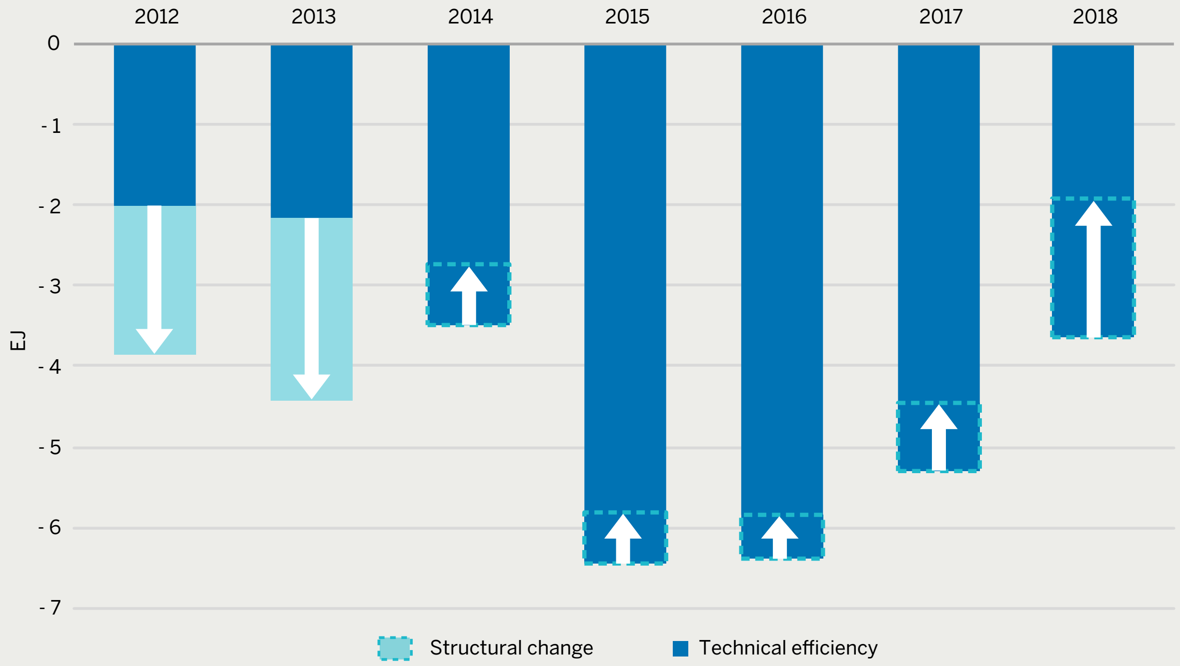
Note: The measures for energy intensity used here differ from those applied to global energy intensity. Here, energy intensity for freight transport is defined as final energy use per tonne-kilometer; for passenger transport it is final energy use per passenger-kilometer; for residential use it is final 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 2011 U.S. dollars at purchasing power parity).

BOX 4.3 • THE EFFECT OF STRUCTURAL FACTORS ON ENERGY DEMAND

In any year, energy demand is affected by a combination of energy-using activities, structural effects, and technical energy efficiency. Analysis of some of the world's major economies shows that in 2012 and 2013, structural effects reduced final energy demand by the same or more than the energy savings achieved by technical energy efficiency improvements alone (Figure B4.3.1).

However, in recent years, structural impacts have added to energy demand, offsetting some of the energy savings brought about by technical efficiency improvements. Final demand across major economies grew by over 4 percent between 2015 and 2018, a slight increase over previous years. This reflects the effect of population and economic growth, as well as structural shifts in the nature of energy-using activities in various economic sectors. For example, evidence suggests that, on average, consumers have increased their travelling distances, have changed their modes of transport to more energy-intensive options, own more appliances, and live in buildings with larger floor areas. It is estimated that such structural effects alone were responsible for an almost 1.5 percent increase in energy use between 2015 and 2018 in some of the world's major economies. The recent shift in energy-using behavior in these countries might be at least partially related to low crude oil prices during the period 2014–17.

FIGURE B4.3.1 • **Combined effects of technical efficiency improvements and structural effects on demand, annually, 2012–18**



Source: IEA 2019a.

Note: The "major economies" referred to in the above analysis are IEA Member Countries—Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States—plus Argentina, Brazil, China, India, Indonesia, and the Russian Federation.

EJ = exajoule.

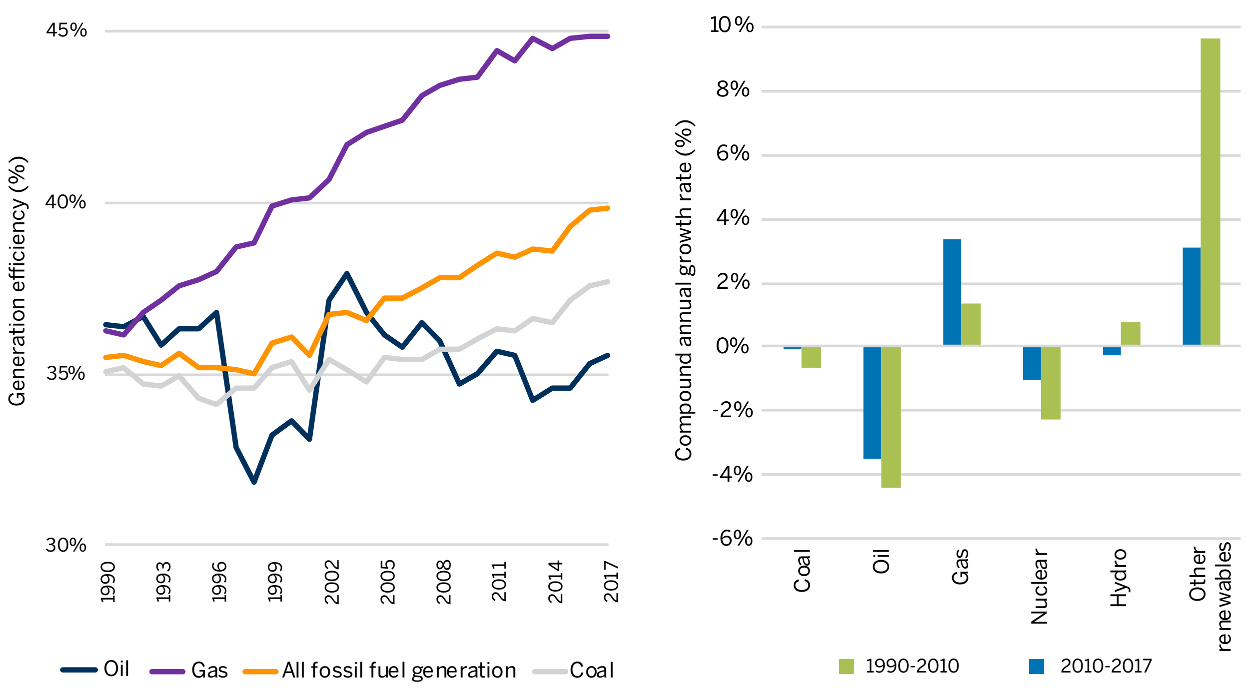
TRENDS IN ELECTRICITY SUPPLY EFFICIENCY

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 has steadily improved since 2000, after showing flat rates of improvement during the preceding decade, to reach nearly 40 percent in 2017 (Figure 4.9, left).

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

In 2017, renewable energy comprised only 17.3 percent of global electricity consumption; nevertheless, it made a notable contribution to energy efficiency. Between 2010 and 2017, renewable electricity sources other than hydropower grew at an annual average rate of 10 percent, up from 3 percent in the period 1990–2010 (Figure 4.9, right). Hydropower electricity also grew at a faster rate than during the preceding period. Conversely, growth rates for fossil fuel generation were all lower in 2010–17 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 primary energy into electricity. That increasing the share of renewable electricity helps to reduce primary energy intensity shows the 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), 1990–2017



Source: IEA, UNSD, and World Bank (see footnote 2).

BOX 4.4 • RELATIONSHIP BETWEEN THE EFFECT OF DEMAND- AND SUPPLY-SIDE FACTORS ON EMISSIONS

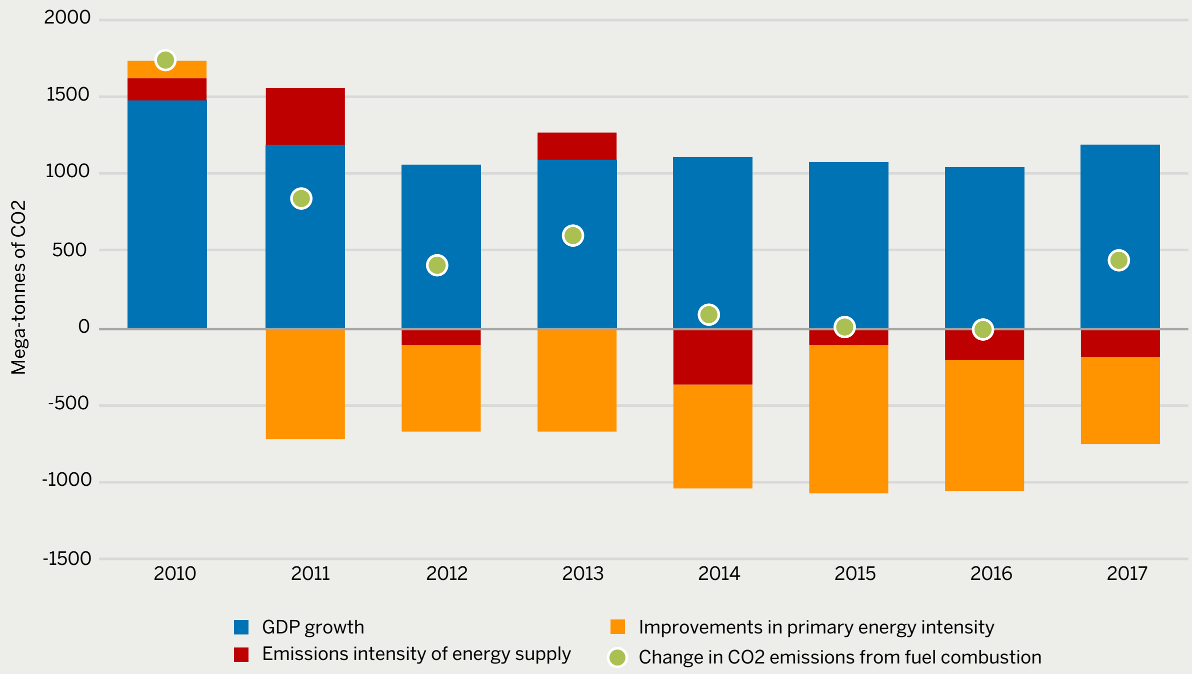
Carbon emissions associated with the energy sector are one of the biggest contributors to human-induced climate change. The goal of reducing global emissions therefore depends largely on reducing primary energy intensity. Given that the time frame for action is shrinking, it is important to determine where in the energy system countries should target their efforts.

Each year, changes in energy sector emissions are determined by a combination of factors, including changes in energy-using activities, the intensity of both the supply and demand sides, and the emissions intensity of the energy mix. Decomposition analysis allows for the identification of the factors responsible for annual changes in emissions.

Analysis shows that in 2010, the rise in global emissions was driven by economic growth, a more emissions-intensive energy mix, and declines in the energy intensity of supply and demand. Since then, the major factor helping to reduce the growth of energy-related emissions has been improved final energy intensity, thanks largely to efficiency gains in buildings, industry, and transport. Another factor helping to lessen annual growth in emissions is the switch to renewable energy sources, which has reduced the emissions intensity of the energy mix annually since 2014.

The effect of an efficient energy supply (the ratio of primary energy needed to supply a unit of final energy demand) has frequently changed, in some years helping to reduce annual emissions growth, while in others, increasing emissions. This reflects yearly variations in the energy supply mix, such as changes in electricity demand, which are often determined by factors such as weather.

FIGURE B4.4.1 • Decomposition of energy sector emissions, 2010–17



Source: IEA, UNSD, and World Bank (see footnote 2).

Note: Countries covered are IEA member countries plus Argentina, Brazil, China, India, Indonesia, Russia, and South Africa—together representing around 75 percent of global energy use.

CO_2 = carbon dioxide; GDP = gross domestic product.

EMERGING TRENDS: DIGITALIZATION

Digitalization is rapidly transforming the energy sector, with possible implications for the achievement of SDG 7.3. By gathering and analyzing data from a vast network of sources, digital technologies have the potential to optimize energy production and consumption at a scale that would otherwise not be possible. With the proliferation of digital devices and low-cost sensors, a wealth of data is now available to optimize energy use: linking data from smart meters, commuter movements, mobile telephone networks, consumer purchasing decisions, social media, weather conditions, and more.

Digitalization makes end-use energy more efficient while distributing flexible load, generation, and storage. By broadening energy efficiency, digitalization contributes to system efficiency. Connected components of the energy network increase end-use efficiency and in doing so support "prosumers" and integrate new sources of demand response. Together they help make the system more efficient (IEA 2019a).

Although a complete accounting of digitalization is still uncertain—along with its promise of energy efficiency—research suggests global potential. IEA estimates suggest that in the building sector, digitalization could cut total energy use by 10 percent by 2040, creating a cumulative energy savings of 234 exajoules—equivalent to more than half the final demand consumed globally per year (IEA 2019a). Some models of urban transport suggest that digital innovations such as teleworking, shared mobility, and connected and autonomous vehicles could reduce transport carbon emissions by more than 50 percent in 2050 compared to business-as-usual emissions (ITF 2019).

It is important to note, however, that digitalization also poses risks. For example, the rapidly shifting transport landscape (e.g., ride-hailing and micromobility) creates uncertainty around net energy use. Depending on which effects dominate, models estimate that digitalization and automation trends could have a range of different effects on final transport energy demand. Optimistic scenarios in which efficiencies are maximized could halve transport energy use compared with current levels; pessimistic scenarios see transport demand doubling (Waduda, MacKenzie, and Leiby 2016). Smart policies are therefore key to ensuring that digitalization leads to a more energy-efficient and sustainable energy system (see below).

POLICY RECOMMENDATIONS AND CONCLUSIONS

Recent shortfalls in energy intensity—below rates that would meet SDG target 7.3—will require strengthened government policies on energy efficiency. Decades of global experience demonstrate that well-designed and -implemented energy efficiency policies can deliver a range of benefits beyond energy and emissions savings. Governments can realize these benefits through straightforward policy decisions.

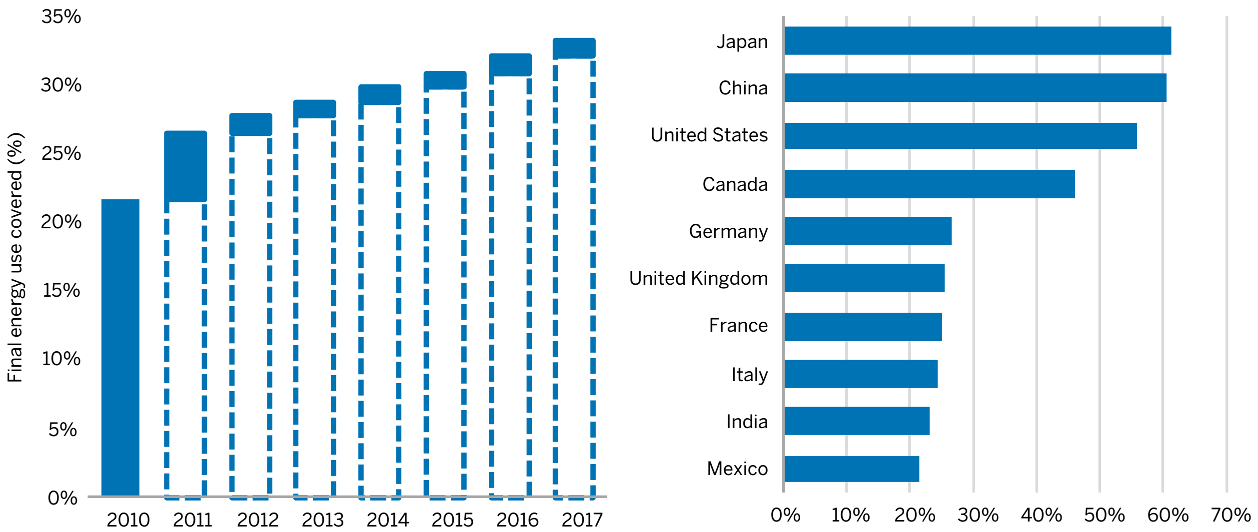
Strong policy action is also vital to signal to investors that energy efficiency is a long-term priority, which will create more certainty for investors and catalyze the transformative investments needed to return the world to a path leading to the fulfillment of SDG target 7.3.

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 educated decisions. Here, we describe some options and policies.[29]

Analysis of energy use covered by regulatory instruments[30] 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, 2010–17 (left), and 2017 coverage in the 10 countries with the highest total primary energy supply (right)



Source: IEA 2019a.

29 More information and examples can be found in 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 forthcoming recommendations of IEA's Global Commission for Urgent Action on Energy Efficiency.

30 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 (as in the Technology Collaboration Programme on Energy Efficient End-Use Equipment, 4E-TCP [IEA 2016]). To date, over 80 countries have adopted MEPS, covering more than 50 different types of technologies in different 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.

Japan, for example, encourages companies to compete with one another to obtain the official “Top Runner” label. Consumers know this label confers a “best in class” energy efficiency rating. The program covers everything from passenger cars to refrigerators. Performance standards are dynamic, so every few years the most efficient devices are set as the new standard for everyone to meet (METI 2015). In operation since 1999, Top Runner has increased the international competitiveness of Japanese companies and given consumers access to efficient and highly cost-effective equipment. The program also reduced oil imports by more than 220,000 barrels in 2015 (METI 2015).

Government actions to reduce the cost of energy-efficient equipment include economic incentives such as grants or loans. But bulk procurement policies are another tool for easing the cost of energy efficiency investments. Bulk procurement has governments leveraging their considerable purchasing power to procure energy-efficient services or products. Bulk procurement creates economies of scale, cuts the costs of services and products, and in some cases fosters new or spin-off markets.

India, for example, is procuring millions of efficient lights through a national program called Unnat Jyoti by Affordable LEDs for All (UJALA), which has already delivered more than 300 million lamps across India.[31] Although the program receives no public subsidy, consumers are able to pay for the lamps partly up front and partly out of the ongoing savings. The purchasing power of the large program means that consumers pay only Rs. 70 (USD 1) for an energy-efficient light-emitting diode (LED) bulb, well below the market price.

POLICIES FOR LEVERAGING DIGITAL TECHNOLOGIES TO SCALE UP EFFICIENCY

Emerging digital technologies could be harnessed to make them more energy efficient so they do not simply add to global energy demand. But this would require concerted policy action across several fronts. IEA’s Readiness for Digital Energy Efficiency policy framework (IEA 2019a) identifies eight principles for policy makers to consider when planning for emerging digital technologies. Many of these principles would require energy policy makers to work closely with their counterparts across the government to address complicated, cross-cutting issues such as data protection, privacy, and access. The eight principles are as follows:

1. Improve access to energy-related data
2. Ensure adequate protection for cyber security and data privacy
3. Strengthen trust in digital technologies
4. Ensure energy markets value the services provided by digital energy efficiency
5. Ensure equitable access to digital technology and infrastructure
6. Increase digital skills and plan for job market transformation
7. Minimize negative environmental impacts
8. Encourage technology and business model innovation

31 India’s UJALA program is described at https://eeslindia.org/content/raj/eesl/en/Programmes/UJALA/About-UJALA.html.

BOX 4.5 • MARKET DESIGN AND INCENTIVES FOR EFFICIENCY INVESTMENTS

In addition to applying the right mix of available efficiency policy instruments, policy makers may also need to consider how the design of energy and power markets may create incentives and disincentives to efficiency investments. With conducive regulatory frameworks, and opportunities to bid into capacity markets, for example, policy makers have an opportunity to incentivize greater investments in energy efficiency

Light-emitting diode (LED) street lighting is a further example of how efficiency incentives may be affected by power market design. Converting older street lighting technologies to LED can generate energy savings of between 40 and 70 percent, not to mention additional maintenance savings and improved urban lighting. Thanks to these large potential savings, LED projects can offer competitive and swift returns. In some countries, however, municipal and other public lighting projects are not being deployed at scale due to energy market distortions (which may have adverse effects not only on efficiency but also on supply quality and system costs). These may include the way in which electricity generators and network distribution companies are regulated and compensated, for example, through obligated procurement or power purchase agreements with a regulated price for electricity set above competitive market rates. In cases where a utility operates street lighting infrastructure, and in parallel obtains a fixed amount from municipalities for the electricity to operate that infrastructure, there is little incentive for the utility to invest in conversion to LED lamps.

Policy makers wishing to address these kinds of distortions might consider regulation more aligned with market mechanisms as well as with social, economic, and environmental objectives. In addition to delivering carbon emission reductions and reducing consumer energy bills, such an approach can lower system costs, improve quality of supply, and incentivize efficiency gains across the distribution network. It can also lessen risks and cut transaction costs, creating a more attractive environment for efficiency investments.

ENERGY EFFICIENCY INVESTMENT

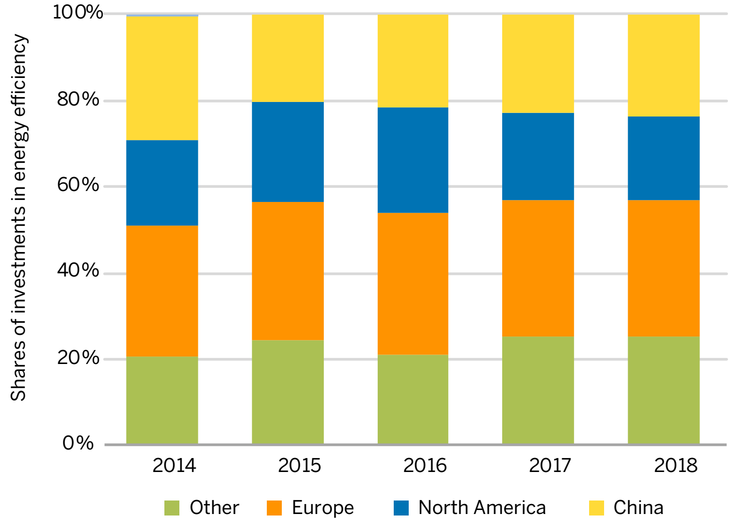
Annual global investments in energy efficiency have remained largely unchanged since 2015. Investments into energy efficiency typically fall into one of the following four key areas:

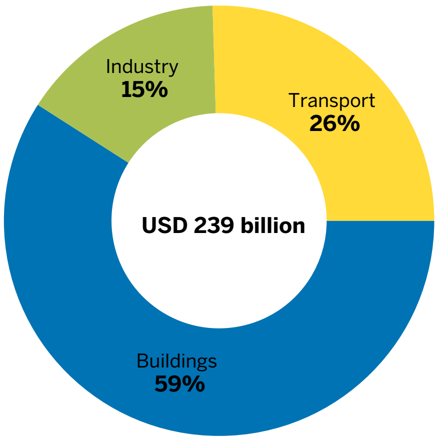
1. Incremental spending on more efficient technologies
2. Project investments by energy service companies
3. Green mortgages, green bonds, and property-based repayment schemes
4. Climate mitigation investments by international financial institutions

In 2018, incremental efficiency investments across the buildings, transport, and industry sectors stood at USD 236 billion, representing a growth rate of less than 1 percent compared to average annual investment between 2015 and 2017 (Figure 4.11). While declining slightly in 2018, the buildings sector consistently receives the highest share—nearly 60 percent—of total investments. Industrial energy efficiency investments increased in China by 12 percent and in India by 5 percent in 2018, but have continued to decline in the United States since 2015. Transport efficiency investments increased only slightly in 2018, and mainly in freight, while sales of less-efficient light-duty trucks increased (IEA 2019a).

Deploying readily available efficiency technologies is one of the most cost-effective means of saving energy while reducing emissions and achieving wider SDG objectives. At current levels, however, the world is not investing enough in efficiency, suggesting a major missed opportunity. Unlocking the full potential of efficiency would require current annual investment levels to double by 2025, and double again between 2025 and 2040, according to IEA (2018) analysis.

FIGURE 4.11 • Energy efficiency investment by region (left) and sector (right), 2018





Source: IEA 2019a.

HVAC = heating, ventilation, and air conditioning.

CONCLUSIONS

The improvement rate for energy intensity has slowed over the past few years, falling below the annual 2.6 percent initially projected as a prerequisite to reaching SDG target 7.3. The year 2017 saw a 1.7 percent improvement from 2016—the lowest since 2010. The average rate over that seven-year period, 2.2 percent, was better than the 1.3 percent annual average of the previous decade, but still low enough to require an average rate of more than 3 percent every year through 2030 in order to meet the target of halving energy intensity by 2030. Early estimates for 2018 and 2019 suggest improvement rates of 1.3 percent and 2.0 percent, respectively, indicating that the slowing progress since 2015 may be turning around.

The 3 percent target remains within reach, given substantial investment in cost-effective energy efficiency improvements on a systematic scale. In addition to reducing emissions and mitigating global warming effects, improved efficiency at this scale would be a key factor in achieving affordable, sustainable energy access for all. The recent slowdown of intensity improvements, the potential opportunities for investment, 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.

Key to the progress some countries are making toward energy efficiency has been the decoupling of their economy from their energy use. This is most noticeable in countries like Japan, where minimally energy-intensive sectors (e.g., the services sector) 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 service 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 every segment of the sector aside from freight shows improved efficiency rates. 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-scale data collection, analysis, and utilization can help to optimize demand and consumption at scale and improve energy efficiency at a systems level. Sector-specific digitalization solutions are also having a marked effect on energy efficiency. Some applications for the urban transport sector, for example, could achieve a 50 percent reduction in carbon emissions by 2050 against business-as-usual rates. This burgeoning trend is not exempt from risks, however. In addition to the opportunities to optimize efficiency, digitalization also can improve access to energy and in some cases drive up demand. 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 the technology and resources it needs to double the rate of energy efficiency improvement by 2030, over the rate observed between 1990 and 2010. 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 7.3, improve economic development, and ensure universal access to clean, efficient energy.

METHODOLOGY

Total primary energy supply (TPES) in megajoules (MJ)	This represents the amount of energy available in the national territory during the reference period. It is calculated as follows: Total primary energy supply = Primary energy production + Import of primary and secondary energy – Export of primary and secondary energy – International (aviation and marine) bunkers – Stock changes. (The definition is consistent with International Recommendations for Energy Statistics). *Data sources:* IEA Energy Balances, supplemented by UNSD for countries not covered by IEA.
Gross domestic product (GDP) in 2011 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 2011 USD PPP. *Data source:* World Development Indicators.
Primary energy intensity in MJ/ USD (2011) PPP	$Primary\ energy\ intensity = \frac{TPES\ (MJ)}{GDP\ (USD\ 2011\ PPP)}$ Ratio between TPES and GDP is measured in MJ per USD (2011) 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:* IEA Energy Balances, supplemented by UNSD for countries not covered by IEA.
Value added in USD (2011) 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:* World Development Indicators.
Industrial energy intensity in MJ/ USD (2011) PPP	$Industrial\ energy\ intensity = \frac{Industrial\ TFEC\ (MJ)}{Industrial\ value\ added\ (USD\ 2011\ PPP)}$ Ratio between industry TFEC and industry value added, measured in MJ per USD (2011) PPP. *Data sources:* IEA Energy Balances and World Development Indicators (for value added).
Services energy intensity in MJ/ USD (2011) PPP	$Services\ energy\ intensity = \frac{Services\ TFEC\ (MJ)}{Services\ value\ added\ (USD\ 2011\ PPP)}$ Ratio between services TFEC and services value added measured in MJ per USD (2011) PPP. *Data sources:* IEA Energy Balances and World Development Indicators (for value added).

Agriculture energy intensity in MJ/ USD (2011) PPP	$Agriculture\ energy\ intensity = \frac{Agriculture\ TFEC\ (MJ)}{Agriculture\ value\ added\ (USD\ 2011\ PPP)}$ Ratio between agriculture TFEC and agriculture value added measured in MJ per USD (2011) PPP. *Data sources:* IEA Energy Balances and World Development Indicators (for value added).
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/tonne-km	$Freight\ transport\ energy\ intensity = \frac{Freight\ transport\ TFEC\ (MJ)}{Tonne\text{-}kilometers}$ Ratio between freight transport final energy consumption and activity measured in MJ per tonne-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 TPES input to power generation. *Data source:* IEA Energy Balances.
Power transmission and distribution losses (%)	$Power\ transmission\ and\ distribution\ losses = \frac{Electricity\ losses}{(Electricity\ output\ main + Electricity\ output\ CHP + Electricity\ imports)}$ 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.
Data sources cited in this table	IEA World Energy Balances database, https://www.iea.org/data-and-statistics/. UNSD Energy Balances database, https://unstats.un.org/unsd/energystats/. World Development Indicators database, http://datatopics.worldbank.org/world-development-indicators/. IEA Mobility Model.

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