circular carbon economy

01

Reduce: Energy Efficiency.

iea

International Energy Agency

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Reduce. Reuse. Recycle. Remove.

Acknowledgement

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Table of contents

Table of contents

Figures

Boxes

Executive Summary

Energy efficiency is at the forefront of the effort to transform global energy systems; it reduces energy costs, drives economic development, improves health and well-being, and reduces carbon emissions. Within the circular carbon economy framework, the "reduction" of energy demand, compared to what it otherwise would be, through energy efficiency will be critical to ensuring the effectiveness of the "reuse, recycle and remove" stages that follow.

Energy efficiency policies can help economies grow and allow greater access to affordable energy services, while reducing negative impacts of energy consumption. Implementing the full range of currently available, economically viable efficiency solutions alone could create a 50% reduction in energy intensity by 2040 compared with today. It would mean only a marginal increase in total energy consumed, despite an expected doubling in the size of the global economy, with associated benefits of energy-related greenhouse gas (GHG) emissions reduction.

IEA modelling shows the potential of existing technologies to deliver an annual energy intensity improvement rate of 3.6%, if fully deployed. This would provide around 40% of the GHG emissions abatement required by 2040 to be in line with the Paris Agreement. However, annual rates of improvement in the energy intensity of the global economy have slowed in recent years, from a high of 3% in 2015 to 1.3% and 2% in 2018 and 2019, respectively. A combination of increased economic activity, changing economic structure, more extreme weather days and lagging policy adoption have contributed to the slowing of annual improvement.

Governments can capture a wide range of benefits through investment in efficiency. These include: social benefits, like improved public health, energy access and job creation; economic benefits, such as reduced pressure on government budgets, cost savings at the individual/household level and improved energy security; and environmental benefits, including improved air quality and less pollution. Achieving the intensity gains mentioned above would save households worldwide USD 550 billion in annual energy costs by 2040.

Similarly, research shows that enhancing efficiency in the air conditioning sector, one of the fastest-growing sources of global electricity demand, could decrease emissions and greatly reduce peak demand in electricity systems. All markets show the potential to double the efficiency of air conditioning equipment with the right policies. A recent analysis of the Saudi Arabian cooling market showed that investment in improving cooling efficiency could see full payback within just two years. Likewise, proliferation of clean, efficient cooking technologies could help reduce premature deaths from household air pollution by almost 1 million per year in 2040.

The disruption to global energy systems in 2020 caused by the Covid-19 pandemic will also have many serious implications for energy efficiency. At the same time, stronger energy efficiency action offers opportunities for short-term economic stimulus and job creation, as well as putting the world on course for a more energy-efficient future.

In light of the recent Covid-19 crisis, many governments are working to stimulate economic activity through recovery packages. Investment in energy efficiency remains one of the most cost-effective, jobs-intensive instruments for economic stimulus. According to the IEA's Sustainable Recovery Plan for the Energy Sector, driving up the efficiency of buildings, appliances, industry and transport vehicles represents one of the most effective strategies for job creation, creating around 10 to 15 jobs for every million dollars of capital investment (IEA, 2020h). It also has the advantage of short lead times for scaling up activity and many of the jobs are created locally.

Looking ahead, energy efficiency presents a wide range of opportunities for economic and environmental transformation using readily available, affordable technology in every sector. Technological innovation is not the primary barrier to early progress; rather, it is the levels of ambition and political will that will drive the scale up of energy efficiency. .

Governments play a vital role. Through ambitious policies and strong incentives, and by encouraging private-sector leadership, governments can accelerate the uptake of efficient technologies and help solutions reach the scale needed to achieve global goals. For example, strengthened energy efficiency policies could ensure that the average building of 2040 is 40% more efficient than current buildings. Similarly, policies to support industrial efficiency could result in a doubling of value created per unit of energy used across the industrial and service sectors by 2040 compared with current levels.

Governments have a diversity of pathways available to implement accelerated, ambitious policy action on energy efficiency. However, they should keep in mind a common set of principles and recommendations when considering efficiency policy as part of their climate and energy strategies, both in the short term and the long term.

Governments need to be ambitious and take a broad approach by covering all sectors in their efficiency planning. It is important for them to lead by example by investing in energy efficiency of their own operations, whether through procurement policies or investment in government-owned infrastructure. Similarly, governments should engage at all levels of society to plan, implement and achieve their strategies, embracing municipal and sub-national government, civil society, industry, finance and the private sector.

Digital innovation offers huge potential to drive new progress in energy efficiency, including unlocking innovative business models and financing. It also allows for a more "systems thinking" approach to energy efficiency that looks at system optimisation rather than simply at energy end use.

Lastly, global collaboration, such as the excellent activities of the G20, is instrumental in ensuring harmonised approaches, peer-to-peer learning and stronger collective action.

G20 Actions/Recommendations

Energy efficiency is poised to play a crucial role in the circular carbon economy and presents enormous potential to create transformative change in our global energy system.

Energy efficiency investments have the capability to generate jobs and boost local economies while supporting the transition to a clean energy future.

A broad approach will be most effective. The wide diversity of measures available to policy makers provides the opportunity to integrate energy efficiency into policies across government and the economy. These measures include regulation, incentives, information campaigns, fiscal measures, voluntary agreements and more.

Additionally, a growing understanding of behavioural sciences supports the development of energy efficiency policies that are more effective and better adapted to the needs of communities.

While across-the-board investment in energy efficiency is needed, a few high-priority sectors stand out as accounting for a significant share of the potential benefits. One such sector is efficient space cooling in residential and non-residential buildings. Cooling is the fastest-growing energy end use globally and represents 12% of the world's energy saving potential from efficiency. Investment and regulations to encourage uptake of high-efficiency air-conditioning technology should especially be prioritised by countries predicted to see growing demand for cooling services in the coming years. Enhancing international collaboration on this important subsector would support an accelerated global transition to cleaner and more efficient cooling technologies, more effective building envelopes and more integrated cooling systems, such as district cooling.

Digitalisation also represents a key emerging opportunity for more efficient energy systems. It supports system-wide efficiency by leveraging real-time data and advanced analytical and data processing capabilities to identify efficiencies and capture value. In fact, research shows that digitalisation could reduce energy demand from the global buildings sector by 10% by 2040. It also provides opportunities for consumers to better understand their own energy use and improve household or facility efficiency, thus reducing waste and saving on energy costs – an especially important factor during times of economic recovery. Importantly, digitalisation also offers greater potential for system-wide optimisation of supply and demand, and brings together the concepts of flexibility and end-use efficiency in new and powerful ways.

In all areas, energy efficiency policy making is clearly seen to benefit from international exchange and collaboration, which should be further encouraged.

01

Introduction

A. Energy efficiency within the context of the circular carbon economy

At the heart of the circular carbon economy are the four Rs: reduce, reuse, recycle and remove. The first R, reduce, is the first line of action. Energy efficiency solutions enable continued economic growth and better quality of life without commensurate growth in energy demand. Without energy efficiency progress, annual increases in economic activity would have significantly greater effects on global carbon emissions. In fact, energy efficiency improvements made between 2000 and 2018 were responsible for avoiding 13% additional energy use and 14% more carbon emissions (IEA, 2019a; IEA, 2020a). Additionally, efficiency measures are projected to contribute half of potential emission reductions to 2030 and nearly 40% to 2050, as shown in Figure 1 below (IEA, 2019b).

Energy efficiency policies can reduce energy intensity – the energy needed to produce a unit of GDP. Improvements in energy efficiency support the transition to a circular carbon economy and ease the demand for the more costly or technologically advanced solutions covered by the reuse, recycle and remove factors. In fact, IEA analysis shows that investing in all energy efficiency technology opportunities that are affordable and readily available could see the size of the economy double while maintaining current levels of energy demand. In other words, if the global community realised all existing cost-effective energy efficiency potential now, we could halve energy intensity by 2040 (IEA, 2018a).

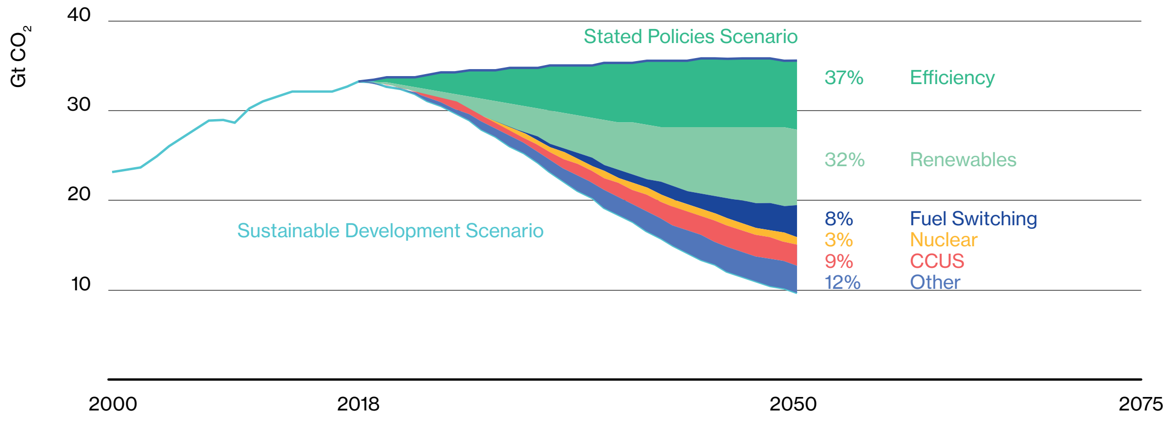

Figure 1. Additional reductions in CO_2 emissions by measure under the Sustainable Development Scenario relative to the Stated Policies Scenario
Source. IEA (2019b), World Energy Outlook.

B. The impact of the Covid-19 pandemic

The Covid-19 pandemic is primarily a global health crisis. In addition to the health impacts and tragic loss of life, the Covid-19 pandemic has major implications for global economies, energy use and carbon emissions (Figure 2).

From mid-March to mid-April 2020, the share of energy use affected by containment measures jumped from 5% to 50%. Initial IEA analysis of daily data collected for 30 countries showed that countries in full lockdown experienced an average 25% decline in energy demand per week, while countries in partial lockdown averaged an 18% decline during that period.

The full effects of the pandemic remain uncertain, but it is clear that it will have an impact on the uptake of energy efficiency, and on the wider energy system. It is estimated that total global energy demand for 2020 is projected to drop by 6%, which is the largest relative decline in 70 years and the biggest ever decline in absolute terms. This is expected to lead to an 8% fall in energy-related CO_2 emissions. While this would be the lowest level of emissions since 2010, the decline is almost entirely attributable to reductions in economic activity, as opposed to structural changes in the energy sector, meaning that emissions are likely to rebound as economies begin to return to business-as-usual operations.

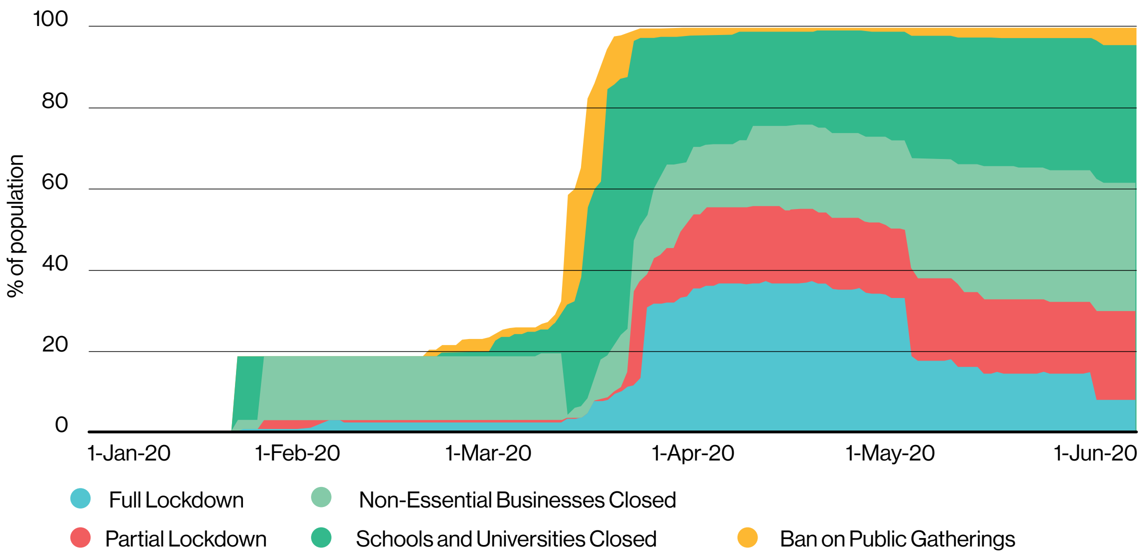

Figure 2. Share of global population under containment measures (IEA 2020)
Source. IEA (2020b), Global Energy Review 2020.

C. Trends before Covid-19

Prior to the Covid-19 pandemic, energy efficiency trends had suffered an unexpected slowdown. The 1990s, 2000s and early 2010s saw a steady improvement in global average energy intensity. The latest data show a decrease in improvement rates in all sectors. The transport sector is a notable exception to the recent slowdown, where fuel efficiency standards in major markets have driven continued improvements in energy intensity.

The average annual rate of improvement in global primary energy intensity between 2010 and 2017 was 2.2%, an improvement over the 1990-2010 rate of 1.3%. Falling from a high of nearly 3% in 2015, 2018 showed a 1.3% rate of improvement over 2017 – the smallest improvement since 2010 (Figure 3). The 2019 rate of 2.0% is an upswing in this trend; however, when normalised for weather impacts, energy intensity only improved by 1.6% compared to the previous year (IEA, 2020c). Even with that deceleration, energy efficiency remains the largest contributor to emissions abatement, responsible for almost 70% of the decreases in energy demand seen in 2019 (IEA, 2020c).

The past decade's efforts have not met the annual intensity improvement rate needed to achieve the UN's Sustainable Development Goals, which include a target of doubling the global rate of improvement in energy efficiency by 2030. The global slowdown has only increased the urgency of action on energy efficiency improvement. To achieve the UN Sustainable Development Goals' energy intensity target, the global community will have to reach an average annual improvement rate of 3.0% every year until 2030 (IEA et al., 2020).

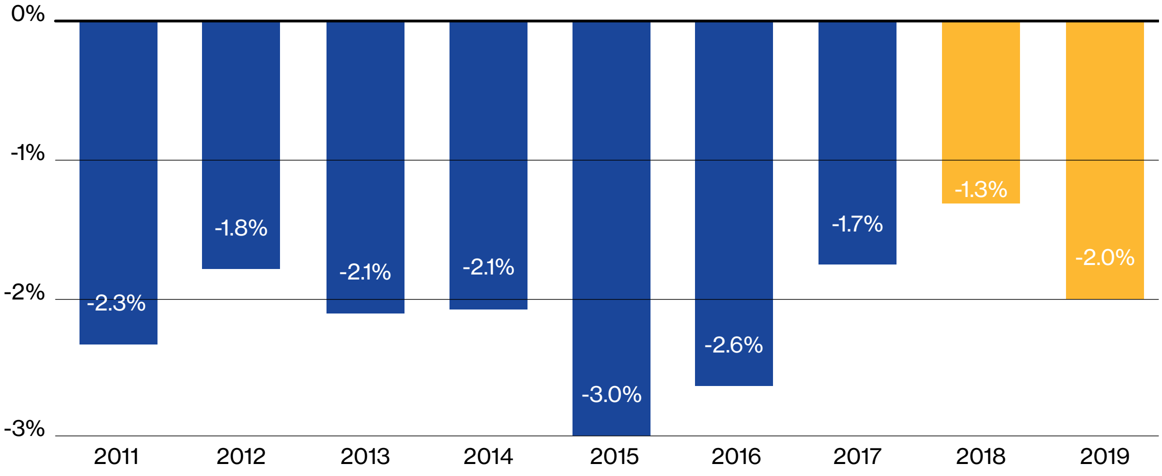

Figure 3. Changes in global energy intensity 2011-19
Source. IEA et al. (2020), Tracking SDG 7: The Energy Progress Report

D. Causes of slowdown

Although energy efficiency contributed the most to energy intensity improvements in 2019 as illustrated in Figure 4, it yielded total energy savings 11% lower than in 2018. This decline reflects, in part, stagnation in the introduction of new energy efficiency policies in recent years. As of 2018, about one-third of the world's energy use was covered by efficiency policies with mandatory requirements. Increasing the coverage and strength of mandatory and other energy efficiency policies is a key lever to creating energy efficiency gains (IEA, 2019c).

Energy efficiency obligation programmes covered 18% of global final energy use in 2018, remaining flat compared to 2017. These programmes require energy companies to achieve an energy efficiency target – typically, but not always, a set amount of energy savings. Voluntary schemes, as well as financial incentives, market-based instruments and capacity-building programmes, also play an important role. The breadth of coverage and the strength of these policies have only improved marginally in recent years. This lack of growth has been one of the key factors contributing to the slowing of energy intensity improvement.

Regionally, trends have differed. The majority of energy intensity improvements came from the largest global energy users, including China, the United States, Europe and India, as well as from Japan and Russia. China's 2019 improvement rate, although higher than the global average, was its lowest since 2011 at 2.6%. The United States saw an improvement of 2.9% in 2019, driven largely by energy efficiency improvements, despite its energy intensity increase in 2018 (IEA, 2020c).

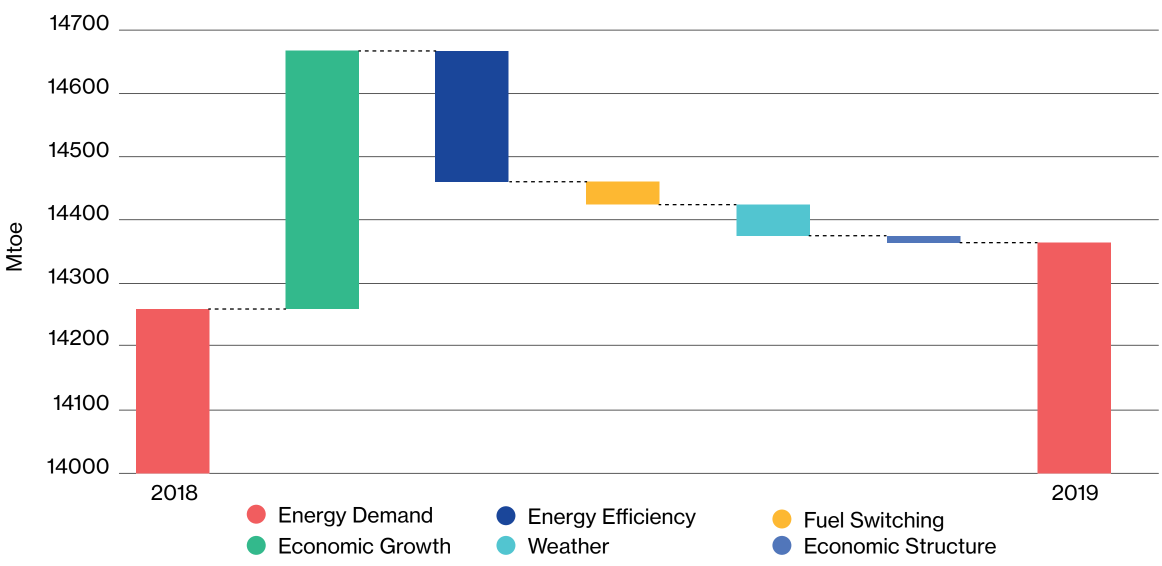

Figure 4. Change in global primary energy demand and causes, 2018-19
Source. IEA (2020c), Global Energy Review 2019.

1. Activity

A significant proportion of the slowdown in energy intensity improvement can be attributed to changes in activity driving energy demand. These include population trends, distances travelled and economic growth. Generally, increases in activity lead to increased energy demand, and without sufficient improvements in energy efficiency policies or technology uptake, energy intensity can increase at the same time. Between 2015 and 2018, increasing economic activity levels in the world's major economies created over 9% more energy use, blunting the impacts of improved technical efficiency (IEA, 2019d).

For example, half of the 0.8% energy intensity increase in 2018 in the United States was due to a hotter than average summer and a colder than average winter, which drove activity change through increased demand for heating and cooling (IEA, 2019c).

2. Structure

A second factor contributing to the slowdown in energy intensity improvement is structural. Changes in the structure of the economy can have differing impacts on energy use. For example, growth in low-intensity sectors like the service sector can soften overall energy intensity, whereas expansion in high-intensity sectors will increase energy demand and with it, energy intensity.

Analysis has revealed that structural factors began to have a negative impact on energy intensity improvements in 2014, increasing energy use by nearly 1.5% from 2015-18. This shift may be partly linked to low crude oil prices during the period 2014-17. These low prices were reflected in energy costs and had knock-on effects, such as increased demand for larger passenger cars (IEA, 2019d).

In the industrial sector, the rate of Chinese crude steel production increased in 2017 and 2018 due to increased domestic demand and favourable prices. This led to a rise of over 3% in global steel production in 2018. Steel production is an energy-intensive sector, with Chinese steel production alone representing approximately 4% of total global final energy use. As demand for steel in China rises, global energy intensity increases (World Steel Association, 2019).

3. Technical efficiency

The final factor contributing to the rate of change in overall energy intensity is technical efficiency. This represents the change in efficiency of technologies, including appliances, vehicles and buildings, as well as infrastructure. This can also be impacted by uptake trends of more or less efficient products and services. Technical efficiency avoided 6% of energy use between 2015 and 2018 (IEA, 2019d).

An interesting example is the effect of increased use of digital devices and applications on global energy intensity. Despite the rapidly increasing popularity of devices, internet traffic and data centre activity, impacts on global energy use have been mitigated by exponential improvements in the efficiency of digital infrastructure (IEA, 2020d).

The rippling cultural impacts of increased digitalisation on overall energy intensity rates are more difficult to predict. Some digital activities, such as high-quality video streaming and smart buildings, may create a net increase in demand as they grow more popular. On the other hand, increased availability of digital conferencing and remote working may lead to a sharp downturn in work travel and commuting, which could have significant impacts on transport demand and the associated energy use. This question has become especially relevant in 2020, with the Covid-19 pandemic necessitating sweeping changes in the landscape of office work, among many other things.
The IEA's Sustainable Recovery Report provides deeper insight into this and many of the other changes to the energy landscape resulting from the Covid-19 pandemic.

E. Multiple benefits of energy efficiency

Energy efficiency's value reaches far beyond energy savings. It has the power to deliver multiple benefits for society, the economy and the environment (Figure 5). These benefits can support progress towards the Sustainable Development Goals beyond Goal 7.3.

Energy efficiency enhances energy security, improves access to energy and other essential services reducing poverty, improves air quality and public health and more. Achieving the doubling of energy intensity by 2040, as mentioned earlier in this section, would result in China and India's annual energy imports being nearly USD 500 billion lower than they otherwise would be. Families worldwide could benefit from over USD 550 billion in avoided energy spending in homes and on transport fuel. This transformation would also cut key air pollutants such as sulphur dioxide, nitrogen oxides and particulate matter by one-third compared with today. In particular, more efficient cooking could help reduce premature deaths from household air pollution by almost 1 million per year in 2040 (IEA, 2018a).

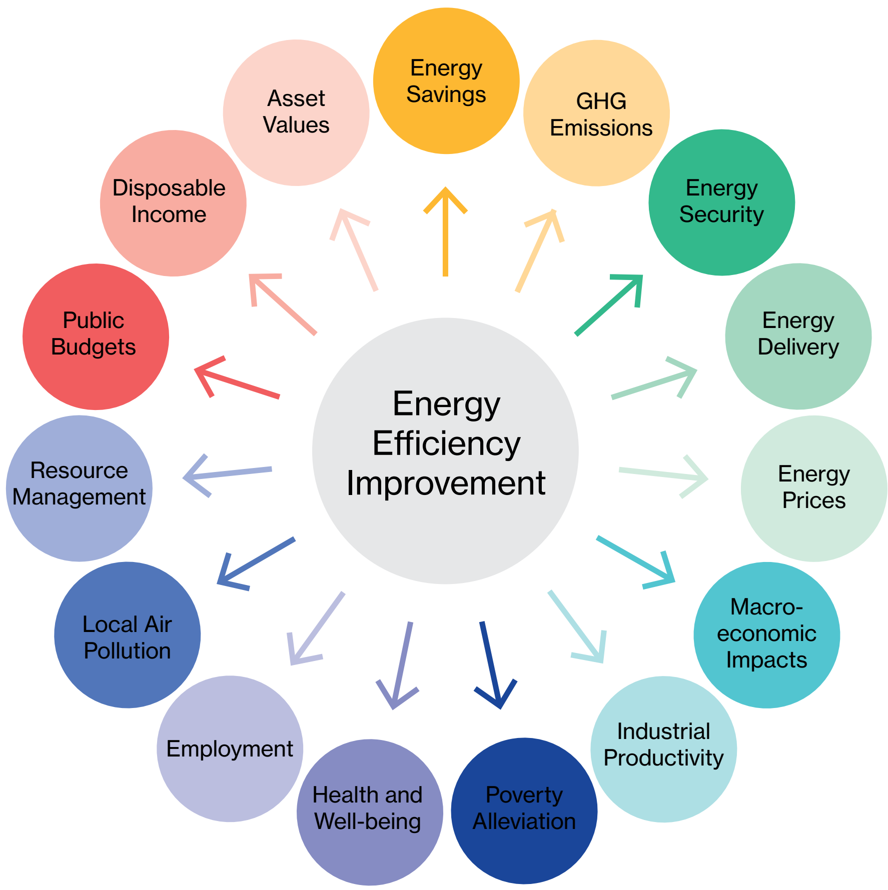

Figure 5. The multiple benefits of energy efficiency improvements
Source. IEA (forthcoming), The Multiple Benefits of Energy Efficiency.

Thanks to the breadth of these benefits, energy efficiency policies and programmes can find support across sectors, governments and civil society by connecting with a diversity of priorities and perspectives. For example, many governments are centring on energy efficiency in their Covid-19 recovery packages, like the European Commission has done with its Green Deal Recovery Package (Parnell, 2020).

Numerous studies have been published that quantify the multiple benefits of energy efficiency across sectors. One such body of research being undertaken by the IEA maps the many benefits that energy efficiency can provide, including social and economic development, public health, job creation, and air quality (IEA, forthcoming).

02

Current Status

Over the time period 2010-2017, overall energy intensity rates improved as compared to the previous two decades, but those rates varied widely by sector, as shown in Figure 6. Using sector-specific intensity indicators, it can be seen that sectors other than transport experienced a decline in average annual improvement. This deterioration is most noticeable in the service and agriculture sectors, where the rate of improvement was cut in half. (IEA, IRENA, UNSD, World Bank, WHO, 2020)

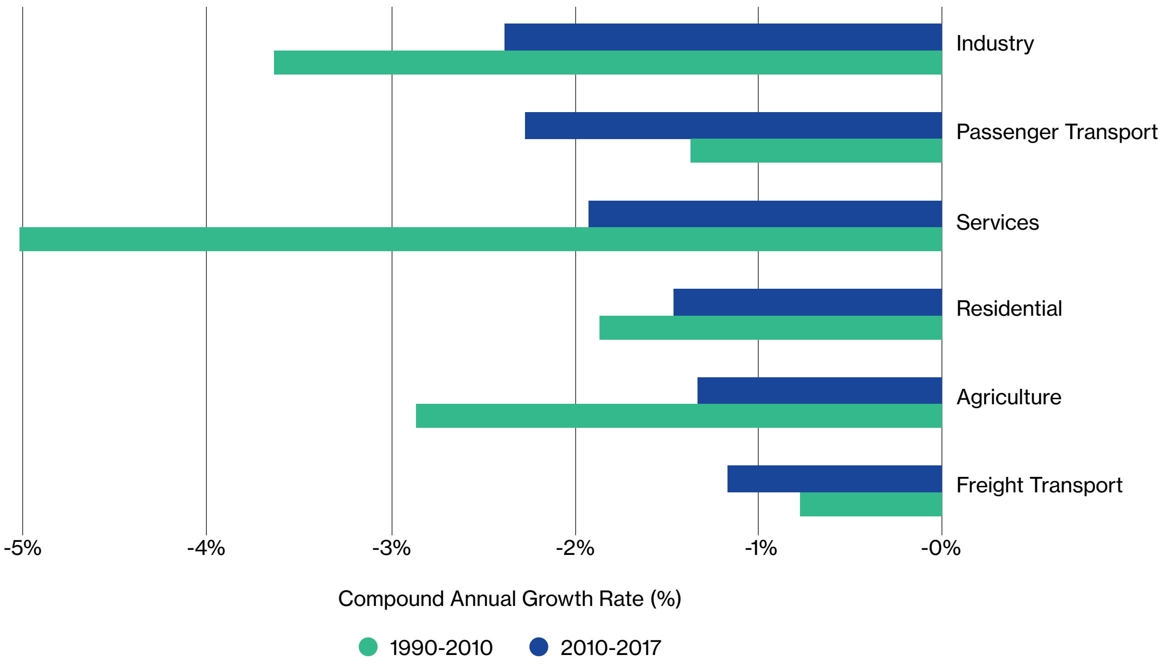

Figure 6. Rate of change in energy intensity by sector, 1990-2010 and 2010-17
Note. Intensity is defined in each sector as a measure of energy use per unit of activity or value added.
Source. IEA et al. (2020), Tracking SDG 7: The Energy Progress Report.

[1] Intensity is defined in each sector as a measure of energy use per unit of activity or value-add.

A. Transport

Transport currently represents 29% of total final energy demand worldwide (IEA, 2020e). Passenger ground transport was responsible for 45% of transport emissions in 2018. Road freight comes in second with 29%, followed by aviation at 12%, shipping at 11%, rail at 1%, and other (2%) (IEA, 2019e). Transport emissions are often correlated with increases in economic activity and consumer incomes. This is not a given, however. Improved transport efficiency can avoid increased energy use, and thus emissions (Figure 7).

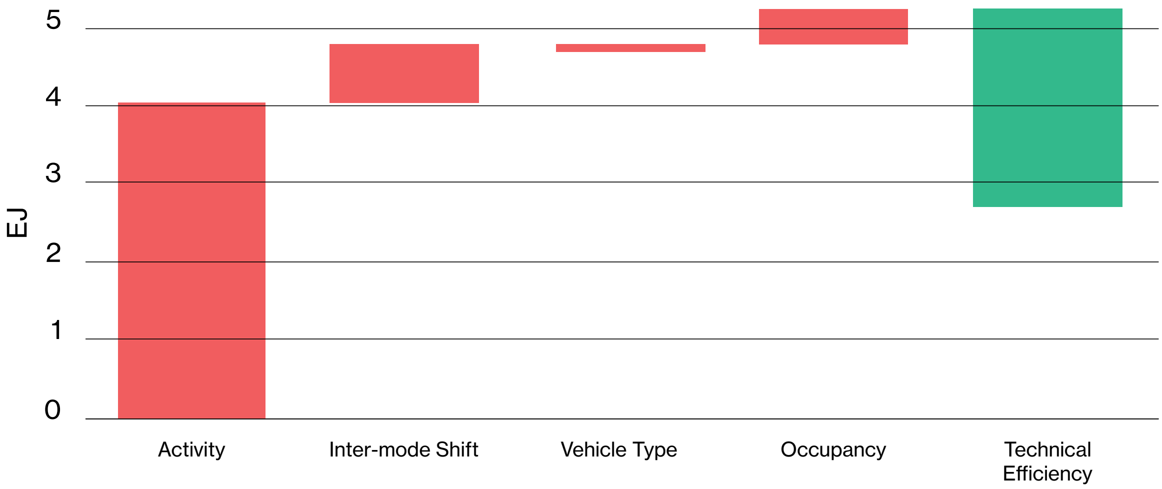

Figure 7. Factors influencing passenger transport changes in energy use, 2015-18
Source. IEA (2019d), Energy Efficiency 2019.

There has been considerable innovation in passenger transport technologies in recent years. Private car transport has become more efficient through the popularisation of new types of cars and engines. Diesel vehicles have been one of the largest contributors to passenger vehicle fuel efficiency improvements, but sales have dropped recently, in part due to pollution concerns.

Electric and hybrid vehicles are, in general, considerably more efficient than the standard internal combustion engine vehicle. However, considerable investment in infrastructure, like charging stations, is needed to bring these technologies to scale and make them accessible and affordable. Other new modes of personal transport, like electric two-wheelers (already mainstream in Asian markets, but only recently growing in popularity in Europe and North America), powered bicycles, scooters and hydrogen engines are on the horizon as potentially new game-changing technologies.

Public passenger transport has also seen increases in efficiency through technological advances. Many cities around the world have been upgrading or replacing their public transport fleets with newer, more energy-efficient infrastructure, such as electric buses and improved train systems.

Likewise, aviation has realised an average annual improvement rate of 3.7%. Though some of this improvement is due to improved technology and more efficient aircraft, most of it can be credited to the increase in the average number of passengers per flight. Those improvements helped aviation to avoid an additional 68% of energy consumption in 2017, which is equivalent to the total fuel demand of international shipping (IEA, 2018a). It remains uncertain how the Covid-19 pandemic will affect aviation energy intensity in the long term, but it is clear that the industry has been heavily disrupted.

Technological advancement is improving efficiency in the road freight sector as well. Some truck manufacturers are developing electric models and piloting overhead lines on key highways. To support this transition, some countries have recently put into place more stringent fuel efficiency standards for freight, although they have had a more limited impact, offsetting demand growth by less than 1% (IEA, 2018a).

B. Buildings and Appliances

Buildings are responsible for about 30% of global final energy use. Growth in energy demand for buildings is primarily driven by structural factors, especially in cities and regions with rapid population and economic growth. However, since 2000 there has been a decoupling of energy demand from floor area growth. In spite of a 3% annual increase in total floor area and increasing residential floor area per capita, building energy intensity has improved by 1.6% annually (Figure 8).

Residential buildings consumed more than three times the energy of non-residential buildings in 2017, although non-residential buildings have seen energy consumption grow twice as quickly as residential buildings since 2000 due to economic growth (IEA 2018a).

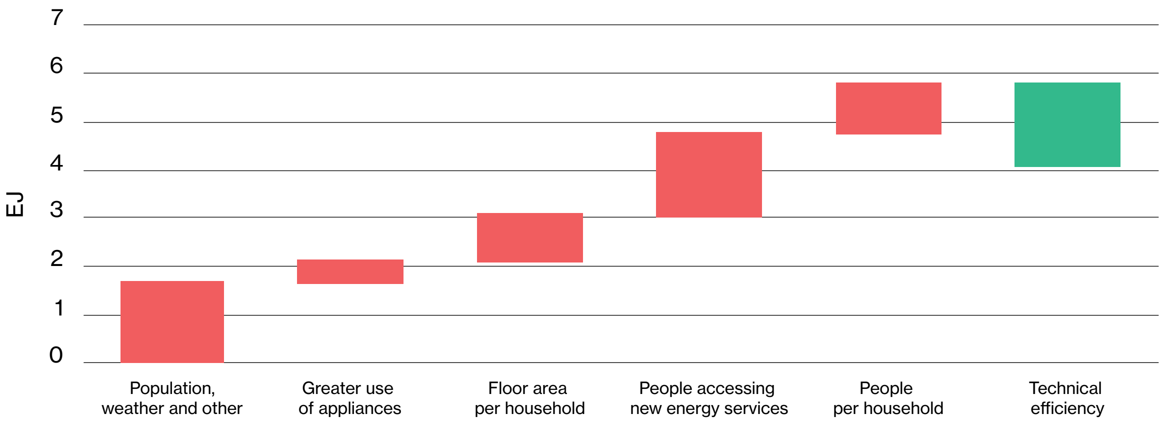

Figure 8. Factors influencing residential buildings change in energy use, 2015-18
Source. IEA (2019d), Energy Efficiency 2019.

Space cooling is the fastest-growing end use driving energy demand in buildings, having nearly doubled since 2000. Due to a combination of increasingly hot weather and growth in consumer spending power, cooling appliance demand has been growing rapidly. There are over 1.6 billion air-conditioning units in use today, and they now consume over 2 000 terrawatt-hours (TWh) of electricity per year, more than double the total electricity use of Africa (IEA, 2018b). While there have been big energy efficiency gains within the sector, there remains significant potential to close the gap between market averages and best available technologies.

Improved cooling efficiency is especially important for non-energy related GHG emissions. The gases used by many cooling appliances, such as hydrofluorocarbons (HFCs), can have a global warming potential nearly 10 000 times more potent than CO_2. With the expected rapid growth in cooling demand, these gases could contribute approximately 20% of climate change-inducing emissions by 2050. The recently passed Kigali Amendment to the Montreal Protocol sets out a phase-down in HFCs. However, the majority of GHG emission reductions are available from greater energy efficiency, leading to lower emissions from reduced electricity production. Digitalisation will also enable the development of new business models, such as cooling as a service (K-CEP, 2020).

Some of the key technologies that are proven to deliver energy efficiency in buildings include insulation, LED lighting, heat pumps and low-emissivity windows. LED lamps have been rapidly adopted in many markets in recent years due to increased affordability of the technology. This improved access has been driven by, among other things, scaling-up programmes and bulk procurement programmes that enable manufacturers to produce higher quantities at lower cost, and then sell the products at more affordable rates to consumers.

Digitalisation is also creating new opportunities for efficiency transformations in the buildings sector. New digital tools are becoming popular that can support decision-making for energy use and efficiency investments across the building cycle – from construction through occupancy. For example, building energy management systems (BEMS) are frequently used in non-residential buildings and provide improved access to real-time information to support buildings operations and demand management.

C. Industry

Since 2000 the industrial and service sectors have witnessed a near doubling in activity, driven by rapid growth in emerging economies, especially in China and India. The resulting increase in energy use has been offset, however, by considerable structural and efficiency shifts.

Improved efficiency avoided an additional 20% of energy use in the industrial and service sectors from 2000 to 2017, equal to the total final energy use of India. Just under one-third of these efficiency gains were realised in China through strong policies to regulate energy-intensive manufacturing facilities like cement and chemicals manufacturing (IEA, 2018a).

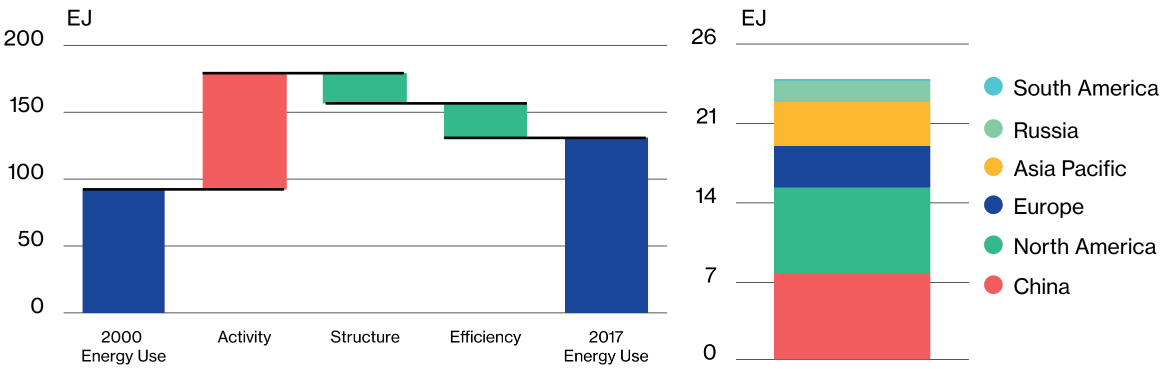

Figure 9. Energy use patterns in the industrial and service sectors (left) and the regional contribution to efficiency savings (right) in major economies, 2000-17

Source. IEA (2018a), Energy Efficiency 2018: Analysis and outlooks to 2040.

Energy efficiency and structural change both contributed to reductions in energy intensity, with structural change matching 90% of the contribution from technical efficiency. Especially in growing economies like China and India, a sectoral shift away from energy-heavy manufacturing toward the service sector has offset around a quarter of the impact from rising activity (IEA, 2018a). Savings in the industrial sector have also been driven by China's Top 10 000 Programme and India's Perform, Achieve and Trade programme, which are two of the most impactful industrial efficiency policies globally (IEA, 2020a).

While technical efficiency is improving, growth in industrial output is compounding long-term trends. Chinese steel and US manufacturing continue to drive an escalation in energy-intensive economic output globally. Various subsectors could help put industry back on track. The increase in iron and steel production activity needs to be offset by ramped-up recycling and investment in technology improvements, such as electric arc furnaces, which can improve intensity by 60-70%. As a further example, the scrap metal subsector could develop better collection and sorting systems to improve recycling rates. Similarly, more recycling of chemicals, pulp and paper could reduce the intensity of production. In the cement subsector, improved components and component rations could support a decrease in manufacturing energy intensity (IEA, 2018a).

03

Outlook

A. The Covid-19 pandemic will affect the short-term outlook

Short-term energy trends have been massively disrupted by the Covid-19 crisis, with unprecedented energy impacts, months-long restrictions on social and economic activity and mobility, and the economic impacts that result. IEA's modelling of 2020 energy trends is based on a scenario where the recovery from the depths of the lockdown recession is only gradual and is accompanied by a substantial permanent loss of economic activity, despite macroeconomic policy efforts (IEA, 2020b).

Under this scenario energy demand is expected to contract by 6% in 2020. This would be more than seven times larger than the impact of the 2008-09 financial crisis on global energy demand. All fuels are affected (Figure 10), with oil likely to be hit the hardest – a drop of 9% or 9 million barrels per day (mb/d) on average across the year, returning to 2012 levels.

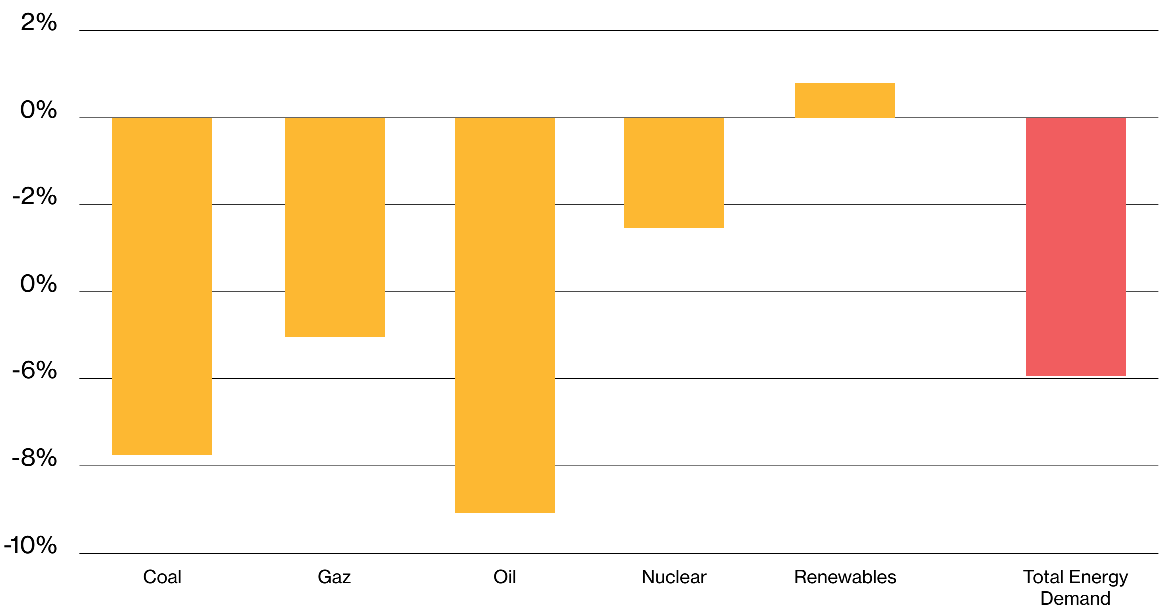

Figure 10. Projected change in primary energy demand by fuel in 2020 relative to 2019

Source. IEA (2020b), Global Energy Review 2020: The impacts of the Covid-19 crisis on global energy demand and CO_2 emissions.

Global energy-related CO_2 emissions are expected to decline by 8%, or almost 2.6 gigatonnes (Gt), to levels of 10 years ago. Such a year-on-year reduction would be the largest ever, six times larger than the previous record reduction of 0.4 Gt in 2009 – caused by the global financial crisis – and twice as large as the combined total of all previous reductions since the end of World War II. As after previous crises, however, the rebound in emissions may be larger than the decline, depending on how stimulus spending is directed.

A fall in economic activity is also likely to have an impact on investment in energy efficiency. Global energy efficiency investment has remained stagnant for the last few years, and intensity improvements have lagged behind the levels needed to meet global goals. A total of USD 250 billion was invested in energy efficiency across the buildings, transport and industrial sectors in 2019. However, spending is set to fall in 2020, possibly by more than 10% in all key sectors (IEA, 2020f).

B. Increased activity will have an impact on the longer-term outlook

For the longer-term outlook on energy efficiency, this section will focus on the IEA's Stated Policies Scenario (STEPS). This scenario provides a detailed sense of the direction in which today's policy ambitions would take the energy sector. It incorporates policies and measures that governments around the world have already put in place, as well as the effects of announced policies, as expressed in official targets and plans. Under this scenario, there is an increase in energy consumption to 2040 and global energy-related emissions do not reach a peak. The effects of an expanding economy and population on energy demand outweigh the strength of today's push for a more efficient and lower-emission energy system (IEA, 2019b).

Over the next 20 years, it is anticipated that:

- The global population will increase by around 20%, to 9.1 billion.
- There will be over 30% more households and over 50% more total building floor area.
- There will be a large increase in demand for many energy services, such as for cooling, which could see ownership of air-conditioning equipment triple.
- Industry value added will increase by over 70% and services by over 80%.
- There will be two-thirds more passenger car kilometres driven.
- Road freight activity will increase by around 80%.

Global final energy consumption was almost 10 billion tonnes of oil equivalent (Btoe) in 2018, an increase of 2.2% compared with 2017. In the STEPS scenario, it rises to almost 12.7 Btoe by 2040, an increase of around 1.1% per year on average, while global energy intensity improves by 2.3% per year. Implementation of the STEPS scenario results in energy intensity improvements and an expansion of renewable energy, but the rate of improvement is not sufficient to achieve the energy-related Sustainable Development Goals.

In 2018, global energy-related CO_2 emissions reached a record high of 33.2 Gt CO_2. Under the STEPS scenario, despite improvements in efficiency and increased renewables, energy-related emissions do not peak. They rise by just over 100 million tonnes per year on average between 2018 and 2040, to reach 35.6 Gt CO_2 (IEA, 2019b).

Under the STEPS scenario, by 2050, 736 million people will still be without access to electricity and 1.538 billion will be without access to clean cooking. Furthermore, there will be over 5 million premature deaths from energy-related outdoor air pollution (IEA, 2019b).

Annual investment in energy efficiency increases in the STEPS scenario from USD 240 billion in 2018 to around USD 445 billion by 2030, and to USD 635 billion a year thereafter to reach a cumulative total of USD 11.7 trillion over the period to 2040.

Bridging the gap to the rapid emissions reductions and other benefits seen in the Sustainable Development Scenario (SDS) would require significantly more ambitious policy action in favour of efficiency and clean energy technologies, including decarbonised fuels, and a major rebalancing of investment flows. The potential for energy efficiency to contribute to better carbon management is substantial.

04

Carbon management potential

The energy system is responsible for around 75% of GHG emissions (IEA et al., 2020). Consideration of how energy is consumed and ways to improve its efficiency are essential to overall carbon management and energy transitions.

The SDS scenario, developed by the IEA, models the potential changes that could help the world to achieve the goals set out in the Paris Agreement. According to the SDS scenario, energy efficiency represents the greatest opportunity for emissions reduction, equivalent to 37% of the additional efforts required in the SDS scenario relative to the STEPS scenario. By reducing the energy intensity of transport, buildings, and the industrial and services sectors, it is possible to mitigate the energy demand resulting from increased activity and structural changes in the economy. If the world were to implement all of the cost-effective energy efficiency measures currently available, energy-related GHG emissions would peak before 2025, not accounting for changes caused by the Covid-19 pandemic (IEA, 2019b).

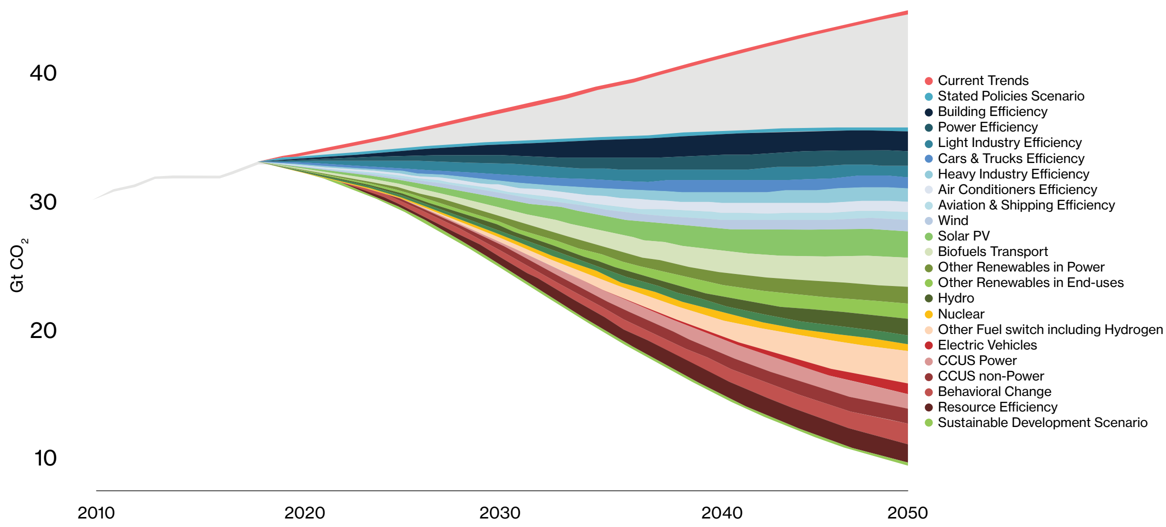

Figure 11. Energy-related CO_2 emissions and reductions in the Sustainable Development Scenario by source, relative to the STEPS scenario

Source. IEA (2019b), World Energy Outlook.

To achieve the Paris Agreement, the SDS scenario reveals that an annual improvement rate of 3.6% in global primary energy intensity will be required through 2030. This rate is possible with currently available, cost-effective technologies and policy approaches.

When compared to the STEPS scenario, energy efficiency is the biggest contributor to the reduction in final energy consumption in end-use sectors, responsible for 60% of the savings (IEA, 2019b). These savings will require varied action across regions and sectors, to reflect local market forces and opportunities. Figure 12 illustrates this variation and highlights the proportion of the improvement already incorporated into current policies as modelled by the STEPS scenario.

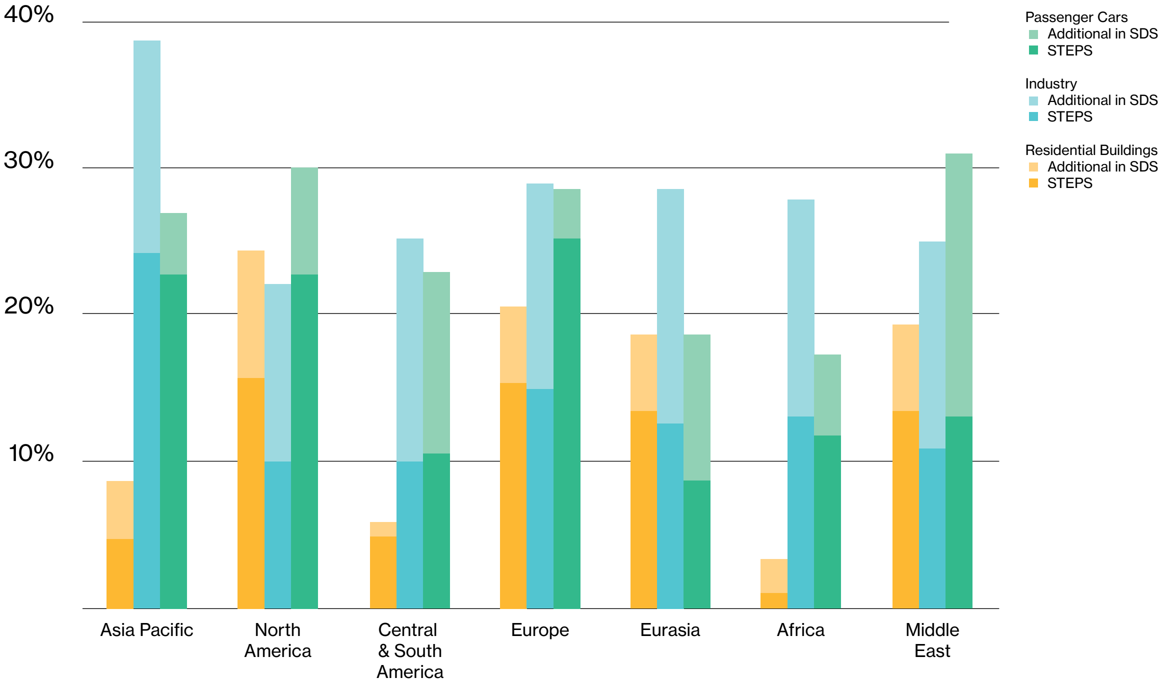

Figure 12. Improvement in energy intensity by sector and region in the STEPS scenario and SDS scenario, 2018-30

Source. IEA (2019b), World Energy Outlook.

It is important to note, however, that energy efficiency alone is not enough to achieve the emissions reduction goals of the Paris Agreement (Figure 11).

A. Buildings

IEA analysis finds that the largest contribution to global efficiency gains can be realised in the buildings sector, at more than 40% (IEA, 2019b). This considerable improvement will be driven mainly by more efficient cooking and other appliances, and efficient solutions for space and water heating and space cooling, including buildings codes and envelopes. Existing technologies are sufficient to achieve this rate of improvement, despite increasing demand. The key challenge is making best-in-class solutions affordable and mainstream on the market. Many countries have put in place policies that set energy efficiency requirements for new buildings and retrofits to help scale up efficiency solutions. Other countries, such as the United States, Mexico and South Korea, have also implemented programmes that provide incentives to end users to replace or upgrade appliances with more efficient models (IEA, 2020a).

As the fastest-growing end use in buildings, cooling represents 12% of the global energy savings potential. Without efficiency, activity increases would more than double the energy consumed for space cooling by 2040. IEA analysis shows that energy efficiency for cooling can offset much of those climate, activity and structural impacts, limiting the growth of energy consumption for cooling between now and 2040 to 19% (IEA, 2018a).

A wide range of energy efficiency policy measures are available to meet growing demand for cooling while tempering resulting emissions. Many are grounded in simple improvements to building envelopes. Investment in improved insulation reduces the need for both heating and cooling alike, avoiding energy consumption, creating energy savings and improving indoor comfort year after year. For example, global energy consumption for space heating could be halved if all countries implemented best practices (IEA, 2018a).

District heating and cooling also represent proven, cost-effective opportunities to reduce energy intensity for thermal comfort, especially in dense or urban areas. District cooling systems, for example, can effectively provide cooling services using 50% less electricity compared to other cooling technologies (UNEP, 2015). To encourage research and deployment of district heating and cooling systems, Saudi Arabia, China and Russia, with the support of Singapore, established a new initiative within the G20's Energy Efficiency Leading Programme called District Energy Systems (IPEEC, 2019).

Improvements in cooling technology have led to a range of best-in-class cooling appliances. However, as illustrated in Figure 13 these technologies are yet to become mainstream. Bringing top of the line technology to scale will require more effective policies and regulations, such as mandatory minimum energy performance standards (MEPS) and building codes (IEA 2018a). A recent study suggested that improving the energy efficiency of residential air-conditioning stock in Saudi Arabia could save 33 TWh per year, and governments could recover the cost of phasing out inefficient units within two years (Krarti and Howarth, 2020).

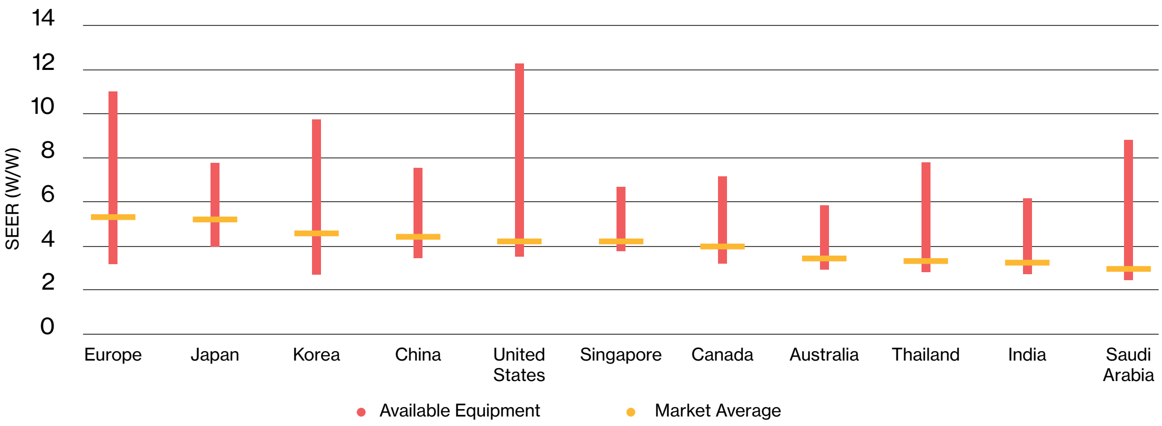

Figure 13. Efficiency ratings of available air conditioning units by regional metric

Note. The standards, test procedures, temperatures bins and metrics used to evaluate efficiency ratings differ among countries, so ranges should not be compared across countries. SEER = Seasonal Energy Efficiency Ratio. CSPF = Cooling Seasonal Performance Factor. APF = Annual Performance Factor. COP = Coefficient of Performance. ISEER = Indian Seasonal Energy Efficiency Ratio. IPVL = Integrated Part Load Value.

Source. IEA (2020), Future of Cooling.

Lighting and appliances also play an important role in reaching global climate goals. These two end uses represent nearly 40% of the average annual investment required. Improvement in their efficiency manifests itself differently from heating and cooling, as it is largely driven by smaller, more regular investments by consumers. For that reason, MEPS are often paired with innovative incentive programmes to help take advantage of economies of scale (IEA, 2018a).

Programmes like the Super-efficient Equipment and Appliances Deployment (SEAD) initiative are working around the world to spread awareness and encourage uptake of more ambitious MEPS and other efficiency policies for appliances. The SEAD initiative has led a number of successful programmes to further these efforts, including the SEAD Policy Exchange Forum, a study of Indonesia's standards and labelling programme for air conditioners, and the Global Lighting Challenge, which exceeded its campaign goal to deploy 10 billion energy efficient lighting products worldwide (IPEEC, 2019). In 2016 India, the United Kingdom and the European Commission took over as co-leads of the initiative, with the IEA taking over co ordinating duties in 2019.

B. Transport

Transport represents more than 20% of the potential to reduce global emissions with energy efficiency under the SDS scenario. While global vehicle ownership is expected to increase by 45%, performance standards and growth in electric vehicle sales is expected to enable energy consumption for transport to remain at a similar level to 2018, and for oil demand in the transport sector to decrease by 40% (IEA, 2019b).

One of the most significant transport subsectors for improvement is aviation. 2018 analysis anticipated demand to increase by 3.8% annually, tripling 2010 demand by 2040 (IEA, 2018a). The Covid-19 pandemic has radically shifted the outlook for this subsector, with global aviation activity dropping 60% below the 2019 average by March of 2020 (IEA, 2020b; 2020c). Rebound effects and behaviour change toward the sector overall in the wake of the global crisis remain uncertain, and are explored in more detail in the IEA's Sustainable Recovery Report.

According to the SDS scenario, fuel consumption per revenue passenger kilometre in the aviation sector could be reduced by 55% by 2040. In the short term, replacing and retrofitting aircraft with more efficient models and engines could create incremental improvements. The biggest potential, however, lies in redesigning aircraft for greater efficiency. These types of solutions and technological innovations, such as electric motors and fuel cells, are unlikely to be realised in the short term due to long lead times, high investment costs and the relative speed of the transformative R&D needed (IEA, 2018a).

For short-haul passenger transport, high-speed rail presents another option for improving transport efficiency. High-speed rail is more than 11 times more energy efficient than aviation per passenger kilometre. High-density corridors that have built high-speed rail systems, such as the Eurostar's routes between London, Brussels and Paris or the route between Guangzhou and Wuhan in China, have realised considerable improvements, achieving between 48% and 58% decreases in air traffic on these routes (IEA, 2018a).

C. Industry

Over the coming decades, industrial efficiency can be improved along a number of avenues. Despite growing industrial activity, structural shifts away from heavy industry toward services and other less energy-intensive sectors will provide enormous opportunity to improve efficiency and further the decoupling of industrial output from emissions. Within the SDS scenario, industry represents around 30% of the total additional end-use energy savings over the STEPS scenario (IEA et al., 2020). The required efficiency actions vary widely across the many subsectors, but IEA analysis reveals that many of the biggest gains can be captured through increased and improved materials recycling (IEA, 2018a).

Improving the policy coverage of industrial activity will be an important lever in driving improved industrial efficiency. Currently China, India and Japan have the highest levels of industrial efficiency policy coverage. Because China and India are likely to continue to be responsible for the largest share of growth in industrial energy demand globally, expanding and strengthening their existing policies should support continued progress in industrial energy intensity and influence global manufacturing standards.

It is important to note that the less energy-intensive manufacturing sectors represent 70% of the energy savings opportunity across industry according to 2018 analysis. This category of subsectors includes food, beverage, automotive and textiles manufacturing. The technology required for this improvement is available and includes high-efficiency heat pumps for generating low-temperature heat and improving the efficiency of electric motors (IEA, 2018a).

Potential improvements in energy-intensive manufacturing also exist using affordable, accessible technologies. There is a strong link between material efficiency and energy efficiency. For example, metals manufacturing can recapture the value of materials and improve energy efficiency significantly by improving scrap metal recycling rates. Iron and steel manufacturing intensity could fall by 25% and aluminium manufacturing could see a 28% reduction by 2040. These potential improvements represent significant progress over historical trends since 2000 of 5% and 16% respectively. This gain is largely driven by scrap recycling, though there are opportunities to improve the efficiency of primary metals production (IEA, 2018a).

The situation for the chemicals and petrochemicals subsector is somewhat different. Because of expected demand increases, efficiency will be unable to compensate for increased energy use in the petrochemical manufacturing process. In fact, analysis reveals that petrochemicals will account for more than one-third of the growth in oil demand by 2030 and nearly half in 2050, outpacing trucks, aviation and shipping. Despite this expected demand increase, energy intensity still has the potential to improve by 14% by 2040 thanks to combined measures that leverage the benefits of energy efficiency, carbon capture, utilisation and storage, coal-to-gas feedstock shifts and increased recycling. These combined processes can support reduction in carbon emissions and other environmental impacts, even if the potential for energy use reduction is constrained. This is one reason why hydrogen may become an important key to emissions reduction in such sectors (IEA, 2018a).

D. Leveraging Covid-19 stimulus efforts

Two of the critical requirements for achieving energy efficiency goals are taking urgent action and scaling up solutions.

There are many opportunities to incorporate energy efficiency into Covid-19 stimulus and recovery packages to support longer-term recovery goals, such as job creation, market activation and more. The IEA's Sustainable Recovery Plan model identifies 30 specific energy measures for governments to consider in the development of their recovery schemes. The model shows that investment in a more sustainable, efficient energy sector could save or create approximately 9 million jobs and reduce energy-related GHG emissions by 4.5 billion tonnes. The plan, which calls for USD 1 trillion in annual investment globally, is grounded in energy efficiency, with almost 40% of the spend allocated to efficiency measures across transport, buildings and industry. To realise the savings and ramp up investment, effective policy will be required to address barriers to the uptake of cost-effective energy efficiency.

The energy efficiency policy and market environment today is much different to that following the 2008-09 global financial crisis – for example, today many of the foundational elements for a rapid scaling-up of energy efficiency are in place, including best-in-class policy options, cost-effective technologies, robust supply chains and sustainable business models. However, energy efficiency will require a range of strategic policy interventions in order to quickly scale it up and unlock its full potential. Previous stimulus and energy efficiency programmes offer governments and policy makers valuable insights into programme design and implementation.

Key learnings on energy efficiency and economic stimulus

- Governments can deliver stimulus at scale and speed by leveraging existing programmes and standardising designs, eligibility criteria and contracts; choosing "shovel-ready" options for retrofits and technology upgrades; and considering how energy efficiency can be built into all government stimulus programmes.

- Important market considerations include aiming for high energy efficiency without constraining programme delivery; setting sufficiently attractive incentives to deliver high uptake without significantly increasing programme costs and risks; considering the capacity of suppliers to scale up rapidly while maintaining quality and safety of products and services; and considering the consumer motivations and demand for products and services.

- Government can facilitate better outcomes from large-scale investment programmes by addressing unnecessary regulatory barriers; turning short-term impacts into long-term transformations by raising energy efficiency standards; and considering the resource efficiency impacts and recycling sector opportunities as part of programme design.

energy efficiency programmes offer governments and policy makers valuable insights into programme design and implementation.

05

Barriers

There are already known and cost-effective solutions to realising much higher levels of global energy efficiency. Furthermore, well-known policy tools are available to deliver them. However, before listing these enabling policy approaches, it is worth considering briefly the common barriers to adopting energy efficiency.

A. Information barriers

Purchasers and installers of energy-using equipment and systems may lack expertise or knowledge on best available or most appropriate technologies to improve energy efficiency. Without easy access to consistent and comparable information on the energy consumption and efficiency of equipment and systems, actors will not be able to judge, let alone install, the most efficient options. The Trans-Tasman Equipment Energy Efficiency Programme is one example of an approach to addressing this challenge. The programme sets regulations for MEPS and energy rating labelling on household appliances across Australia and New Zealand to help end users make more informed choices at the point of sale .

For larger industrial consumers, lack of information can mean a lack of disaggregated data on metered energy consumed by processes and components. Without such information, it is challenging for site managers to prioritise and identify which components or systems to target. Energy management systems can be a useful tool for companies to understand and control their energy systems, and to identify opportunities for efficiency gains. The German government has established a number of policy actions and incentives to provide funding for the installation of energy sensors and software programmes, as well as training and capacity building. They have resulted in the uptake of certified energy management systems in around 9 000 companies nationwide (Energiewende Direkt, 2019).

Governments can also implement programmes to support households and businesses in improving efficiency through financial or advisory support. Indonesia's Lampu Tenaga Surya Hemat Energi programme, launched in 2017, helps to bring energy efficiency solutions to households with low levels of energy access. The programme has provided LED lamps, small PV modules and lithium batteries to more than 200 000 homes across 15 provinces (IEA, 2018a).

B. Financial barriers and market failures

Higher up-front costs are sometimes necessary to increase energy efficiency, though they are often offset by long-term financial savings from reduced energy consumption. This increase in the initial cost may be a considerable barrier to consumers without access to capital, or similarly for companies with internal competition for capital.

In many cases the upfront investment for increased efficiency pays for itself very quickly and at a high rate of return. The efficiency investment identified in the IEA's analysis repays itself twice over for households and transport, and at a rate of 7:1 for industry over the lifetime of the measure (IEA, 2018a). Often, a lack of access to the appropriate financial mechanism can be the reason why cost-effective measures are not taken up. Innovative business models are emerging to overcome upfront financial concerns. They include metered savings-based performance contracting models, as offered by energy service companies (ESCOs), or "as a service" models (such as cooling as a service). Barriers can exist to these emerging business models becoming established, which range from regulatory constraints, to consumer trust in new businesses, to initial capital to set up such models.

Many international collaborations have been established to overcome such barriers. One such initiative, the Energy Efficiency Finance Task Group, is led by France and Mexico as part of the G20's Energy Efficiency Leading Programme. It supports countries in developing more robust investment-grade policy and investment frameworks to build capacity, instruments and interest in energy efficiency (IPEEC, 2019).

Failure to recognise and quantify the financial value of non-energy benefits of efficiency will weaken the business case for many efficiency measures. For example, financial benefits from improvements in productivity and reliability in industry, or the reduction in healthcare costs from improved thermal comfort in homes, can raise the overall value and cost-effectiveness of the energy efficiency project – often many times over the value of the energy-saving benefits alone.

C. Misaligned incentives and behavioural barriers

Split incentives – where one actor pays for the efficiency improvement, while another actor receives the energy-saving benefits – is another well-known barrier to the uptake of increased efficiency. This is often the case for landlords and tenants for rental properties, but can also be an in issue for companies where different departments have different responsibilities and motivations for capital investment and paying energy bills. In the manufacturing of energy-using equipment – and the absence of other constraints – manufacturers have an incentive to design lower-cost equipment (which may be less efficient once it is installed and in use) rather than producing more efficient equipment.

Behavioural inertia can also pose a problem for wide-scale energy efficiency uptake. For example, energy can be a small part of many businesses costs, and technical changes to production lines or systems can be intrusive and require additional decision-making. Homeowners may have practical reasons, such as not emptying their lofts to add insulation, or moving out of their homes for a deep retrofit. Additional issues arise during the current Covid-19 crisis, such as social distancing concerns for internal works in homes. On the other hand, many largely vacant office and educational buildings offer an opportunity for upgrade interventions.

D. Technological barriers

In the short term, technological barriers are not the main challenge to delivering significant efficiency improvements. Many technologies are readily available and cost-effective, but suffer from slow deployment.

However, there is the potential across all sectors for continued technological development to improve energy efficiency or bring down further the cost of efficient technologies. The volumes of data being created daily by digital technologies, advanced analytical and data processing capabilities, and improved connectivity offer new opportunities to identify efficiencies across the energy system. Digitalisation helps to measure and capture the value of end-use energy efficiency more effectively in real time. For example, analysis shows that digitalisation could reduce energy demand in the buildings sector globally by up to 10% by 2040 and could increase demand response capacity more than ten-fold, from 40 gigawatts (GW) today to 450 GW in 2040.

Many governments are beginning to think creatively about how to incorporate these new capabilities into policy making to address a range of issues – from balancing data accessibility with privacy, to removing regulatory barriers to encourage innovation. However, the vast amounts data from these types of programmes can be cumbersome to turn into useful knowledge. Countries around the world have experimented with various methodologies, approaches and metrics to best utilise the energy demand and efficiency data created through new digitalised energy systems.

A number of international initiatives have been created to help policy makers leverage digitalisation effectively. The IEA's Readiness for Digital Energy Efficiency framework is a set of critical policy considerations that policy makers can use to ensure that the benefits of digital energy efficiency are captured (IEA, 2019d). The Energy End Use Data and Energy Efficiency Metrics (EUDEEM) initiative, led by France as part of the G20's Energy Efficiency Leading Programme, is working to bring countries together to share knowledge, methodologies and experiences in collecting and using this type of data to inform policy making and evaluation (IPEEC, 2019).

06

Enabling policies

The deep and extensive global experience in energy efficiency policy can provide lessons to policy makers on what works and what does not. Countries, cities and other actors around the world have experimented with a vast range of policies and interventions to encourage the uptake of energy efficiency solutions. These lessons can be adapted to a diversity of contexts and priorities.

One of the main overarching lessons is that energy efficiency policies are most effective when implemented as part of a well-designed comprehensive package that covers many different types of interventions and incentives, coupled with the establishment of clear quantitative targets and monitoring frameworks.

The diversity of policy options can be grouped into several overarching categories. As illustrated in Figure 14, these categories include targets and roadmaps, regulatory policies, informational programmes, incentive schemes and capacity-building programmes.

Targets for energy efficiency improvements		
Regulation	**Information**	**Incentives**
. Building codes . Product MEPS . Sectoral Standards . Vehicle fuel-economy standards	. Campaigns . Certification . Labelling	. Direct investment . Fiscal . Auctions . Utility Obligations
↑	↑	↑
Operational support, training, MV&E, evaluation		

Figure 14. Measures contributing to a policy strategy to increase efficiency
Source. IEA (2018c), Perspectives for the Energy Transition: The Role of Energy Efficiency.

The Recommendations of the Global Commission for Urgent Action on Energy Efficiency

Convened by the Executive Director of the IEA in response to the global slowdown of energy efficiency progress, the Global Commission for Urgent Action on Energy Efficiency was established in June 2019 at the IEA's Fourth Annual Global Conference on Energy Efficiency in Dublin, Ireland. The Global Commission has 23 members and is composed of national leaders, current and former ministers, top business executives and thought leaders.

With analytical support from the IEA, Global Commission members have examined how progress on energy efficiency can be rapidly accelerated through new and stronger policy action by governments across the globe. It has developed this series of practical recommendations to support governments in taking more ambitious action on energy efficiency.

1. Prioritise cross-cutting energy efficiency action for its economic, social and environmental benefits
A stronger, all-of-government policy focus will enhance social and economic development, energy security and resilience, decarbonisation, and rapid job creation and economic stimulus

2. Act to unlock efficiency's job creation potential
Energy efficiency can quickly deliver job growth and can become a long-term, sustainable employment sector

3. Create greater demand for energy efficiency solutions
Efficiency action will be most rapidly scaled up through a focus on increasing demand for efficient products and services and enabling greater levels of market activity

4. Focus on finance in the wider context of scaling up action
Mobilising finance is an essential element of efficiency action, and policies to do so will be most effective if they are part of a wide, coherent approach to driving market scale

5. Leverage digital innovation to enhance system-wide efficiency
Policy makers can take advantage of digital innovation's potential to enable smart control, better energy management and wider energy system optimisation

6. The public sector should lead by example
Governments should lead through investment in public-sector efficiency and driving innovation and higher standards throughout its reach

7. Engage all parts of society
Implementation of efficiency action can happen at all levels of society, with cities, businesses and local communities all playing a particularly important role in its success

8. Leverage behavioural insights for more effective policy
People are at the centre of energy efficiency action, and insights from behavioural science can help design smarter policies

9. Strengthen international collaboration
International collaboration and exchange of best practice allow countries to learn from each other and to harmonise approaches and standards where appropriate

10. Raise global energy efficiency ambition
Governments should be significantly more ambitious in both the short and long term when setting their efficiency targets, policies and actions

A. Targets and roadmaps

Target setting and roadmaps can be useful policy tools for accelerating energy efficiency. By making commitments, setting targets or establishing long-term roadmaps, governments become accountable to achieve a certain level of accomplishment and communicate their priorities to actors in the public and private sector.

Target setting can include international agreements, such as the Paris Agreement, the Sustainable Development Goals, or the Kigali Amendment to the Montreal Protocol. They can also take the form of national goals or long-term roadmaps, as in a country's climate action plan, a national cooling plan, or a nationally determined contribution (NDC).

197 countries have submitted NDCs to the UNFCCC under the Paris Agreement, and of those, 132 have specifically set energy efficiency targets or made reference to the role of energy efficiency in their contributions to achieving the Paris targets. As an example, within its NDC, Australia has committed to developing a National Energy Productivity Plan with a 40% energy intensity improvement target between 2015 and 2030 (World Resources Institute, 2018).

B. Regulatory policies

Many of the efficiency barriers – from split incentives through to information asymmetry – can be overcome through appropriate regulations that mandate efficiency performance. These are especially effective when the marginal cost of increased efficiency is low, or even negative. These types of policies have been found to be very effective for energy-using products or systems, where energy performance can be reliably measured. For example, minimum energy performance standards (MEPS) in energy-using products have been shown to be highly effective, and cost-effective, policy instruments. Over 100 countries now use this policy tool for a range of products. The EU's Eco-design Directive – which mandates efficiency – and its implementing measures have already reduced the European Union's energy consumption by 9% of total current consumption, and lowered costs for consumers.

Fuel economy standards for vehicles have had a large impact on energy consumption, with over half of the total energy efficiency improvements in the transport sector since 2000 resulting from this type of policy alone (IEA, 2018a). Japan's Top Runner Programme is an excellent example of fuel economy standards, basing the requirements on the most fuel-efficient vehicles on the market. Thanks to this programme, the fuel efficiency of passenger vehicles in Japan has improved by 96% over the past two decades, and is intended to improve by 32% by 2030 over 2016 levels (Global Fuel Economy Initiative, 2019).

Similarly, building codes are used to set energy efficiency standards for new buildings, as well as major refurbishments. India's 2017 building energy code for commercial buildings, for example, covers efficiency requirements for most systems, bio-climatic design, heating, ventilation and air-conditioning systems, renewable energy requirements, and more. The code is expected to produce a 50% increase in building energy efficiency by 2030 (Bureau of Energy Efficiency, 2020).

C. Information and awareness

Without reliable information on the energy efficiency of a product or system, it is difficult, if not impossible, for actors to improve energy efficiency. Energy labels have been applied to many types of mass-produced energy-using products. These need to be based on information from representative and reliable testing procedures so that the information presented on the label is comparable. Different types of labels exist, from mandatory comparative labels (like the EU's A-G label) or voluntary endorsement labels (such as the United States' EnergyStar label).

Energy performance certificates for buildings perform a similar function. These types of information labels can be used as the basis for other policy measures, such as incentives for EnergyStar labelled products, or governments only procuring A-rated products. Tax rebates can be given on higher efficiency products. England and Wales have used information on energy performance certificates as the basis for setting mandatory requirements for the sale and rental of properties (Government of the United Kingdom, 2015). Similarly, South Korea's Rebate for Top Energy Efficient Appliances programme reimburses consumers up to 10% of the purchase price for government-certified appliances, and has expanded the programme as part of their Covid-19 stimulus package (C40 Cities, 2020).

Energy audits can provide information and highlight where savings can be captured. Where they have been encouraged (such as Germany's tax relief for companies that implement ISO 50001), a higher rate of efficiency uptake has been observed (IEA, 2018a; 2019d).

Another important tool for policy makers is industry benchmarking. As part of its 2019 G20 Presidency, the Government of Japan instituted a research programme to build capacity and understanding of industry benchmarking. Benchmarking studies, like the exemplar shown in Figure 15, can provide insights into energy consumption, intensity and efficiency, as well as international learning opportunities for improving industrial processes and technologies. Key factors for a useful benchmarking study are reliable indicators and consistent, detailed data. Data collection and benchmarking initiatives are proliferating as more industry actors and policy makers come to understand their value (IEA, 2019f).

Energy use per tonne per of crude steel and share of crude steel production by process route in 2017, G20 countries

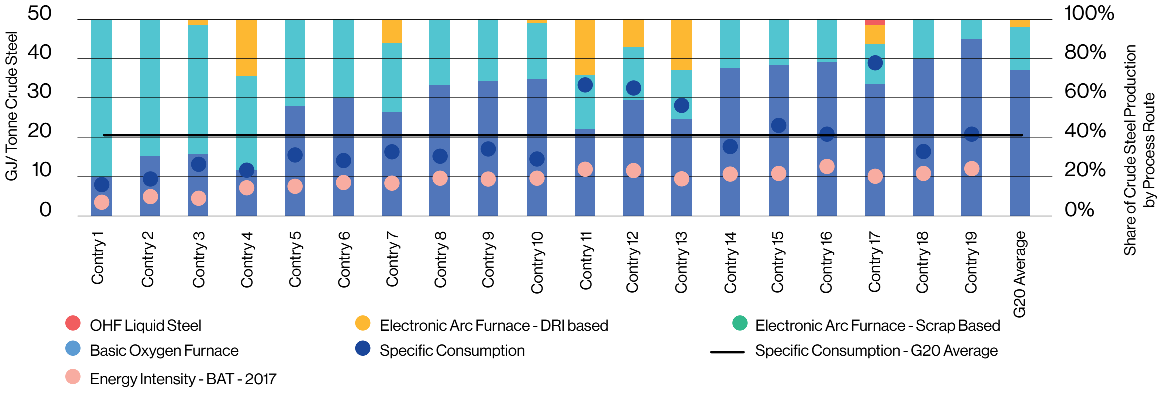

Figure 15. Share of steel production by process route and specific consumption of steel production, 2017

Source. IEA (2019f), International benchmarking, in Atlas of Energy Efficiency: Brazil 2019.

D. Incentives

Various incentives and financing mechanisms can be used to lower the upfront cost and effort of energy efficiency. Government economic recovery responses to the Covid-19 pandemic mean the importance of incentives will increase as stimulus spending becomes a key driver of industry, infrastructure and other capital investment.

Governments can provide different types of incentives to improve efficiency. Direct grants or subsidies are the by far the most common. For example, France incentivises low-emission vehicle purchases through a bonus paid to people who buy vehicles that fall under a certain emissions threshold. Likewise, there is a marginal charge applied to vehicles with emissions above certain limits (European Alternative Fuels Observatory, 2019).

Tax relief can also be an effective tool to incentivise the uptake of efficient equipment. For example, Norway provides a range of tax incentives for the purchase of energy-efficient electric vehicles, which has helped the country become the global leader in electric vehicle ownership, at 13% of the total national stock (IEA, 2018d) (IEA, 2020g). The range of other incentives includes debt financing, loans, direct investment and equity financing facilities. An analysis of incentives provided by the governments of the major economies showed that USD 12 billion was spent on national incentives in 2018 (IEA, 2019d).

Energy efficiency obligation programmes, or energy efficiency resource standards in the United States, are market-based instruments that require energy companies to achieve an energy efficiency target, usually set as an amount of energy savings to achieve. The obligations can be placed on different actors in the supply chain, but are usually energy retailers or distributors. Some obligations employ white certificates to track compliance, which can be traded to reduce costs and enable aggregation of smaller measures. Efficiency obligation programmes are used extensively in Brazil, China, Europe and the United States, and now cover 18% of the final energy used in the world (IEA, 2019d).

Auctions, including tendering programmes, where bids are invited for funds to deliver energy efficiency outcomes, include forward capacity auctions that allow energy efficiency to compete against other supply- and demand-side resources to meet energy system adequacy requirements (IEA, 2017).

Public procurement schemes can drive down prices by enabling production at scale. In 2013, Argentina's capital, Buenos Aires, launched a public procurement programme to upgrade all of the city's street lighting with LED lamps. In addition to the market benefits created, the 160 000 new lights and digital sensors reduced carbon emissions by more than 50 000 tonnes annually, more than halved the city's energy spend on lighting, reduced maintenance costs by 30%, and improved public safety throughout the city (Buenos Aires Ciudad, 2019).

Energy service companies (ESCOs) are key enablers of investment in energy efficiency, because they deliver efficiency projects based on long-term contracts tied to energy performance. They can finance initial project costs directly or with the involvement of a third party, while the customer is not required to make upfront capital expenditure. This contracting structure is critical to the success of ESCO financing, since upfront costs for efficiency upgrades often present a barrier to investment, and long-term contracts allow ESCOs to deliver more comprehensive energy efficiency improvements. In 2018 the global ESCO market was worth over USD 30 billion (IEA, 2019d).

New financing and business models are being developed to address the upfront cost of more efficient technology, but also realise more efficient operation of equipment. Paying for a service as an operational rather than a capital expenditure may also overcome organisational barriers. For example, the Cooling as a Service (CaaS) initiative, led by the Basel Agency of Sustainable Energy (BASE) on behalf of K-CEP, is working to scale up the global market for space cooling as a service (BASE, 2019).

E. Capacity building

Finally, programmes and policies to build capacity are essential for any energy system transformation. A diversity of examples are available of successful programmes and policies that help to build an energy efficiency workforce or up-skill existing construction, manufacturing, or other workforces that have a role in the energy system.

Certification programmes, like the National Australian Built Environment Rating System (NABERS), help to build advanced skills among a new or existing workforce to support a desired transition. In the NABERS example, the Australian government introduced a range of programmes to train and accredit building assessors to assess and audit building efficiency against the NABERS efficiency certification scheme (NABERS.gov, 2020).

Similar programmes exist around the world to train workforces and build capacity in technical skills, programme evaluation, monitoring and verification, operational support and retraining. These types of programmes provide enormous opportunity not only for energy efficiency acceleration, but also for job creation and economic development in communities hard hit by the Covid-19 pandemic.

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