



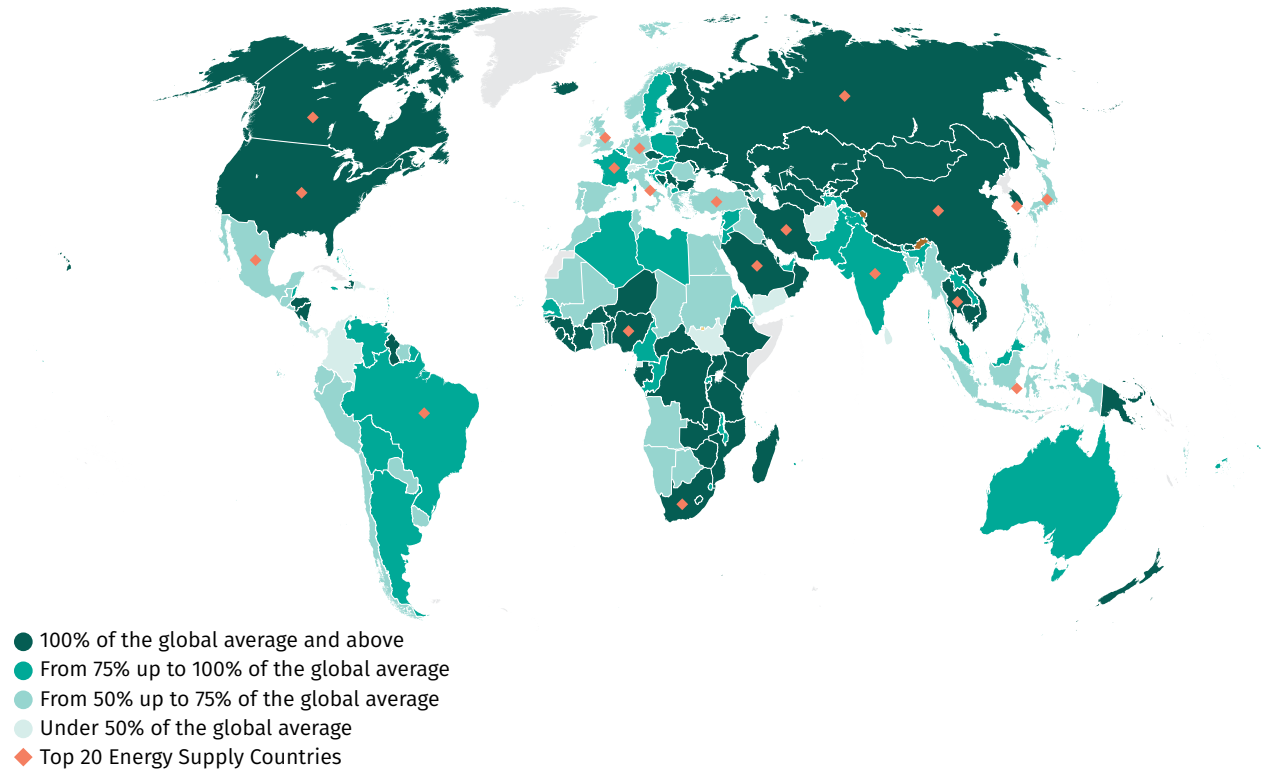
CHAPTER 5 – **ENERGY EFFICIENCY**

MAIN MESSAGES

- **Global trend:** During the period 2014-15, global primary energy intensity fell by 2.8%, reaching 5.3 megajoules (MJ) per 2011 purchasing power parity dollar (PPP \$). This is the fastest decline since 2010, the start of the tracking period. Thus, the headline indicator for energy efficiency, which is the compound annual growth rate of primary energy intensity since 2010, improved from -2.0% (2010-14) to -2.2% (2010-15).
- **2030 target:** However, this rate is still short of the -2.6% target needed to meet the 2030 Sustainable Development Goal (SDG) 7.3 target for energy efficiency. Historical trends show that a 2.6% annual improvement was achieved in only three individual years since 1990, making the goal challenging. Each year that the improvement rate is not met raises the effective target for the remaining years to 2030, and this now stands at -2.7%.
- **Regions and income groups:** On a global level, GDP grew nearly twice as fast as primary energy supply¹ in 2010–15, but results were mixed among regions and income groups. A lack of consistent progress was noticeable in the Western Asia and Northern Africa region and the Latin America and Caribbean region, with Western Asia and Northern Africa being the only region where GDP growth did not outpace energy supply. All income groups achieved faster GDP growth than energy supply, but progress continues to be slow in low-income countries, where energy intensity is higher than the global average.
- **Demand-side intensity:** Globally, although the industry sector still consumes the most energy, it made the most progress toward improved efficiency, which was especially noticeable in the upper- and lower-middle-income groups. Among high-income countries, transport remains the highest energy-consuming sector. Recent innovations in digitalization and electric mobility represent a key opportunity for policy makers to drive reductions in transport energy intensity, especially for freight transport. Residential energy intensity increased in low- and middle-income countries since 2010. As housing demand and service levels grow with economic development in low- and lower-middle-income countries, energy efficiency in the residential sector is critical to avoid costly lock-ins of inefficient buildings and appliances.
- **Supply-side intensity:** The average thermal efficiency of fossil fuel powered electricity generation continues to increase, reaching 39% in 2015. This increase is driven primarily by more efficient natural gas power plants. By contrast, the average efficiency of coal-fired plants remained relatively stagnant, suggesting limited uptake of supercritical technology. There was a similar lack of progress in the thermal efficiency of oil-fired power generation. Power transmission and distribution losses remained unchanged, and continue to show a strong correlation with income levels, highlighting the potential for improvement in developing countries.

- Largest energy suppliers:** The performance of the world's top twenty countries in terms of energy supply is critical to achieving the SDG 7.3 target. In 2015, these countries accounted for nearly 80% of total primary energy supply. Encouragingly, six of them, including two of the world's top five (Japan and the United States), seem to have reached a peak in energy demand, and reduced their annual primary energy supply in 2010–15 while continuing to grow GDP. Eight of the largest countries also outperformed the world average in reducing their energy intensity during the tracking period, with China, Indonesia, Japan, and the United Kingdom exceeding 3% improvement.

FIGURE 5.1 • Primary energy intensity in 2015 (MJ/2011 \$US PPP)



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

THE STORY IN PICTURES

GLOBAL TRENDS

Global primary energy intensity is declining consistently, but at a variable and insufficient pace, making the SDG7 target challenging

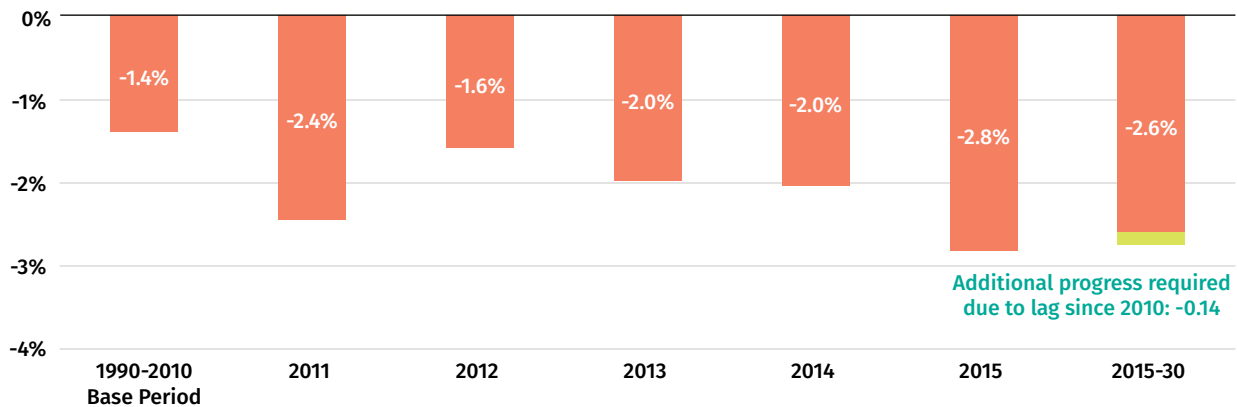
FIGURE 5.2 • Global primary energy intensity and its annualized change, 1990-2015



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

Due to underperformance in 2010-15, more rapid improvements beyond the original target will be required in the remaining years 2016-2030

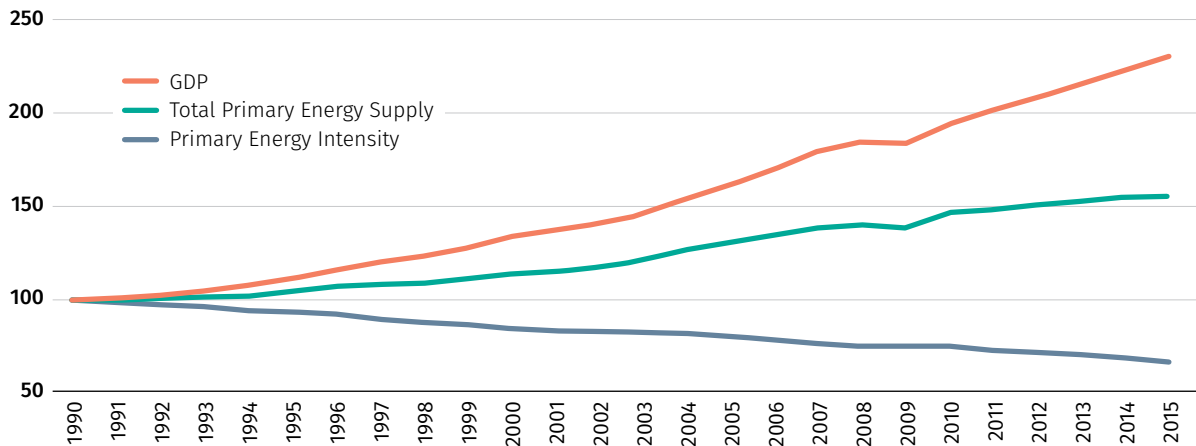
FIGURE 5.3 • Compound annual growth rate of primary energy intensity by period, and target rate for 2015-30 (%)



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

The decrease in total primary energy intensity means that in 2015, each unit of energy produced nearly 1.5 times more gross domestic product (GDP) than in 1990

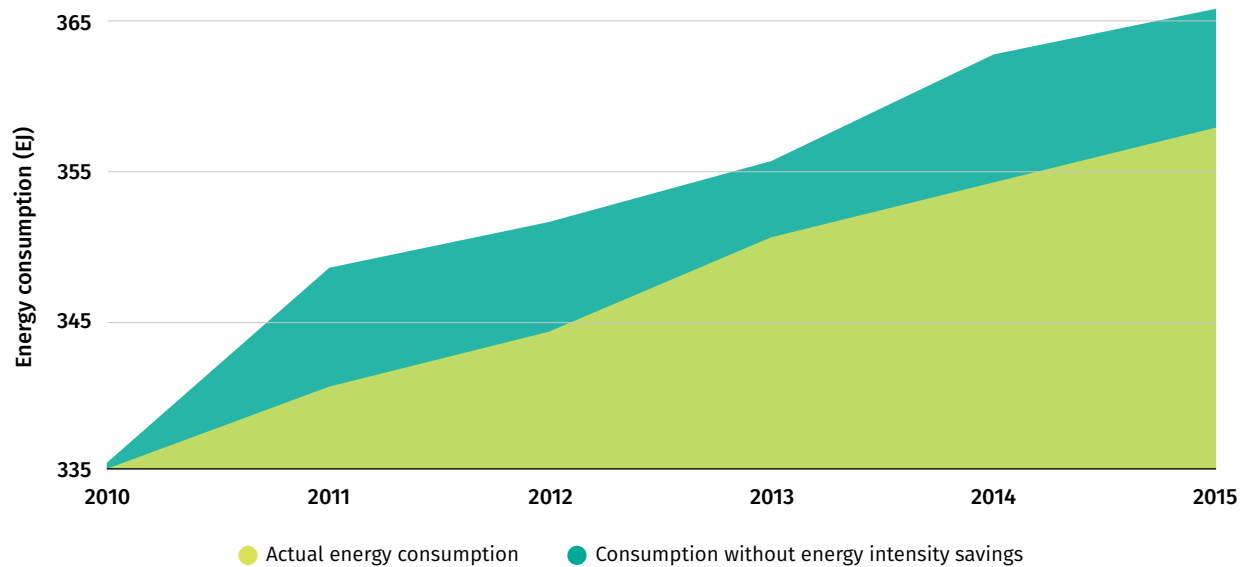
FIGURE 5.4 • Trends in underlying components of primary energy intensity at a global level, 1990-2015 (Index, 1990=100)



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

Cumulative energy savings from intensity improvements since 2010 are large enough to meet India’s energy needs in 2015

FIGURE 5.5 • Final energy consumption with and without energy savings from intensity improvements

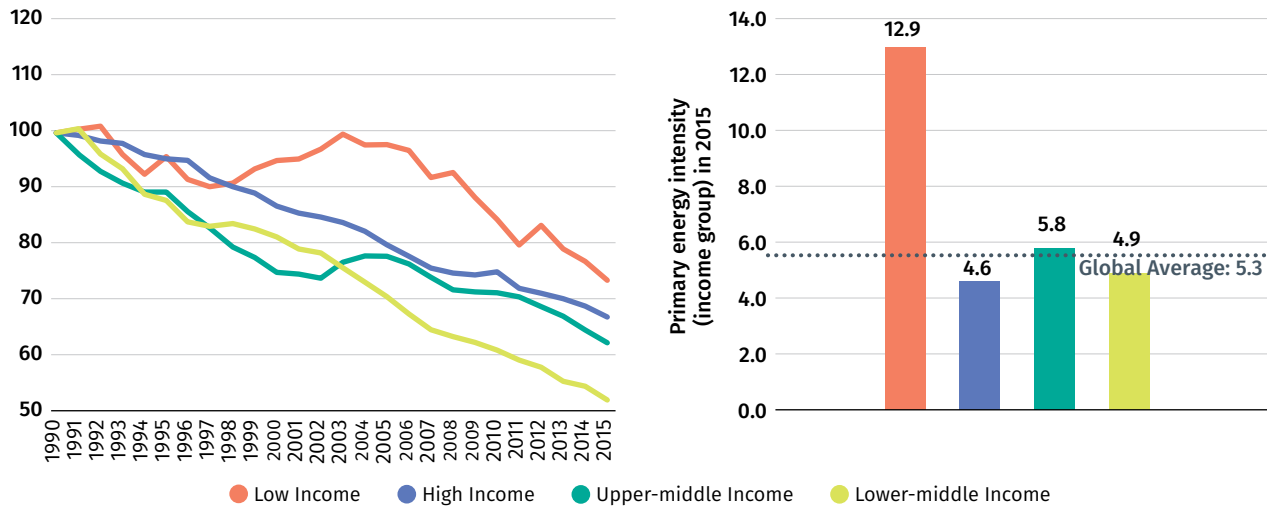


Source: WHO Global Health Observatory; WDI data

REGIONS AND INCOME GROUPS

All income groups are making progress in reducing energy intensity, particularly lower-middle income and upper-middle income countries

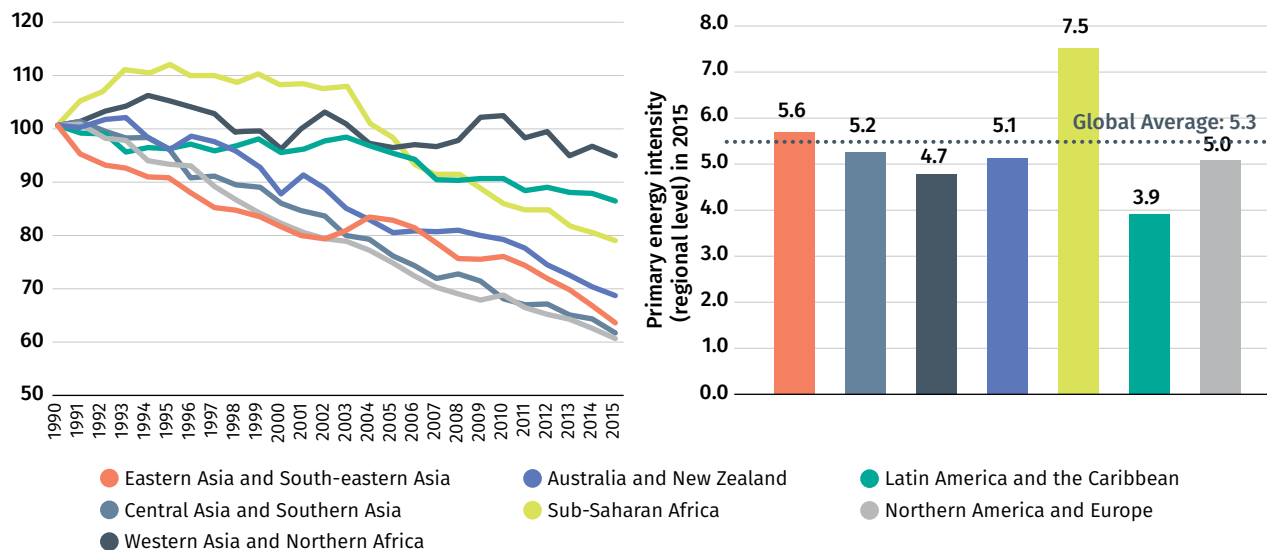
FIGURE 5.6 • Primary energy intensity by income group, as an index (1990=100) for 1990-2015 and in absolute terms for 2015



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

However, regional progress is uneven, with Western Asia and Northern Africa, in particular, barely having reduced primary energy intensity since 1990

FIGURE 5.7 • Primary energy intensity at a regional level, as an index (1990=100) for 1990-2015 and in absolute terms for 2015

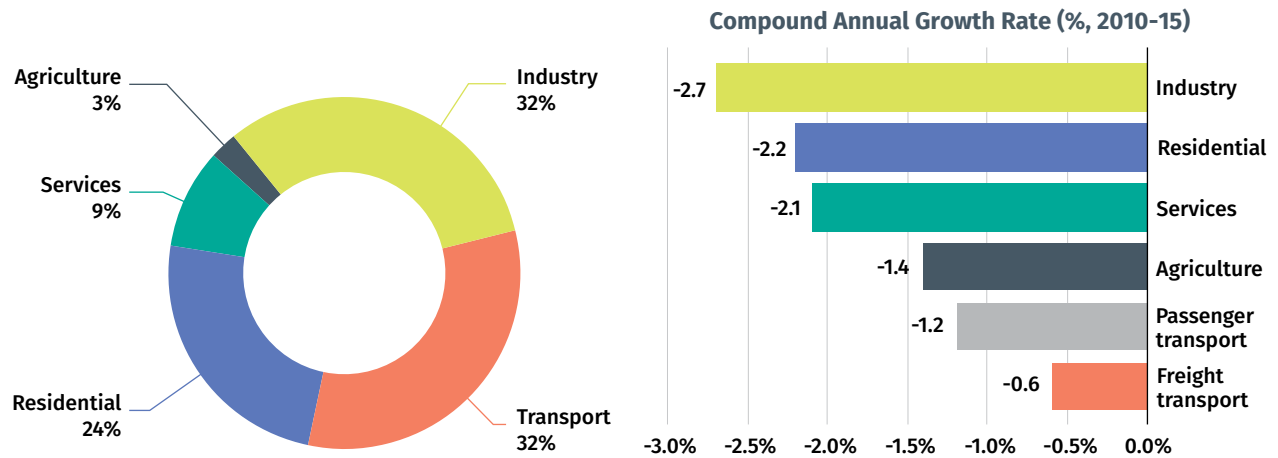


Source: International Energy Agency (IEA), United Nations Statistics Division (UNSD) and World Development Indicators (WDI) data

DEMAND-SIDE EFFICIENCY

Energy intensity reductions were driven primarily by industry, which has the largest share in final energy consumption and the fastest rate of improvement among all end-use sectors

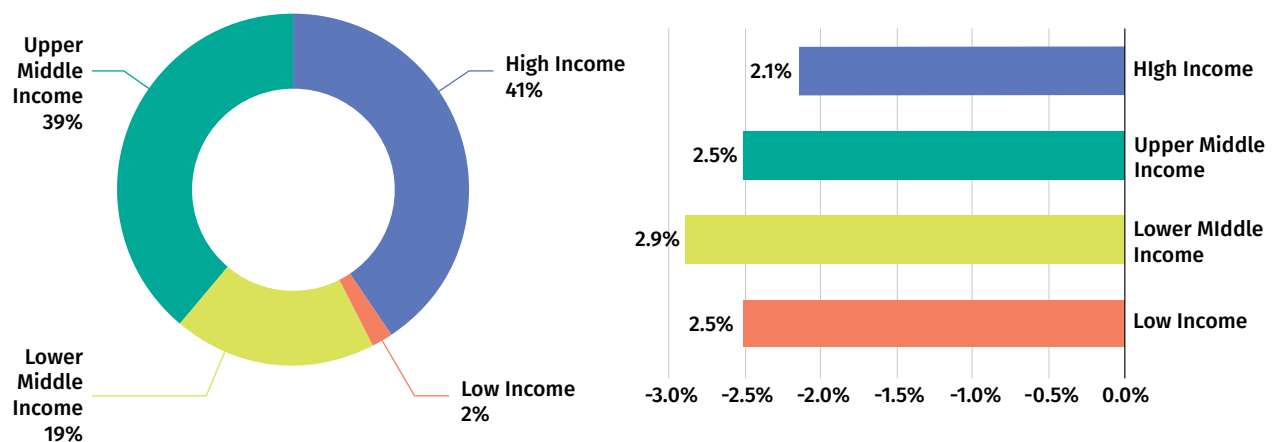
FIGURE 5.8 • Breakdown of total final energy consumption by sector, 2015; and compound annual growth rate of energy intensity by sector, 2010-2015



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

High income and upper-middle income countries account for more than three quarters of energy savings

FIGURE 5.9 • Breakdown of total final energy consumption by income group, 2015; and compound annual growth rate of energy intensity by income group, 2010-2015

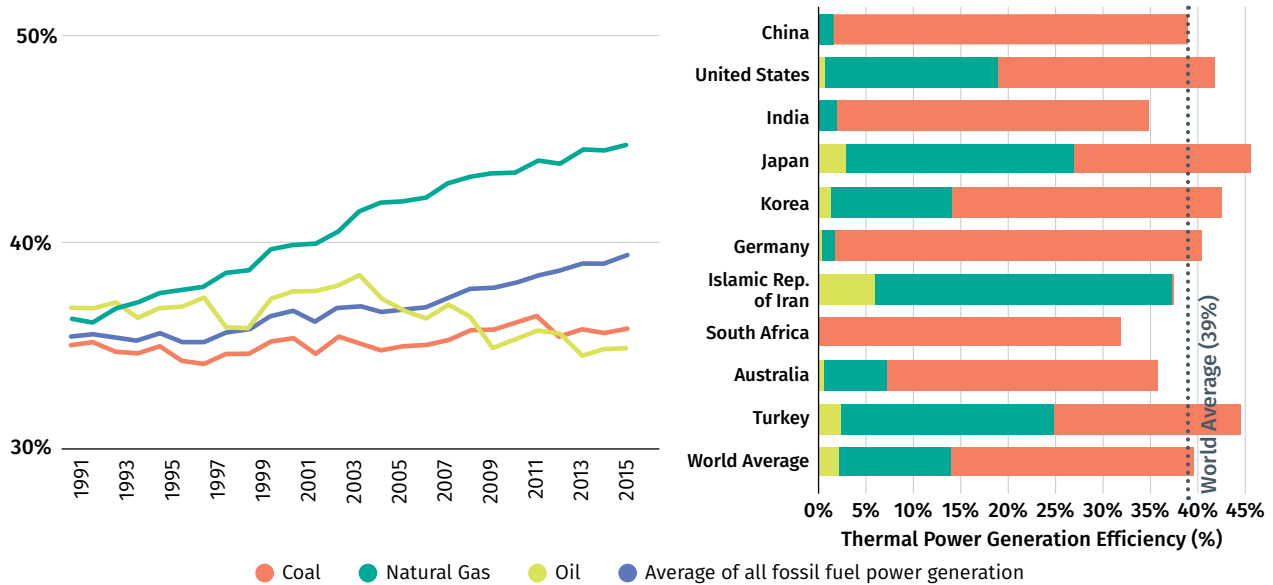


Source: International Energy Agency (IEA), United Nations Statistics Division (UNSD) and World Development Indicators (WDI) data

SUPPLY-SIDE EFFICIENCY

Rising global thermal power generation efficiency reflects greater efficiency and adoption of natural gas power plants, but more widely used coal-fired plant has not raised its efficiency

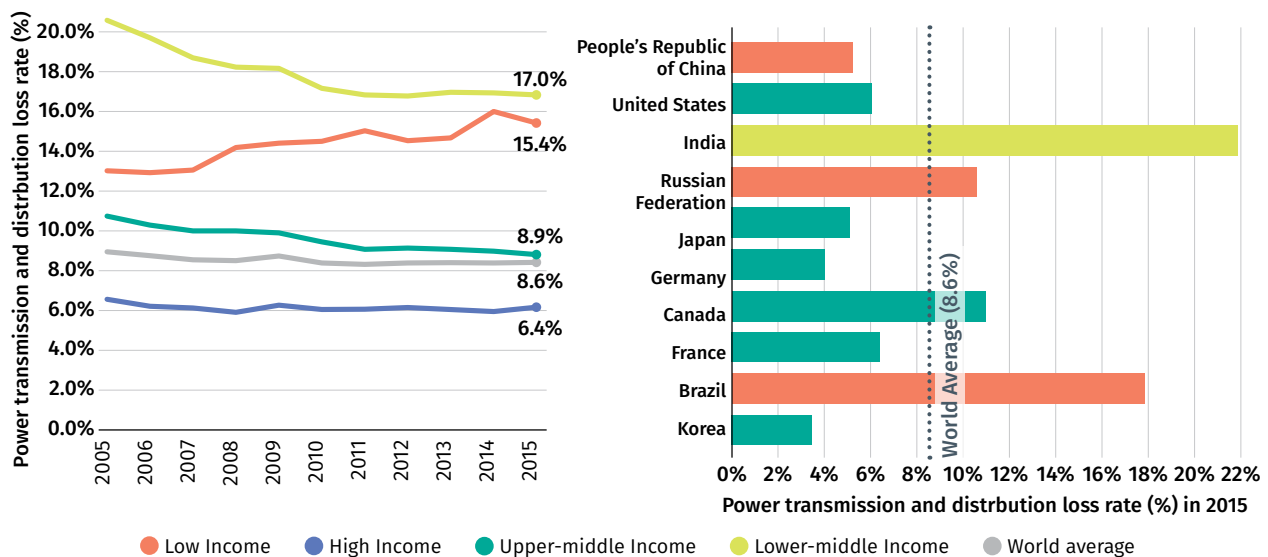
FIGURE 5.10 • Thermal efficiency of fossil fuel power generation by fuel, 1990-2015; and by top 10 thermal power producers, 2015



Source: International Energy Agency (IEA)

Power transmission and distribution loss rates of income groups suggest a significant improvement potential as income levels rise, particularly in Brazil and India

FIGURE 5.11 • Power transmission and distribution loss rates by income group, 2005-2015; and by top 10 power producers, 2015

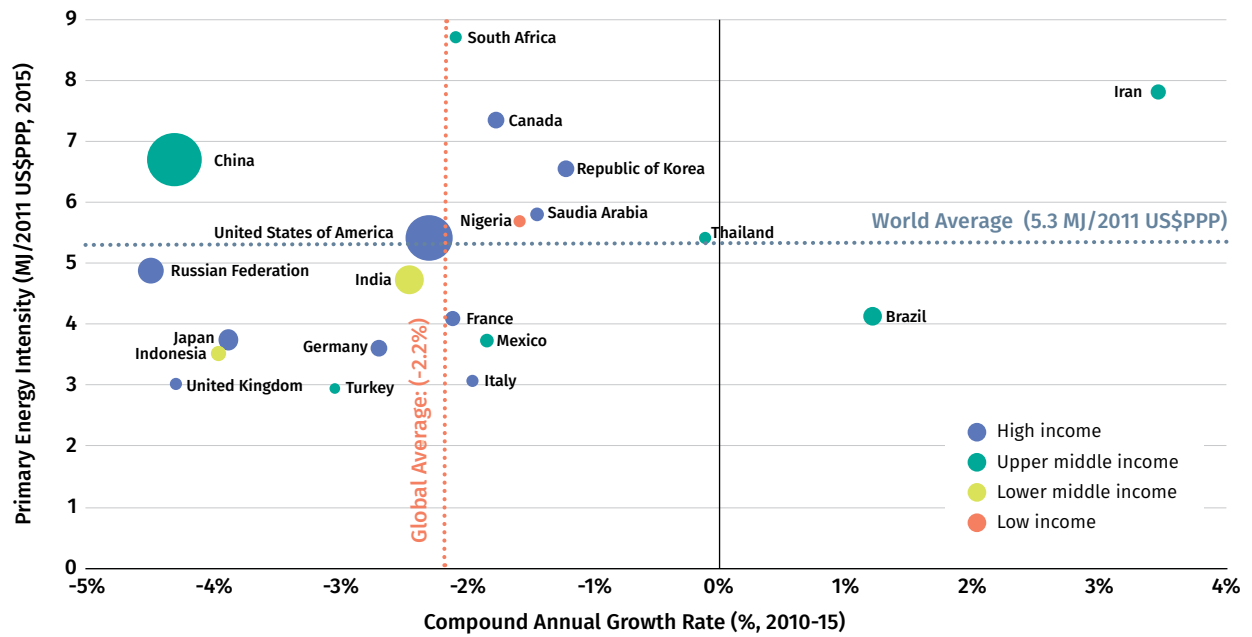


Source: International Energy Agency (IEA)

COUNTRY TRENDS

Eight of the world's largest energy users reduced their energy intensity more rapidly than the world as a whole

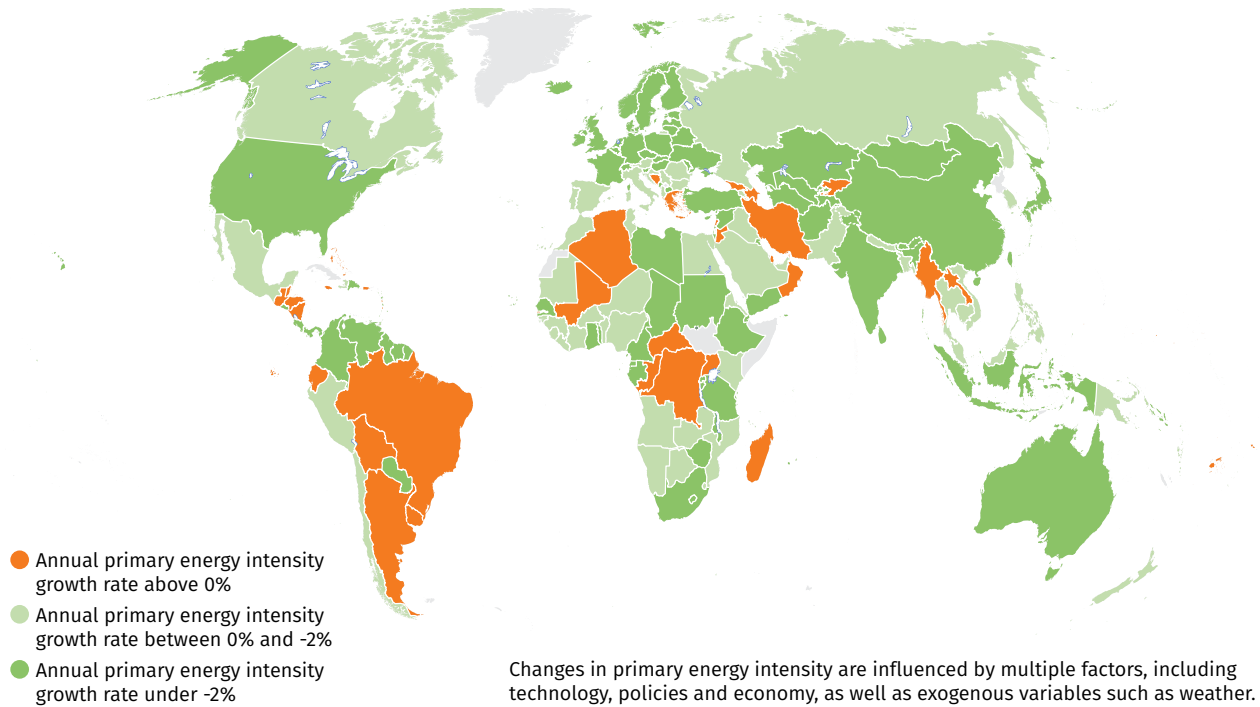
FIGURE 5.12 • Top 20 energy supply countries' compound annual growth rate of energy intensity, 2010-2015, and primary energy intensity, 2015, with bubbles scaled to energy supply



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

Despite strong progress in many large economies, a number of countries have seen their energy intensity systematically increase during the 2010-2015 period

FIGURE 5.13 • Compound annual growth rate of primary energy intensity, 2010-15



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

POLICY IMPLICATIONS

Energy efficiency is imperative to sustainable development – it can narrow energy access gaps, minimize growing energy demands, improve service levels, and lower costs for all sectors of the economy.

The Sustainable Development Goal 7.3 target of doubling the global rate of improvement in energy efficiency by 2030 is tracked through improvements in energy intensity. Reducing energy supply relative to GDP growth decreases energy intensity and creates significant economic, environmental, and social benefits. Energy intensity is the direct inverse of energy productivity. A reduction in energy intensity is directly correlated with an increase in energy productivity, meaning that more economic output is achieved for every unit of energy consumed. As SDG 7 is currently under review by the United Nations (UN), Policy Brief #1 on ensuring universal access to electricity, and Policy Brief #4 on “Doubling the Global Rate of Improvement in Energy Efficiency” outline priority actions on energy efficiency.

In 2015, the global economy continued its long-term trend of decreasing its primary energy intensity by achieving its highest rate of annual improvement since 1990. This was the first time since the start of the tracking period in 2010, that the SDG7 target rate of improvement (2.6%) was surpassed. Global energy demand decreased by 0.8% while GDP grew over 3%. Continuing this trend through 2030 will remain a challenge given the growing energy demands of many emerging economies. Policymakers can benefit from a wealth of proven policies and available technologies, prioritizing the most impactful sectors in their respective countries.

The impacts of energy intensity improvements cannot be ignored. In terms of economic expenditures, energy intensity improvements between 2000-2015 have avoided over \$4 trillion in global spending¹ The global economy produced an additional \$40,000 (USD PPP 2011) per MJ of energy in 2015 compared to 2000. Energy intensity improvements have avoided a billion tonnes of greenhouse gas emissions per year since 2014.²

¹ IEA World Energy Statistics and Balances 2017 (database)

² IEA Energy Efficiency 2017, adapted from World Energy Statistics and Balances 2017 and CO2 Emissions from Fuel Combustion (databases)

REGIONAL AND INCOME GROUP VARIATIONS

BOX 5.1 • TRACKING ENERGY EFFICIENCY

Energy efficiency policy development requires a sound national energy balance, with detailed demand-side data, in order to understand the dynamics of energy-use across various sectors. Energy intensity (energy use per unit of activity) is a key metric used in efficiency analysis and policy development. However, in addition to improvements in energy efficiency, energy intensity is also influenced by other factors, including the electricity generation mix, structure of an economy, the exchange rate, the affordability of energy services, the size of a country, climate and behaviour.

To generate a greater understanding of energy efficiency, data relating energy use to specific activities at a subsector level are required. Examples include lighting energy use per unit of floor area in buildings, or energy use per unit of production in an industry subsector. The availability of data necessary for a more detailed understanding of energy efficiency trends is variable across countries. Therefore, a critical need is to increase the quantity and quality of data necessary for analysis of energy efficiency trends in order to better understand the impact of policy measures and areas where further action is needed. Further information about the development of energy efficiency indicators has been published by the World Bank's Regulatory Indicators for Sustainable Energy (RISE) index,¹ and the International Energy Agency (IEA)² with training courses also available for policymakers and statisticians.³

¹ <https://rise.worldbank.org>

² <https://www.iea.org/publications/freepublications/publication/energy-efficiency-indicators-essentials-for-policy-making.html>

³ <https://edx.iea.org/>

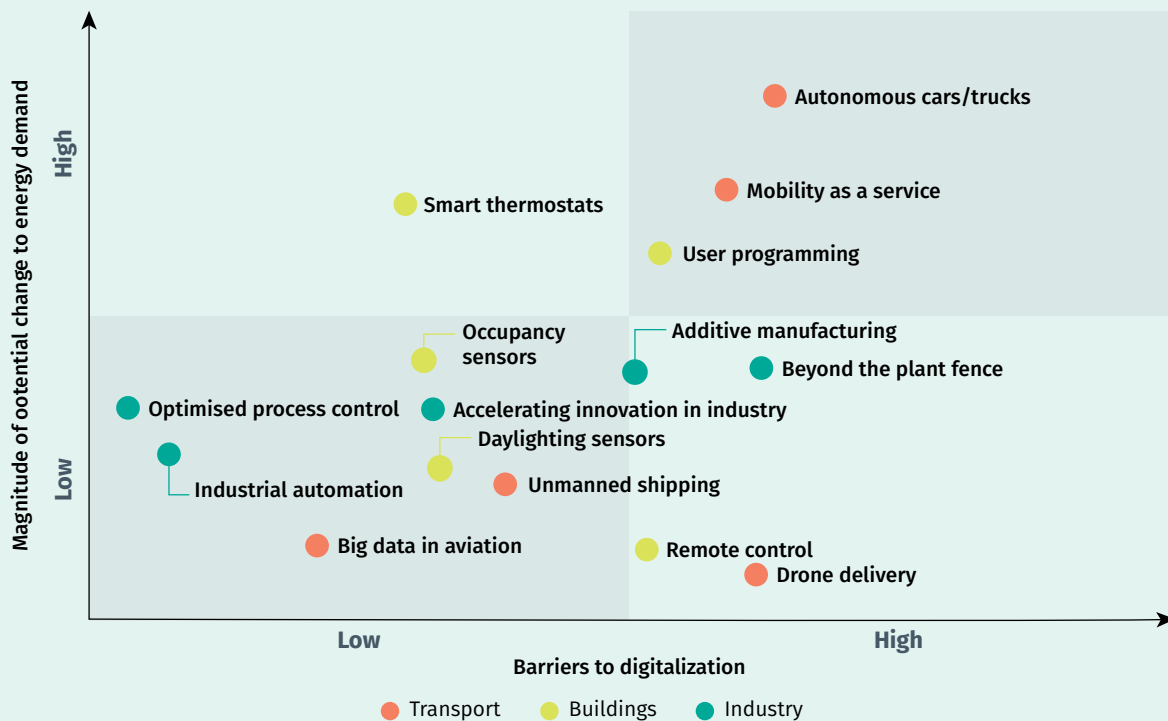
Since the start of the tracking period in 2010, energy intensity improved each year in all regions other than the Western Asia and Northern Africa region, where a yearly regression occurred on two separate occasions. The GDP growth of most countries in this region is tied heavily to energy intensive oil and gas extraction. The sharp decline in oil and gas prices throughout most of the tracking period partly explains the modest pace of GDP growth relative to energy supply. Despite large increases in energy demand, emerging economies in the Asia and the Pacific and the Africa regions have now surpassed the global rate of improvement in energy intensity, but intensity levels continue to be higher than the world average. High income countries throughout Europe and the Americas are also showing consistent decline in energy intensity during the tracking period, but at a slower rate than low and middle income countries.

The performance of the world's 20 largest energy supply countries is critical to achieving the SDG7 target. In 2015, these countries accounted for nearly 80% of total primary energy supply worldwide. The pace of energy intensity improvement in eight of the world's twenty largest energy supply countries (referred to as the Top 20) surpassed the world average of 2.2% during the 2010-2015 tracking period. China, the world's largest energy consumer, led the way with an energy intensity improvement rate of over 4%. Brazil and Iran were the only two top 20 countries that did not improve energy intensity since 2010. According to the World Bank's Regulatory Indicators for Sustainable Energy (RISE) index, top 20 countries score significantly higher than the world average on energy efficiency policies and regulations, which may provide a possible explanation for performance on reducing energy intensity.

BOX 5.2 • INNOVATIVE TRENDS: DIGITALIZATION CAN IMPROVE ACCESS TO ENERGY SERVICES AND ENABLE SYSTEMS EFFICIENCY

Improvements in data collection, analytics and connectivity, which form the fundamental elements of digitalization, are set to have a big impact on energy systems across the buildings, industry and transport sectors. There is however high uncertainty on the potential impacts of digitalization given the speed of technology developments and the extent to which barriers are overcome.

FIGURE 5.15. • Digitalization's potential impact on transport, buildings, and industry



Source: IEA (2017), *Digitalization and Energy*, IEA/OECD, Paris, www.iea.org/digital

In industry, digital metering, monitoring and process controls are already helping many businesses identify and implement efficiency improvements. Advances in digital technologies such as 3D printing and greater connectivity across supply chains and markets offer further opportunities for efficiency gains. In the transport sector, vehicle automation and shared mobility services could revolutionise how people and goods are moved, but the energy implications are unclear, with energy consumption having the potential to increase or decrease substantially, depending on how these technologies are used. In buildings, digitalization is bringing new energy services to consumers, such as smart thermostats, occupancy sensors, remote control and enhanced safety features. IEA modelling estimates that these advances have the potential to cut global buildings energy use by 10% by 2040. However, digitalization also comes with an energy cost, in particular the greater use of standby power by connected devices, which could offset much of the potential savings.

Source: IEA (2017), *Digitalization and Energy*, IEA/OECD, Paris, www.iea.org/digital

An important emerging trend to note is that some developed countries seem to have reached a peak in total primary energy supply, and have even experienced reductions on a yearly basis. Traditionally, reductions in energy supply have occurred only in conjunction with lower output in large economies, for example during economic recessions. Thanks in part to energy efficiency improvements, six of the top 20 energy supply countries – France, Germany, Italy, Japan, the UK and the US – managed to reduce annual energy supply and still continue to grow GDP steadily. It should be noted that all six are high income countries that are not experiencing the same kind of rapid economic growth as emerging economies in the top 20 group such as China, India, Indonesia, and South Africa. Evidently, reducing energy supply should not be the prescribed universal goal to meet the SDG7 target. Rather, improving energy intensity will enable countries to increase the productivity of each unit of energy used.

DEMAND-SIDE EFFICIENCY

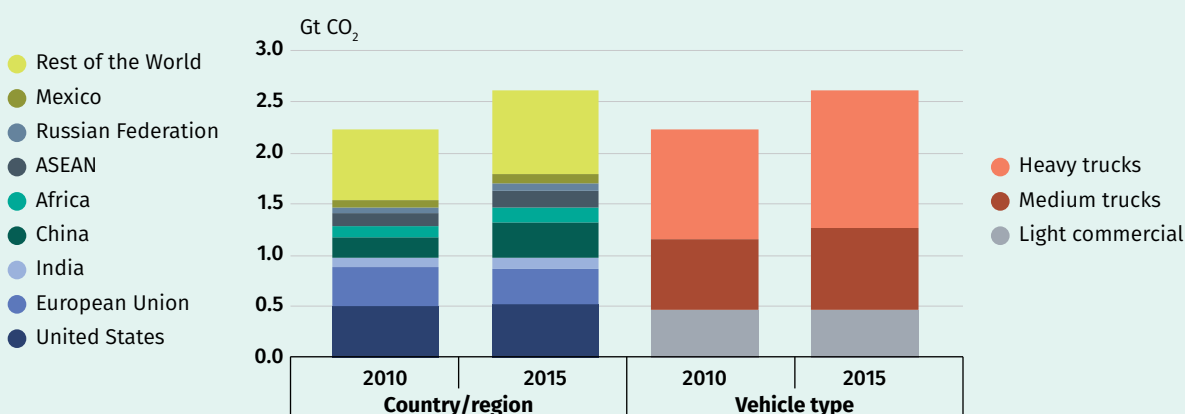
Analyzing the industry, transport and residential sectors is key to evaluate demand-side efficiency since these sectors account for the majority of the world's total final energy consumption. While the industry sector continues to consume the most energy, it has also made the most progress towards improved efficiency. Industrial energy intensity improved by 2.7% per year during the 2010-2015 tracking period, accounting for the largest share of energy savings during that period. Upper middle income and high income countries accounted for 39% and 41% of global energy savings respectively, a combined share of 80%. Amongst individual countries, China had the largest contribution, accounting for more than a third (35%) of global energy savings. The United States accounted for 13%, India for 8%, Japan, the Russian Federation and the United Kingdom of Great Britain and Northern Ireland accounted for 3% each. Savings in the industry sector accounted for the largest contribution in all of these countries. In addition to China and India, other emerging economies such as Malaysia, and Vietnam were also among the world's top 10 highest savings in industrial energy consumption. Efficiency improvements in industry can be attributed to key policy actions and the addition of new and more efficient production technologies in energy-intensive industry processes. Of particular relevance is China's Top 10,000 Energy-Consuming Enterprises Program, which covers two-thirds of the country's energy consumption, and focuses primarily on the industrial sector. It imposes a mandatory absolute energy-saving target of 250 million tonnes of coal equivalent (approximately 7,327 Tj) by 2015, as part of China's 12th Five-Year Plan.

Globally, transport has also improved its energy intensity, but at a slower pace for both passengers and freight. Passenger transport improved its energy intensity by 1.2% per annum in 2010-2015, less than the 1.9% improvement in 2000-2010, while freight transport improved by 0.5% per annum in 2010-2015, less than the 0.8% improvement in 2000-2010. High income and upper middle income countries need to prioritize the transport sector given their growing transport demands, particularly for freight transport. These two income groups are responsible for 90% of transport energy consumption since 2010. Increased freight transport in these advanced economies is an important factor. Although freight transport accounts for 43% of global energy consumption in the transport sector, its share of global emissions from the transport sector is more than 50% and growing (see Box 5.3). This is particularly worrying, considering that only 16% of energy consumption by trucks is covered by fuel economy standards worldwide.

BOX 5.3 • THE SUSTAINABILITY OF ROAD FREIGHT TRANSPORT REQUIRES URGENT POLICY ACTION

In 2015, road freight oil demand grew to 17 million barrels per day – a 50% increase since 2000. Over the period between 2010 and 2015, CO₂ emissions from road freight transport increased by 17%, driven by strong growth in China and India, and the continued expansion of the heavy-duty vehicle fleet. The amount of goods transported by heavy-duty vehicles increased by 65% and truck sales grew by 60%.

FIGURE 5.16 • Global road freight transport CO₂ emissions



Source: IEA (2017), *The Future of Trucks – Implications for Energy and the Environment*, IEA/OECD, Paris, <https://www.iea.org/publications/freepublications/publication/the-future-of-trucks---implications-for-energy-and-the-environment.html>

Despite the large and growing impact of road freight transport, regulatory policy has only recently begun to catch up. While more than 55% of energy consumption by cars was covered by fuel economy standards in 2016, only 16% of consumption by trucks was covered, with standards limited to Canada, China, Japan and the United States, and under development in the European Union, India, Korea, Mexico, and Saudi Arabia. Other policy approaches are available and are having significant impacts in some jurisdictions. Non-regulatory measures such as road tolls, scrappage programmes and voluntary green freight programmes are in place in many markets. Various member states of the European Union have experimented with these types of measures as well as having the highest fuel taxes in the world. In 2016, trucks in Europe were 14% more efficient per tonne-kilometre than those of the United States and 22% more efficient than those in China.

Sources: IEA (2017), *The Future of Trucks – Implications for Energy and the Environment*, IEA/OECD, Paris, <https://www.iea.org/publications/freepublications/publication/the-future-of-trucks---implications-for-energy-and-the-environment.html>

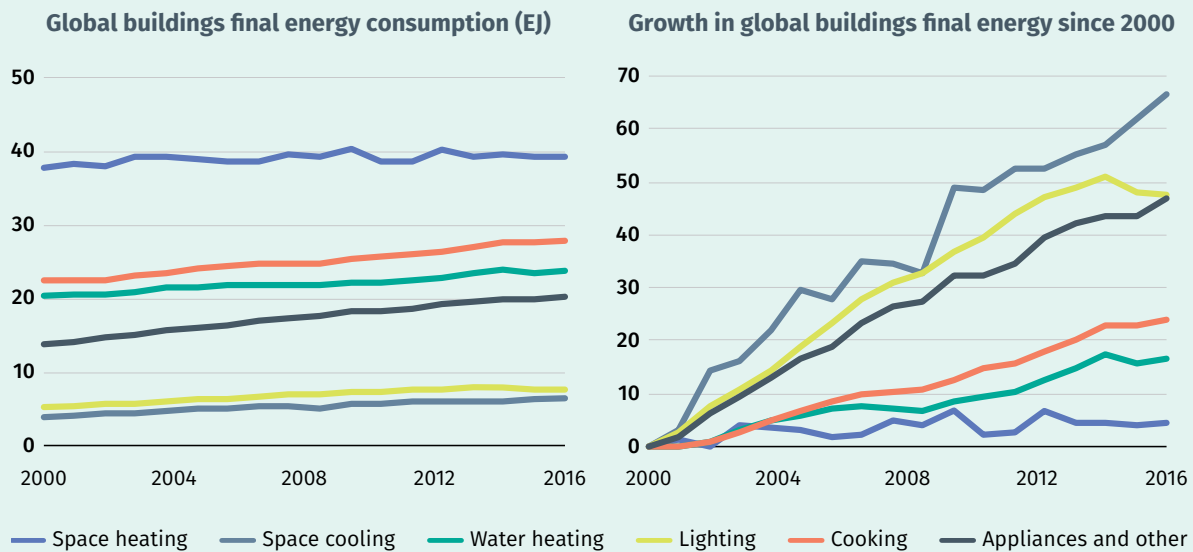
IEA (2017), *Energy Efficiency 2017*, IEA/OECD, Paris, <http://www.iea.org/efficiency/>

Low and lower middle income economies also showed improvements in industrial and transport energy intensity since 2010, but the residential sector should remain the most pressing priority for the lower income groups. Residential energy intensity increased by 2.4% per annum and 1.8% per annum for low income and lower middle income countries, respectively, in 2010-2015. An increase in housing energy demand due to economic development makes the residential sector the highest energy consuming sector among these countries. Households often cannot afford newer, more efficient appliances and heating/cooling systems, which coupled with poor building design and lack of sufficient insulation, result in poor service levels and high cost for energy. Innovations in the lighting sector that produced affordable, energy efficient lighting products are applicable to all income groups. Similar technology innovations for key household appliances and cooling equipment would address the growing residential energy demands in lower income countries. (see Box 4.4)

BOX 5.4 • BUILDING ENERGY USE IN THE 21ST CENTURY: SPACE HEATING IS THE LARGEST BUILDING END-USE BUT SPACE COOLING IS GROWING THE FASTEST

Final energy consumption in buildings continues to grow, with all buildings end-uses increasing since 2000. Space heating, cooking and water heating are the largest buildings end-uses, however they have risen relatively slowly, with less than 25% growth since 2000. Space cooling, lighting and appliances grew the fastest, with each increasing by more than 45% since 2000.

FIGURE 5.17 • Trends in global buildings final energy by end-use



Source: IEA (2017), *Energy Efficiency 2017*, IEA/OECD, Paris, <http://www.iea.org/efficiency/>

Cooling appears to have peaked in the Global North (cold and temperate countries) in 2010 with a slight decrease in space cooling energy consumption, largely driven by efficiency gains in Japan and the United States. However, globally, cooling continues to be the fastest growing building end-use, owing to growth in the Global South (mostly hot countries), where residential buildings have seen more than 300% growth, driven by increased wealth and comfort demands for cooling.

Residential buildings in the Global South also have the largest growth in appliances energy demand with nearly 170% growth since 2000. Lighting energy consumption growth is largest in non-residential buildings, growing by two-thirds since 2000. Lighting appears to have hit a global tipping point in 2015, with higher efficiency lighting enabling growing energy service demand to be met by flat or even decreasing energy consumption for the first time.

Source: IEA (2017), *Energy Efficiency 2017*, IEA/OECD, Paris, <http://www.iea.org/efficiency/>

SUPPLY-SIDE EFFICIENCY

Although the growth of clean renewable power generation has been significant in recent years, thermal power generation with fossil fuels still maintains a majority share in the electricity sector throughout the world. Natural gas is the only source that improved thermal power efficiency considerably since 2010, while coal and oil power efficiency remain stagnant. On a global level, despite the improvement of natural gas efficiency to surpass 45% as of 2015, thermal power efficiency remains below 39% on average worldwide. Coal still accounts for the vast majority of thermal power generation in many large energy consumers such as China, India, Korea, Germany, South Africa and Australia. Among the top 20 countries, half of them had thermal power efficiencies below the world average of 39% in 2015. Thermal efficiency trends clearly dictate that natural gas-powered options should be prioritized over coal-powered or oil-powered options as a long-term investment when thermal generation is necessary.

Losses in natural gas transmission and distribution have maintained a consistent declining trend since 1990. From 2012-2015, however, losses increased slightly. This reversal seems to be caused by loss increases in Malaysia, Pakistan and the Russian Federation, which together account for nearly two-thirds of global losses during this period. In 2015, average global electricity transmission and distribution (T&D) losses stayed relatively constant at 8.6%. This amounted to nearly 2,000 terawatt-hours (TWh) of electricity, equivalent to the entire electricity consumption of India and Japan combined. Although this remains a large amount, it is encouraging not to see any increase in T&D losses given the large amount of renewable energy generation capacity additions during the tracking period, which can put heavy strains on grid operations. The quality of grid infrastructure needs to keep up with the complex demands of new capacity additions. It is not surprising that loss rates remain correlated to income levels. Losses in high income countries have been consistently below the world average and have exhibited an overall downward trend, while those of upper middle income countries have been rapidly declining towards the world average. Lower middle income countries improved the most, reducing losses to 17% in 2015 from above 20% before 2005. Low income countries were the only group that showed an upward trend in T&D loss rate, jumping to 15.4% in 2015 from below 14% before 2005. As low income countries add generation capacity to meet growing energy demands, grid infrastructure needs to be upgraded concurrently to avoid further increases in losses.

CONCLUSIONS

Sustainable Development Goal 7.3 is crucial to the sustainable energy agenda. Energy efficiency will continue to address critical issues in the production, delivery, and consumption of energy for all income levels and geographical constraints. Tracking energy intensity toward the SDG7 target has revealed important priorities for policymakers to focus on. Transport energy intensity needs to improve, especially in high income and upper middle income countries. The residential sector is regressing in energy efficiency, particularly in developing countries with growing heating and cooling needs. On the supply side, the transition to more efficient and clean energy sources, such as renewables and natural gas, is not scaling up fast enough to keep up with 2030 target projections

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