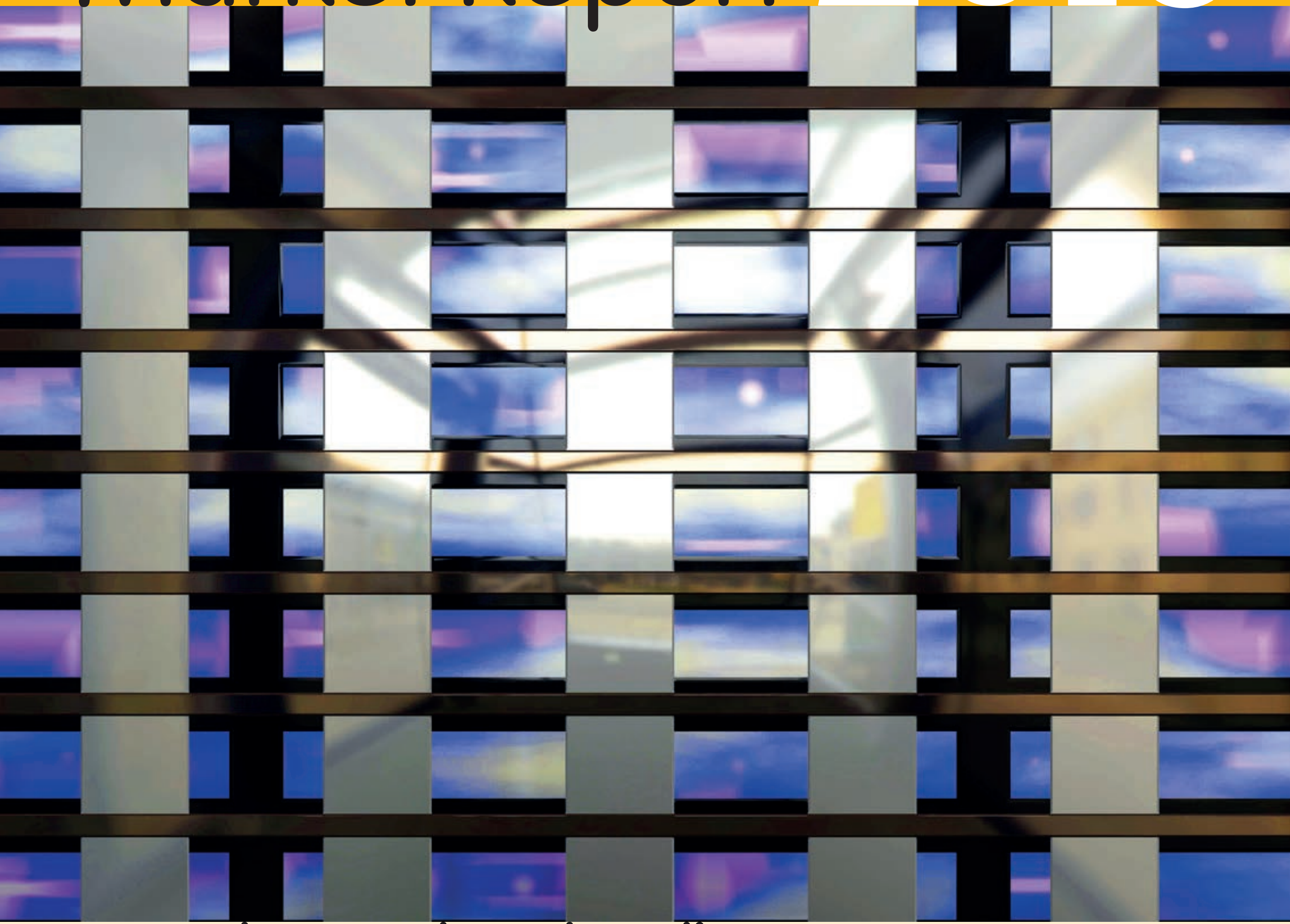
ENERGY EFFICIENCY

Market Report 2015



Market Trends and Medium-Term Prospects

International Energy Agency
Secure
Sustainable
Together

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 29 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

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FOREWORD

Mobilising energy efficiency is an urgent priority. To transition to the sustainable energy system of the future, we need to decouple economic growth from greenhouse gas (GHG) emissions. Energy efficiency is the most important "arrow in the quiver" to achieve this. For its part, the International Energy Agency (IEA) is pursuing a number of strategies to improve energy efficiency both among its member governments and with partner countries. The *Energy Efficiency Market Report* builds awareness and understanding about market activity, its drivers and impacts.

The ongoing, steady improvement in energy efficiency over the past four decades has been one of the most pronounced and significant changes to the global energy system, yet its impacts go largely unnoticed. Per capita energy consumption in IEA countries has dropped to levels not seen since the 1980s yet income per capita is at its highest level and access to energy services is continually expanding. This is why energy efficiency is so important. It is improving prosperity with a domestic, clean "source" of energy.

Energy efficiency investments across the IEA since 1990 avoided USD 5.7 trillion of energy expenditure. But the benefits of improving energy efficiency extend well beyond financial savings, relating also to improved energy security, higher productivity for businesses and reduced greenhouse gas emissions. Approximately 40% of the emissions reductions required by 2050 to limit global temperature increase to less than 2 degrees centigrade would potentially come from energy efficiency.

In an era that is becoming increasingly framed by the rise of fast-developing countries such as the People's Republic of China and India, their efforts on energy efficiency will have a significant impact on the evolution of the global energy landscape. It is in these countries where energy efficiency markets may have the most promise and greatest importance. With significant unmet energy demand in the developing world, energy efficiency markets offer the opportunity to fundamentally alter the trajectory of energy consumption growth. Many developing countries as well as industrialized economies are looking to energy efficiency to reap the multiple benefits that efficiency can provide, including improved air quality, better access to and improved reliability of their electricity systems, and overall greater prosperity for their citizens.

As this report describes, the breadth, scale and effect of the energy efficiency market is sizeable but it is still only a start; we need more – more investment, but also more political will and leadership at all levels to grow this market. The potential is there, the benefits are ready to be realised, and the imperative to act is clear; energy efficiency is poised to be a key component of global inclusive growth along the transition to a sustainable energy system.

Fatih Birol
Executive Director
International Energy Agency

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF BOXES

EXECUTIVE SUMMARY

Per capita energy consumption in IEA countries has dropped to levels not seen since the 1980s yet income per capita has never been higher. Energy efficiency investments over the last 25 years are the primary reason for this uncoupling of energy consumption from economic growth, and have enabled consumers in IEA countries to spend USD 5.7 trillion less on energy, while enjoying higher levels of energy service. The returns from energy efficiency investments have not been limited to straightforward financial gains; *Energy Efficiency Market Report 2015* (*EEMR 2015*) examines the strategic returns to consumers, industries (including utilities) and governments from improvements in energy productivity and energy security and reductions in greenhouse gas (GHG) emissions.

In 2014, the estimate of avoided total final consumption (TFC) from energy efficiency investments[1] increased to over 520 million tonnes of oil equivalent (Mtoe) or 22 exajoules (EJ). Supported by policies that deliver strategic returns, the energy efficiency market is anticipated to grow in the medium term – even in the current context of lower oil prices.

Energy Efficiency Market Report 2015 highlights

- **The energy intensity of countries belonging to the Organisation for Economic Co-operation and Development (OECD) improved by 2.3% in 2014**. OECD energy consumption is now as low as it was in 2000, while GDP has expanded by USD 8.5 trillion, an increase of 26%. This suggests that these countries have successfully decoupled economic growth from energy consumption growth, with energy efficiency being the main contributing factor.

- **Energy security in IEA countries is improving with increased energy efficiency**. In 2014 alone, at least 190 Mtoe (7 790 petajoules [PJ]) of primary energy imports were avoided in IEA countries, saving USD 80 billion in import bills.

- **Energy efficiency improvements in IEA countries since 1990 have avoided a cumulative 10.2 billion tonnes of CO_2 emissions,** helping to make the 2 degree warming goal more achievable.

- **Investments worldwide in energy efficiency in buildings, which account for more than 30% of global energy demand, are estimated to be USD 90 billion** (+/- 10%) and are set to expand.

- **Electricity consumption in IEA countries has flattened partly as a result of energy efficiency improvements; energy efficiency investments since 1990 saved 2 200 terawatt hours (TWh) in 2014.** In the face of flat electricity demand, various electricity utilities are diversifying into energy efficiency services businesses to increase profits.

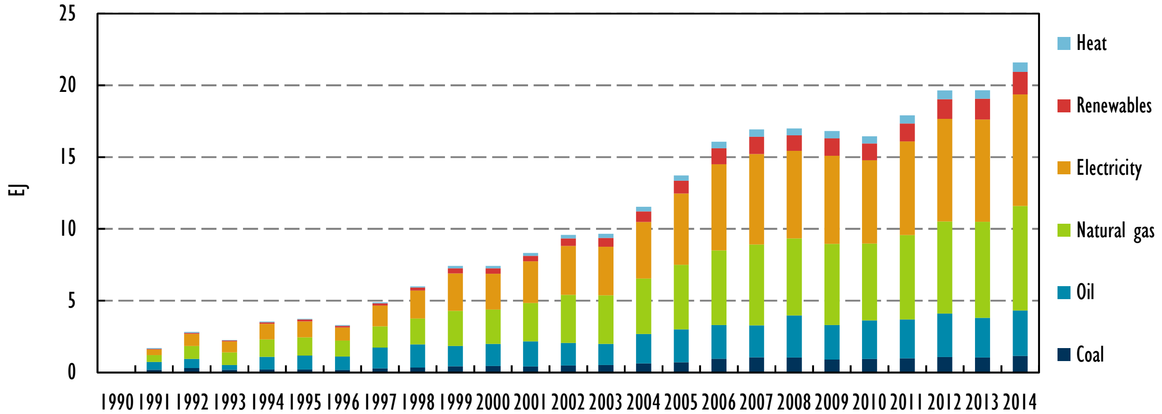
Energy efficiency: "Virtual supply" of over 500 Mtoe

Energy efficiency has been the primary factor in driving down energy consumption in IEA countries over the last decade. In 2014 alone, energy efficiency investments in IEA countries since 1990 generated 520 Mtoe (22 EJ) of avoided TFC, larger than the annual TFC of Japan and Korea combined (Figure ES.1). Avoided TFC from energy efficiency increased by 10% or 46 Mtoe (1 930 PJ) in 2014, the

[1] Avoided consumption from energy efficiency investments is an estimate of how much additional energy consumption would have been required had the energy efficiency of IEA countries not improved but key factors such as GDP, population and economic structure continued to change as observed. See fuller description in Chapter 2.

fastest rate in almost a decade. Cumulatively, investments since 1990 have generated 256 EJ (6 120 Mtoe) of avoided consumption, with reductions in electricity and natural gas use dominating. Energy efficiency , like other fuels, enables more energy service demand to be met, yet its role in the energy system is often overlooked. This "virtual supply" from energy efficiency is increasingly competing with oil, gas, electricity and other more traditional components of TFC.

Figure ES.1 Avoided TFC in IEA countries from energy efficiency investments made since 1990



Diverse returns on investment highlight the multiple benefits of energy efficiency

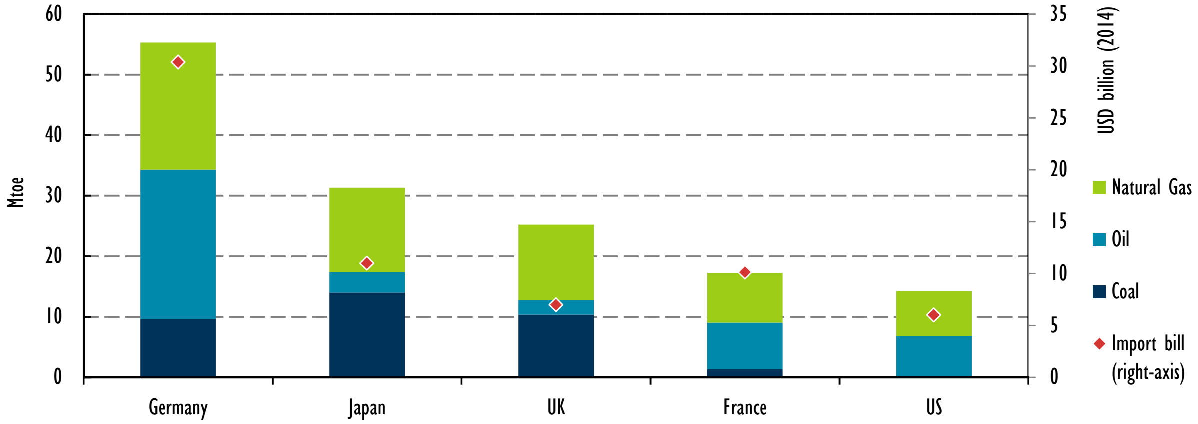
Avoided consumption from energy efficiency delivers sizeable financial returns; the avoided expenditure in IEA countries resulting from energy efficiency investments over the last 25 years can be valued at USD 5.7 trillion to energy consumers, more than the GDP in 2014 of Japan or Germany. In 2014 alone, these avoided energy expenditures totalled over USD 550 billion. These returns to energy consumers are only a part of the picture.

Energy efficiency investments offer diverse returns that go beyond the financial benefits to governments, industry and individuals. Many of the key strategic objectives of diverse stakeholders around the world can be furthered through energy efficiency. Investments in efficient buildings, transport and, industrial processes can, for example, deliver economic, social and environmental benefits. This report evaluates the returns from energy efficiency investments in the domains of economic activity, energy security and climate change mitigation.

Domestically produced, energy efficiency supports energy security

In 2014, energy efficiency investments since 1990 were estimated to have enabled countries to avoid primary energy imports of at least 190 Mtoe (given existing import patterns), with an estimated value of USD 80 billion. Every country generates energy efficiency improvements locally (e.g. through the use of better insulation and more efficient vehicles), making every country a producer of the energy efficiency fuel. Among IEA countries, Germany is estimated to have avoided the highest volume of imports (55 Mtoe), avoiding expenditure of USD 30 billion in 2014. The avoided imports from these investments improved country trade balances, boosting Germany's trade surplus in 2014 by 12% and cutting Japan's trade deficit by 8%.

Figure ES.2 Avoided volume and value of imports in 2014 from efficiency investments in IEA countries since 1990



A "zero-emission" source, energy efficiency reduces climate impacts

Energy efficiency improvements in IEA countries avoided 870 $MtCO_2$ in 2014, and 10.2 $GtCO_2$ over the period since 1990; the cumulative total effectively avoided nearly one year's worth of IEA countries' energy sector emissions to the atmosphere. In the preparations for the UN Framework Convention on Climate Change (UNFCCC) negotiations in Paris in late 2015, the environmental returns from energy efficiency are gaining more attention. By helping to avoid the combustion of fossil fuels at relatively little cost, energy efficiency is set to play a central role in decarbonisation efforts in the medium term.

Strong policies will continue to drive energy efficiency investment, even in a low oil price environment

Energy efficiency investments are set to keep growing driven by more assertive and more comprehensive policies. Several factors indicate that the energy efficiency market will remain robust in the medium term. Principal among these is the existence of strong and increasingly stringent policies, which recognise energy efficiency measures as being among the most cost-effective means of helping to tackle energy security, productivity, local air pollution and climate change challenges.

Recent pronounced downward shifts in global oil prices and regional gas prices have reduced in some economic segments the financial attractiveness of investing in energy efficiency, but are not undermining the market in general. In the United States, an increase in the share of light-duty trucks in 2014 stalled progress on fuel efficiency gains in the new passenger vehicle fleet as a whole, but transport efficiency continues to improve in Germany, driven largely by government fuel economy standards and changing consumer practices.

The fall in oil prices has also provided favourable conditions in some countries to reduce end-use fossil fuel subsidies, which undermine the economic attractiveness of energy efficiency investments. Several economies, including Egypt, India, Indonesia, Malaysia, Mexico, Thailand and the United Arab Emirates, have recently either cut or abolished fuel consumption subsidies. These actions align with the recommendation from the IEA to phase out end-use fossil fuel subsidies by 2030 in order to reduce greenhouse gas (GHG) emissions.

Buildings are a large and growing market for energy efficiency

Global energy efficiency investment in buildings is estimated to have been USD 90 billion (+/- 10%) in 2014. Of the approximately USD 960 billion spent in the residential and commercial building construction market in the United States in 2014, 2.4% (ie. more than USD 23 billion) was invested in energy efficiency, up from 1.9% in 2009. In the People's Republic of China, energy efficiency investments in buildings exceeded USD 18 billion, with more than 60% invested in the residential sector. In Germany, energy efficiency investments exceeded USD 17 billion with 75% directed towards residential buildings and more than 60% targeting energy efficiency retrofits.

Global energy efficiency investment in buildings is projected to increase to over USD 125 billion by 2020, driven in part by expanding efficiency-targeted policies. As energy efficiency codes, standards and programmes are improved and more widely implemented, per-building efficiency investment is projected to increase across most national building markets in the OECD. However, this level is much less than the estimated investment needed – USD 215 billion by 2020 – for the buildings sector in the IEA 2 Degree Scenario (2DS).

Energy efficiency is flattening electricity demand in OECD countries, challenging utility business models, while promoting reliable system expansion in non-OECD countries

The flattening of electricity consumption observed in OECD countries since 2010 is largely due to energy efficiency. Improvements in appliance efficiency alone, underpinned by increasingly stringent product standards, reduced electricity demand by 430 TWh in 2014 in OECD countries. In response to the low growth in electricity demand in OECD countries, electricity utilities are diversifying towards energy efficiency and other energy services businesses to increase earnings. Major European utilities are achieving sales for these product and service lines in the billions of euros, with revenues growing by 3% to 4% annually.

Outside the OECD, utilities are investing in energy efficiency to improve the reliability of their own systems to better keep pace with increasing electricity demand, driven notably by rising incomes and urbanisation. Utilities in many non-OECD countries are making energy efficiency investments to improve transmission and distribution (T&D) infrastructure, thereby reducing losses and outages, and also supporting efforts to expand energy access. Various countries, such as South Africa, are also promoting end-use energy efficiency programmes to improve system reliability.

Different stakeholders are actively building energy efficiency markets to achieve diverse goals

Energy efficiency is playing an increasingly important role in achieving diverse national, regional and even global goals, with policy makers, businesses (including utilities) and consumers as key market actors. In many markets around the world, the combination of energy efficiency policies and new business models is driving large-scale energy efficiency investments, as shown in examples of initiatives by subnational governments, evolving strategies of energy-producing countries, and development-focused targets in Latin America's emerging economies.[2]

[2] The focus on Latin America extends the country and regional reviews of previous editions of the *EEMR*. See *EEMR 2013* and *EEMR 2014* for reviews of Australia, Canada, China, the European Union, France, Germany, India, Indonesia, Ireland, Italy, Japan, Korea, the Netherlands, New Zealand, South Africa, Southeast Asia, Thailand, the United Kingdom and the United States.

Subnational governments emerge as key actors in the efficiency market

Cities and other subnational entities are becoming increasingly active in designing and implementing energy efficiency policies designed to meet local objectives; their actions often drive investments that complement national-level policies and goals.

In Paris, France actions taken municipally since early 2008 under the Paris Climate and Energy Action Plan are estimated to have resulted in about 130 GWh of savings. The Plan stimulated investment of EUR 640 million, creating 1 300 local jobs and 420 jobs elsewhere.

The US state of Massachusetts invested USD 680 million in energy efficiency programmes in 2013. The state estimates that its main efficiency programme, Mass Save, generated USD 2.8 billion in benefits in 2013 through almost 3.3 million, primarily residential, programme participants. This supported a state-level energy efficiency labour market of over 65 000 jobs.

Seoul Korea's "One Less Nuclear Power Plant" plan reduced municipal energy consumption by 2 Mtoe between 2012 and 2014; the plan promoted energy efficiency as a means to avoid the same volume of energy as could be supplied by a new nuclear plant. Energy efficiency efforts have leveraged over USD 1 billion in private energy efficiency investment since 2008.

Tokyo, Japan has implemented a suite of transport policies that enabled an increase of 4.9 billion passenger-kilometres while reducing transport energy consumption by 35%. Investments in energy efficient public transport in tandem with dense residential and commercial developments have allowed the city to achieve some of the lowest energy intensities of buildings and transport in the OECD.

Energy-exporting countries are looking to exploit energy efficiency to strengthen systems and boost exports

Various energy-exporting countries are adopting expansive energy efficiency programmes to manage rapidly rising domestic consumption and boost energy exports.

Saudi Arabia is significantly expanding energy efficiency standards to help stem rapidly rising consumption, with a strong focus on two key energy-using subsectors: passenger vehicles and air conditioning. Recently enacted policy aims to improve the energy efficiency of new passenger vehicles by 20% by 2020 (over current levels). Air conditioners, which are responsible for 56% of all electricity consumption in the country, have been targeted for an efficiency improvement of 35% by 2020. Adopting even more stringent standards (in line with those in the European Union) would free-up 71 million barrels of oil equivalent, representing an additional USD 3.6 billion in export revenue. For Saudi Arabia, and other major energy exporters, this practice of avoiding primary domestic energy consumption so energy saved can be redirected to exports, can serve to add an "efficiency premium" to the export price of oil.

The government of the Russian Federation ("Russia") recognises the potential for energy efficiency to help modernise its resource-dependent economy and is working to strengthen both institutional co-ordination and energy efficiency policies. In 2014, the Ministry of Energy dedicated USD 75 million (RUB 5 billion) towards energy efficiency programmes in 25 regions.

The recent recession is creating uncertainty about government funding for energy efficiency, however, which may limit market development.

The United Kingdom, a former net energy exporter, is using efficiency to soften reliance on imports

The United Kingdom – historically a net energy exporter – is using energy efficiency policies to adjust to life as a net importer. With an old and inefficient stock of buildings, and heavy reliance on imported natural gas for space heating, the UK government has made energy efficiency a priority. The central government has mobilised over USD 1.4 billion per year in energy efficiency investments through obligations on energy utilities and has introduced innovative legislation to drive improvements in the private rental sector. The energy efficiency sector is estimated to have employed more than 136 000 people in 2013.

Latin America's largest economies "tap into" energy efficiency to meet development goals

Energy efficiency is an important tool used in Latin America to meet diverse development goals, including enhanced energy security and social improvements. Brazil and Mexico are at the forefront of energy efficiency policy in the region.

Innovative efficiency programmes are making Mexico a lead country for energy efficiency investment in Latin America. The Efficiency Lighting and Appliances project is expected to save over 9.5 TWh of electricity consumption in 2015, while also improving standards of living for Mexico's poorer families. The plan has helped replace over 1.6 million refrigerators and 200 000 air-conditioning units, and includes over USD 53 million in funding to replace incandescent bulbs with high efficiency lighting.

Motivated by government policies, Brazilian utilities invested over USD 530 million from 2012 to 2014 in energy efficiency programmes that addressed other development objectives such as alleviating energy poverty. In the context of rising per capita energy consumption and electricity system strains (in part due to the recent drought), energy efficiency investments will be key to achieving the government target to reduce electricity consumption by 10% by 2030 (equivalent to 107 TWh of avoided consumption). Public sector investment in energy efficiency is down from a peak in 2011 due to government funding constraints, which is leading to greater reliance on private investment.

The energy efficiency market outlook

New dynamics in the energy sector carry important implications for the future of the energy efficiency market. Comprehensive policy announcements around the globe (including the Intended Nationally Determined Contributions submitted to the UNFCCC) are anticipated to stimulate further interest in pursuing energy efficiency to help achieve a variety of national goals, such as more sustainable economic development, reduced import dependence, increased energy security, and lower levels of local pollution and GHG emissions. In turn, stable and increasingly stringent policies are likely to boost growth of the energy efficiency market over the next ten years, for example, by attracting more capital towards energy efficiency investments in buildings.

The energy efficiency market will continue to evolve as new cycles of stimulating and stalling forces influence economics and investments. Still, the underlying assessment of *EEMR 2015* is that the energy efficiency market can be expected to grow in size, visibility and importance over the next several years. As governments continue to prioritise economic growth, energy security and a healthier environment, energy efficiency improvements will remain an important and cost-effective means to achieve national, regional and international goals.

PART 1

THE MARKET FOR ENERGY EFFICIENCY

1. ENERGY EFFICIENCY INVESTMENT RETURNS AND MARKET OUTLOOK

Summary

- Consumers in countries belonging to the International Energy Agency (IEA)[1] have saved USD 5.7 trillion over the last 25 years as a result of energy efficiency investments that have avoided 256 exajoules (EJ) of total final consumption (TFC). Energy efficiency investments since 1990 avoided the consumption of 22 EJ or 520 million tonnes of oil equivalent (Mtoe) in 2014 which exceeded the annual TFC in Japan and Korea combined and saved consumers USD 550 billion. This "virtual supply" from energy efficiency is becoming competing with oil, gas, electricity and other more traditional elements of TFC.

- **Energy efficiency is produced domestically, supporting energy security**. In 2014, IEA countries are estimated to have avoided primary energy imports of natural gas, oil and coal, totalling at least 7 790 petajoules (PJ) (190 Mtoe), and saving USD 80 billion in import bills. These avoided imports boosted Germany's trade surplus in 2014 by 12% and cut Japan's trade deficit by 8%. Energy efficiency is a domestic fuel that plays a major, but hidden, role in strengthening energy security. The domestic supply from energy efficiency investments over the last 25 years boosted by 16% the share of energy service demand met by domestic production in IEA countries.

- **Significantly reduced greenhouse gas (GHG) emissions can also be attributed to energy efficiency**. Without the avoided consumption generated by efficiency investments since 1990, IEA countries would have emitted an additional 10.2 gigatonnes of carbon dioxide ($GtCO_2$) by 2014. In 2014 alone, 870 megatonnes ($MtCO_2$) were avoided.

- In IEA countries, the avoided consumption generated by energy efficiency investments increased by 10% (1 930 PJ) in 2014 – the fastest rate in almost a decade. Improving efficiency was the primary factor behind the fall in energy consumption in IEA countries over the last ten years. Energy consumption in the wider group of countries belonging to the Organisation for Economic Co-operation and Development (OECD) is now as low as it was in 2000, while gross domestic product (GDP) has expanded by USD 8.5 trillion and an increase of 26%. These figures suggest that economic growth in these countries has decoupled from energy consumption.

- **Investments in energy efficiency are set to keep growing, despite lower oil and gas prices, driven by more assertive and more comprehensive policies**. Tighter regulations on new buildings, products and vehicles, as well as on utilities, are driving efficiency investment levels across many regions, dampening the impact of lower oil and gas prices. Recent policy announcements, including the EU Energy Efficiency Directive and the US Clean Power Plan, will support greater levels of investment, as will the Intended Nationally Determined Contributions (INDCs) submitted to the UN Framework Convention on Climate Change (UNFCCC) over 2014, which entail expanded energy efficiency action.

[1] IEA countries include all OECD countries (www.oecd.org/about/membersandpartners/list-oecd-member-countries.htm) except Chile, Iceland, Israel, Mexico and Slovenia. Collectively, IEA countries represent 90% of the energy consumption in the OECD.

- **The investment climate for energy efficient vehicles is being challenged in some areas by low oil prices**. Recent strong progress on fuel efficiency gains in the US new passenger vehicle fleet stalled in 2014/15 as gasoline prices dropped, with the market share of light-duty trucks increasing. In other countries, such as Germany (which operates within the European Union's fuel economy standards regime and has a higher tax environment), overall efficiency improvements continued in the new passenger vehicle fleet in 2015.

Analysing selected returns on energy efficiency investment

Energy efficiency improvements result from millions of business, household and public sector investment decisions each year, across all sectors of the economy. These investments are vastly different in type and scale, but all increase the level of energy service for each unit of energy consumed. Put another way, efficiency investments reduce the amount of energy required to satisfy energy service demand, even as that demand grows and living standards increase.

Energy efficiency investors seek returns, which may be in the form of monetary savings, increased profits, or in another type of value that satisfies their interests, such as improved comfort. Energy efficiency investments also provide returns to wider society through improvements in energy security, productivity and environmental outcomes.

The *Energy Efficiency Market Report 2015* (*EEMR 2015*) builds on the first two editions by providing an in-depth analysis of the end-use energy efficiency market.[2] This first chapter analyses some of the diverse returns on energy efficiency investments made over the past 25 years. These returns from the avoided consumption generated by energy efficiency investments illustrate the contribution of energy efficiency to decoupling economic growth from energy demand, to improving energy security and to achieving climate change mitigation targets. Finally, the chapter assesses the medium-term prospects for the market in light of recent policy developments and changes in oil prices.

Avoided energy consumption – i.e. the volume of energy saved through energy efficiency improvements – is central to most of the benefits generated by energy efficiency investments.[3] It can be calculated as the volume of joules or tonnes of oil equivalent (toe) not needed following efficiency improvements to acquire a similar level of energy service. In this way, energy efficiency delivers to the original investor a monetary "return" (a value) that reflects market prices. Energy efficiency investments generate an ongoing stream of returns that can deliver multiple values to investors, including households and businesses, as well as to the local and national governments that often set the policies that catalyse these investments. Measurable returns include avoided fuel consumption, related avoided expenditures, avoided energy imports (which help countries to become more energy secure), and avoided emissions (which contribute to meeting climate change mitigation targets) (Box 1.1).

[2] This report focuses on end-use energy efficiency, as opposed to the efficiency of converting primary fuels to end-use fuels or transmitting and distributing end-use fuels.

[3] Some benefits, such as improved health resulting from improvements to the energy efficiency of buildings, are independent of avoided consumption (IEA, 2014a).

Box 1.1 Measuring different types of returns from energy efficiency investments

Many of the returns from energy efficiency derive from the avoided energy consumption associated with the delivery of a given level of energy service.

Avoided final energy consumption (joules [J]) = Counterfactual energy consumption - actual energy consumption

Avoided energy consumption has a value at market prices. This represents a core return to investors that benefit from not having to purchase as much conventional fuel.

Market value (USD) = Avoided final energy consumption (J) x End-user prices (USD/J)

Avoided energy consumption is produced domestically. This has impacts at the national level and can be beneficial to national energy security.

Avoided imports (J) = Avoided primary energy consumption x Import ratio

Avoided imports also have a value at market prices, which is also relevant at the national level.

Value of avoided imports (USD) = Avoided imports (J) x Import prices (USD/J)

Avoided energy consumption reduces the release of various pollutants from energy production and consumption. This has impacts at the local, regional and international level, particularly in terms of CO_2 emissions.

Avoided emissions (CO_2) = Avoided primary energy consumption (J) x Emissions factors (CO_2/J)

EEMR 2015 analyses these returns associated with avoided energy consumption, but a suite of other benefits may also accrue from energy efficiency. These are examined in more detail in the IEA publication *Capturing the Multiple Benefits of Energy Efficiency* (IEA, 2014a), which analyses benefits to the macro economy, to public budgets, to the health of individuals living in poor housing conditions, to industrial investors, and to the wider energy system.

The energy efficiency market faces a fundamental challenge in the broader energy context. Investments in other fuels (including fossil fuels, nuclear and renewables) are regularly tracked and indeed their outputs are traded within and across well-structured markets. This report aims to demonstrate the mechanisms by which energy efficiency can more fully enter fuel markets, with appropriate recognition of its market value.

Estimating the impact of energy efficiency on consumption

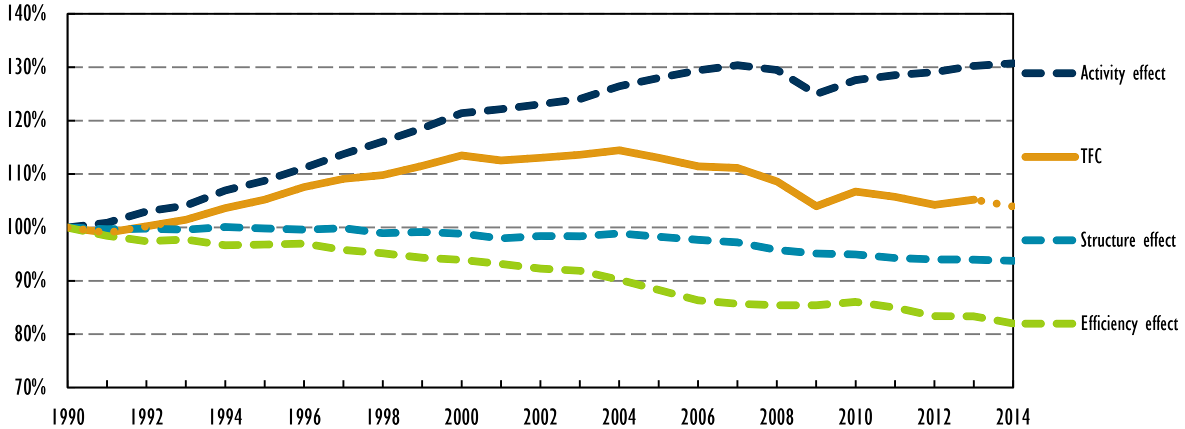
Changes in energy efficiency influence TFC, generating avoided energy consumption, which can be calculated through decomposition analysis (Chapter 2). In this approach, TFC[4] is decomposed into the three main effects that determine overall energy demand in a given country: the **activity effect**, which refers to the impacts of economic and population growth; the **structural effect**, which reflects the impact of shifts in relative levels of gross value-added (GVA) between commercial subsectors, modal shifts in transport, and changes in the floor area, the number of dwelling or appliances

[4] Of the International Standard Industrial Classification groups, mining and quarrying; fuel processing; electricity, gas and water supply; and to a large extent "other industries" are excluded from the analysis. Space heating energy consumption is adjusted for climate variations using heating degree days and cooking energy consumption is adjusted for household occupancy.

per person in the residential sector; and the **efficiency effect** (or intensity effect),[5] which is estimated at subsector level as the change in energy intensity once adjustments have been made for changes in activity and structure.

To investigate the multiple returns associated with avoided energy consumption in IEA countries, *EEMR 2015* uses a base year of 1990 to conduct a long-run analysis up to 2014; in this manner, the impact of energy efficiency investments made over the last 25 years are valued on a year-to-year basis. TFC rose during the 1990s before levelling off in the 2000s and declining over the last decade. The activity effect over this period put upward pressure on TFC, except during the substantial dip in output around the time of the global recession in 2008 and 2009. For the 11 IEA countries presented in Figure 1.1, TFC in 2014 would have been 31% higher than in 1990 without changes in efficiency or structure; however, energy efficiency gains and structural changes had the effect of constraining the actual increase to just 4%. The efficiency effect was the dominant factor in restraining energy consumption; TFC was around 18% lower in 2014 as a result of efficiency improvements since 1990. By comparison, the impact of structural change on TFC was insignificant until 2004, thereafter increasing to 8% in 2014.

Figure 1.1 Changes in aggregate TFC relative to 1990 levels, decomposed by activity, structure and efficiency effects for 11 IEA countries, 1990-2014

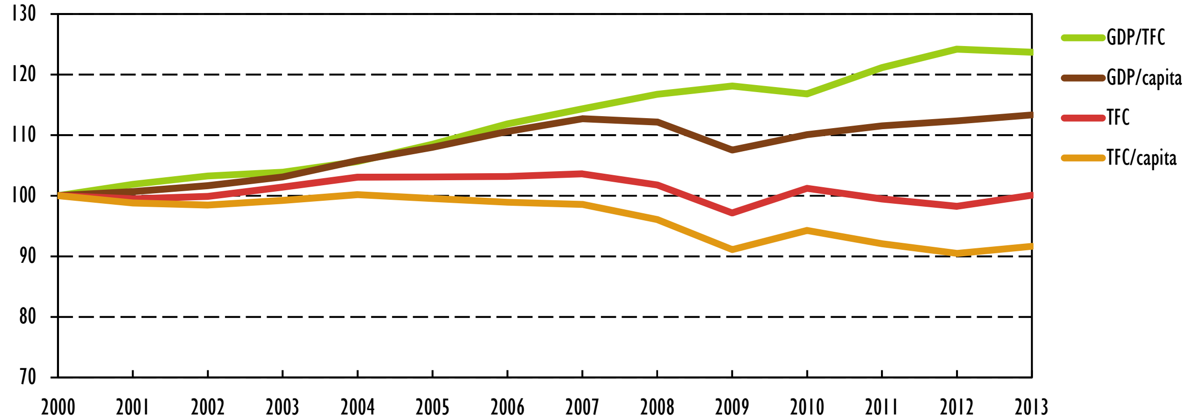


Note: The countries presented in this decomposition chart are Australia, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Sweden, the United Kingdom and the United States. TFC is estimated in 2014 based on total primary energy supply (TPES).

Trends since 2000 show that while GDP per capita increased by 13% in the OECD, energy productivity (the inverse of energy intensity) grew by 24% (Figure 1.2). Meanwhile, TFC is at the same level as in 2000 and energy consumption per capita has fallen by 9%, suggesting that economic growth in the OECD has become decoupled from energy consumption growth.

[5] This report uses the term "efficiency effect" to avoid confusion with the term "energy intensity". The decomposition analysis is undertaken at the lowest level of disaggregation possible so that changes in energy intensity can be used as a proxy for developments in energy efficiency.

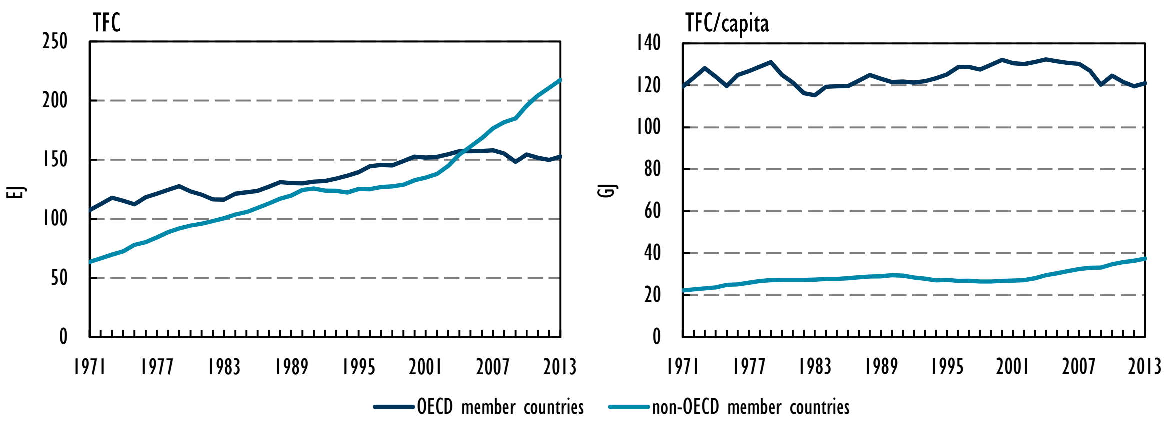
Figure 1.2 Indices in OECD countries of end-use energy productivity (GDP/TFC), GDP per capita (2005 USD PPP), TFC per capita and TFC, 2000-13



Source: IEA (2013b), "Economic indicators", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00471-en (accessed 11 May 2015).

OECD countries have seen a decade-long downward trend that began before the 2008-09 recession, with energy consumption per capita declining by 9% over the last ten years. This runs counter to the increasing consumption trend in non-OECD countries, which shows increasing TFC and increasing energy consumption per capita, albeit at an absolute level that remains well below that found in OECD countries (Figure 1.3). In light of anticipated growth in energy demand in non-OECD countries, energy efficiency can play an important role in supporting sound growth, even without generating savings in absolute terms (Box 1.3).

Figure 1.3 TFC in OECD and non-OECD countries, 1971-2013



Source: IEA (2014b), "World energy balances", IEA World Energy Statistics and Balances (database), available at http://dx.doi.org/10.1787/data-00512-en (accessed 1 May 2015).

Box 1.3 Doing even more with more: the potential of energy efficiency in emerging economies

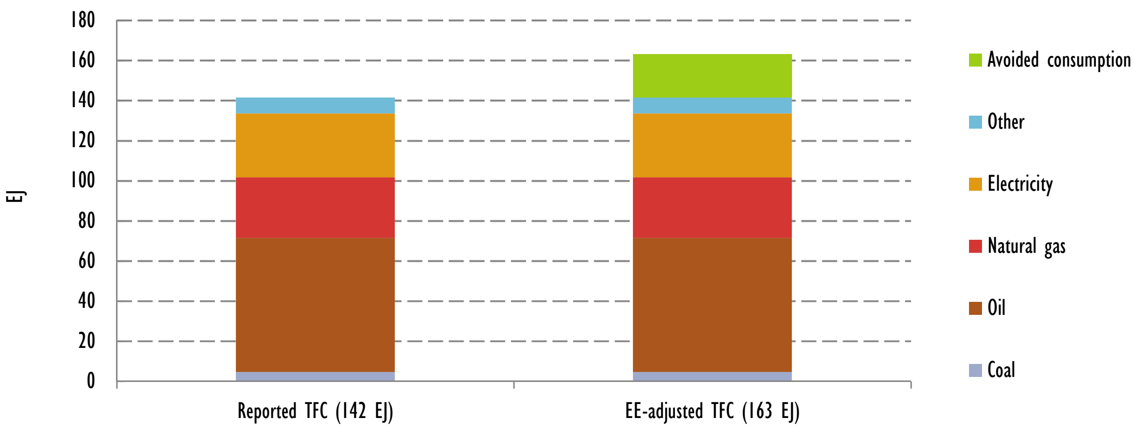
Emerging economies show a trend of rapidly rising energy consumption, with a faster rate since 2002 than at any point over the last 40 years. In 2004, TFC in non-OECD countries overtook TFC in OECD countries for the first time. Over the last decade, OECD consumption has flattened, while non-OECD consumption has accelerated, meaning that by 2013, energy consumption in non-OECD countries was 42% higher than in OECD countries (Figure 1.3). Consumption increases in non-OECD countries largely reflect growing populations, rising incomes, industrialisation, increased energy access and infrastructure development.

Energy efficiency enables emerging economies to improve energy productivity, which in turn can drive economic growth and help to achieve wider social objectives, thereby improving prosperity. This energy efficient prosperity can often involve both improving energy efficiency and rising energy consumption; in comparison to the model of "doing more with less", emerging economies are “doing even more with more”. For example, over the period 2004-13, the People’s Republic of China (hereafter, “China”) improved its end-use energy productivity (GDP/TFC) each year – achieving a 29% improvement overall – while increasing energy consumption (TFC) by as much as 70%.

The virtual supply from energy efficiency

Energy efficiency improvements over the last 25 years led to energy savings – i.e. avoided energy consumption – of 22 EJ (520 Mtoe) in 2014 in IEA countries. This is comparable to the shares of gas (30 EJ) and electricity (32 EJ) in TFC, and almost half of the share of oil (67 EJ), which remains dominant (Figure 1.4).[6] The aggregate avoided consumption over the 1990-2014 period totals 256 EJ (6 160 Mtoe).

Figure 1.4 Contributions of fuels to meeting energy service demand in IEA countries in 2014, without (“Reported TFC”) and with (“EE-adjusted TFC”) avoided energy consumption from investments made since 1990



Source: IEA (2013a), “Energy balances”, *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 and 2 May 2015).

Adjusting TFC to reflect energy efficiency’s contribution through avoided energy consumption

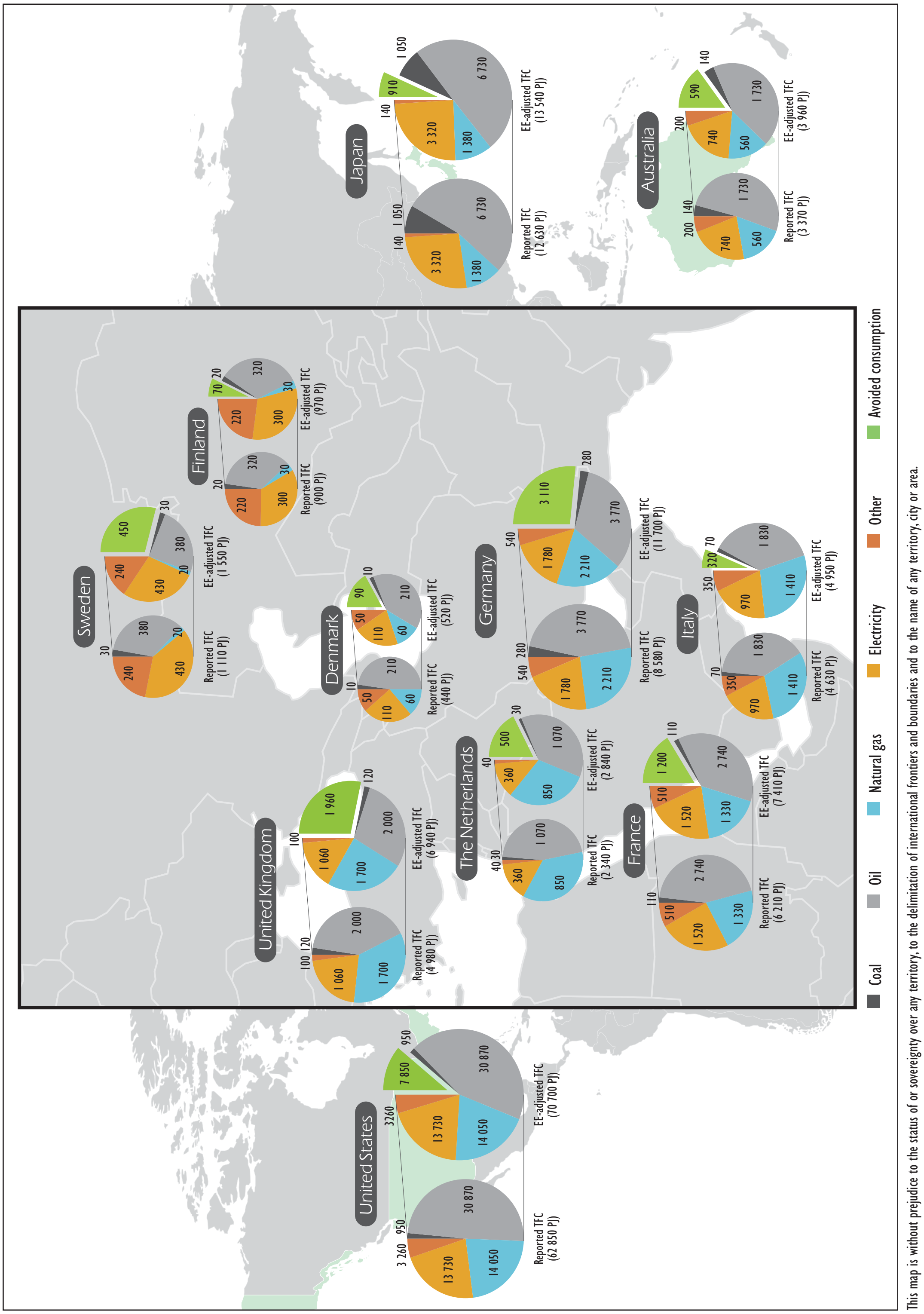
Energy service demand in an economy is met both by actual consumption and, increasingly through improved service delivery as a result of energy efficiency. Examples can be drawn from all end-use

[6] *EEMR 2013* (IEA, 2013c) and *EEMR 2014* (IEA, 2014c) presented analysis of the avoided consumption resulting from investments made since 1973 in a smaller number of IEA countries. Updating those analyses shows that, in 2014, energy efficiency provided 56 EJ or 1 330 Mtoe of virtual supply, exceeding the contribution of all other fuels to meeting TFC (e.g. with 40 EJ, oil is the next-largest contributor). Measured in this way, energy efficiency preserves its place as the “first fuel”. EEMR 2014 estimated global annual investments in energy efficiency at USD 310 to 360 billion.

sectors: a) efficient appliances allow more appliance services to be delivered with the same energy consumption; b) improved vehicle efficiency allows more kilometres to be travelled with the same fuel consumption; and c) improved industrial motors allow greater output with the same fuel consumption. Energy efficiency allows the same level of TFC to deliver more energy services.

Yet TFC charts do not report the virtual supply from energy efficiency. One way to render more visible the contribution of energy efficiency to meeting energy demand is to add to reported TFC the avoided energy consumption generated by the energy efficiency improvements. This adjusted TFC ("EE-adjusted TFC") better reveals an economy's actual energy service demand. The EE-adjusted TFC reflects the larger energy outcomes, which are greater than actual TFC. When values for the contribution generated by energy efficiency investments since 1990 are included, TFC for IEA countries is estimated at 163 EJ in 2014 (Figure 1.4). The comparison between EE-adjusted TFC and actual TFC varies across countries, reflecting different levels of success in achieving energy efficiency improvements (Figure 1.5). The impact of efficiency gains on TFC in 2014 from investments made since 1990 was largest in percentage terms in Germany, Sweden and the United Kingdom.

Figure 1.5 Contribution of fuels to meeting energy service demand in selected IEA countries in 2014, without ("Reported TFC") and with ("EE-adjusted TFC") avoided energy consumption from investments made since 1990



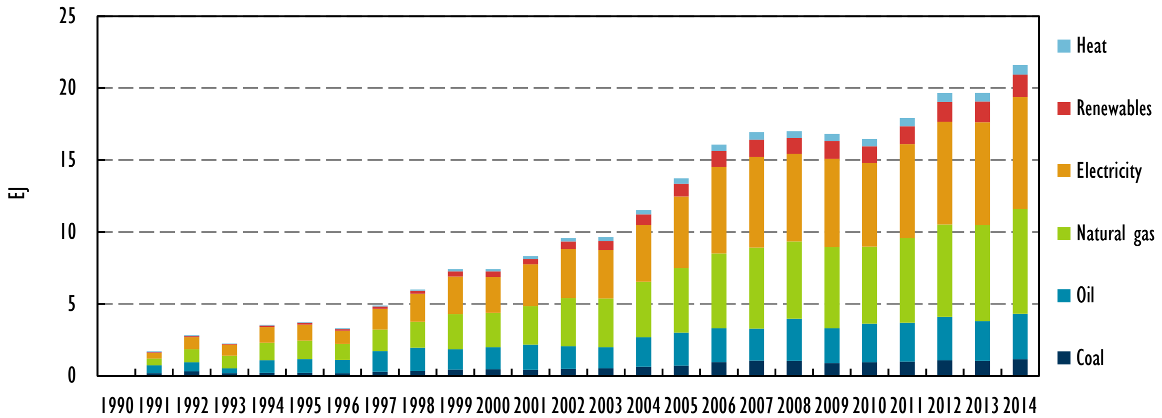
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: IEA (2013a), "Energy balances", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 and 2 May 2015).

Avoided consumption from energy efficiency reduces use of other fuels

Energy efficiency enables reduced use of other fuel sources. In IEA countries, the majority of the avoided consumption has been of electricity[7] and natural gas. Relatively little oil consumption was avoided, as the avoided consumption occurred primarily in sectors other than transport, where oil dominates (Figure 1.6).[8]

Figure 1.6 Avoided TFC in IEA countries, by fuel type, from energy efficiency investments made since 1990



Source: IEA (2013a), "Energy balances", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 and 2 May 2015).

Energy efficiency investments generate value for energy consumers

The avoided energy consumption from energy efficiency has a monetary value for energy consumers investing in energy efficient goods and services that can be expressed in the form of avoided expenditure.[9] Two factors determine this value: the volume of avoided consumption of each fuel and the corresponding price of each fuel at the time the consumption was avoided. To calculate the value, the two factors need to be multiplied. End-user prices[10] from the IEA Energy Prices and Taxes database were applied to the avoided consumption of each fuel in each year to generate an estimate of this monetary value.[11] In 2014 alone, avoided energy consumption in IEA countries as a result of efficiency gains since 1990 generated a corresponding monetary value of USD 550 billion. Since 1990, the cumulative monetary value for this avoided consumption in IEA countries reached USD 5.7 trillion (Figure 1.7), more than the annual GDP of either Japan or Germany.

[7] Electricity is an end-use fuel in TFC calculations. However, subsumed within electricity are the coal, gas, renewables and other fuels used to generate it. Consumption of natural gas, coal, oil and renewables in TFC does not include their use in electricity generation.

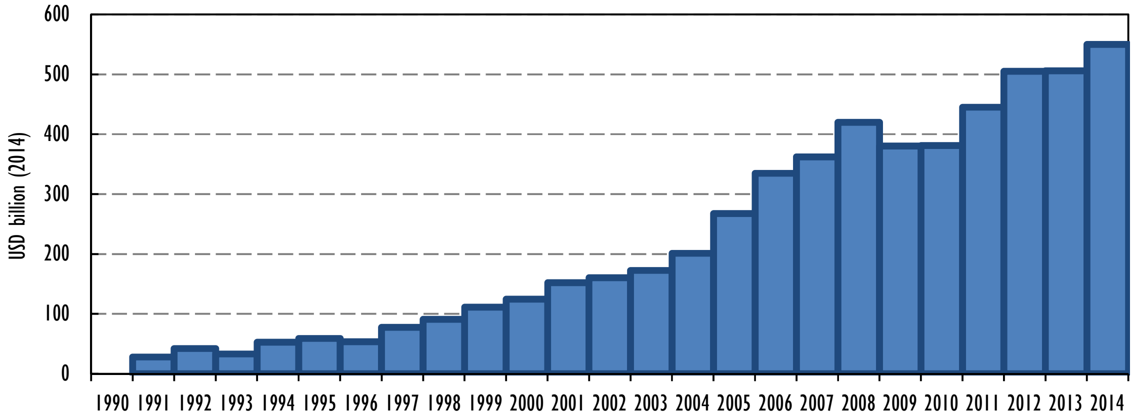
[8] To provide an estimate of the breakdown, by fuel, of the 22 EJ of avoided consumption in 2014, it is assumed that fuel savings in end-use sectors (e.g. industry or residential) are made in proportion to their consumption in reported TFC (by sector) in each year.

[9] At the national level, countries will have benefited more or less than the market value, depending upon the extent to which the avoided fuels are taxed or subsidised. Reductions in consumption reduce both fuel tax revenues and fuel subsidy expenditure, affecting the government sector. End-user prices also contain profit margins to companies in the energy supply chain that will fall with avoided consumption.

[10] End-user prices include taxes.

[11] Prices are expressed in 2014 USD purchasing power parity (PPP) terms to ensure comparability across countries.

Figure 1.7 Avoided expenditure from IEA energy efficiency investments made since 1990



Source: IEA (2013a), "Energy balances", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 and 2 May 2015).

A domestically produced fuel, energy efficiency boosts energy security

For most countries, and indeed all IEA member countries, energy demand is met through a mixture of domestically produced and imported fuels. Energy efficiency, by contrast, is 100% home-grown: the avoided energy consumption results from domestic efficiency action, such as insulation in buildings or the use of more efficient cars.[12] In all IEA countries, taking account of the contribution of energy efficiency pushes up the share of fuels produced domestically relative to those imported. Reducing reliance on imports is central to achieving energy security for many countries both within and beyond the IEA, and energy efficiency allows for a greater portion of energy service demand to be met through domestic resources and action.

Estimating the primary fuel implications of energy efficiency: From TFC to TPES

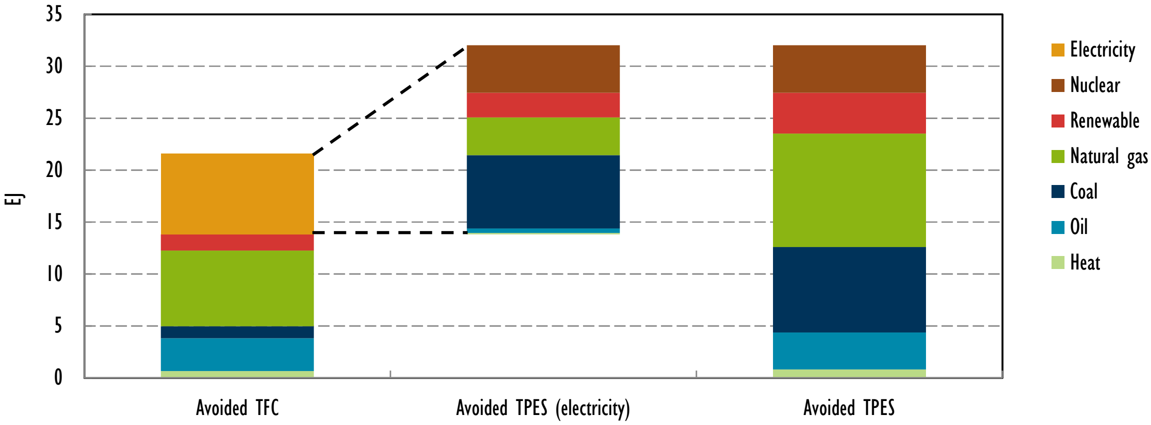
A country's TFC is a measure of consumption by end-users. End-use energy efficiency actions (such as insulating buildings or purchasing more efficient cars) directly affect TFC and are used for the decomposition analysis. Total primary energy supply (TPES) is a measure of all the energy used in a country, including the primary fuels consumed in the generation of electricity. In order to analyse how end-use efficiency gains influence energy security, TPES provides a more useful metric: it enables an examination of how much of the energy needed to fuel a given economy is sourced domestically or acquired through imports. The key factor in moving from TFC to TPES is to convert avoided TFC of electricity into the primary fuels used to generate it (mostly coal, gas, nuclear and renewables in IEA countries in 2014).[13]

[12] Although the products such as cars may have been imported, the generation of the avoided consumption dervies from their domestic use. This is analogous to the oil production from wells produced by drilling equipment that was imported into the oil-producing country.

[13] Electricity is not all produced domestically. Some is traded across national borders, and indeed interconnectors are vital to meeting energy demand in some jurisdictions. However, most electricity is domestically generated, and energy security concerns are often driven by access to primary fuels. In 2013, primary fuel imports for electricity generation in IEA countries were nine times greater than imports of electricity through interconnectors.

The avoided TFC of electricity shown in the decomposition analysis was converted into its primary components using the average fuel mix in each country, in each year (Figure 1.8).[14] Given the efficiency factors associated with transforming primary fuels into electricity, this results in considerably more fuel consumption being avoided. In fact, the amount of avoided energy consumption increases by 48% from 22 EJ (520 Mtoe) in TFC terms to 32 EJ (760 Mtoe) when expressed in TPES terms, with avoided coal consumption showing the biggest absolute increase between the two measures. This reflects that coal is both the most widely used primary fuel in IEA electricity production and the least efficient in conversion terms.

Figure 1.8 Avoided energy consumption in IEA countries in 2014 as a result of energy efficiency investments since 1990, with and without electricity split into primary fuels



Note: Avoided TPES here includes primary fuels used in electricity production. Other end-use fuels have not been adjusted to take account of any losses between their production and consumption.

Source: IEA (2013a), "Energy balances", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 and 2 May 2015).

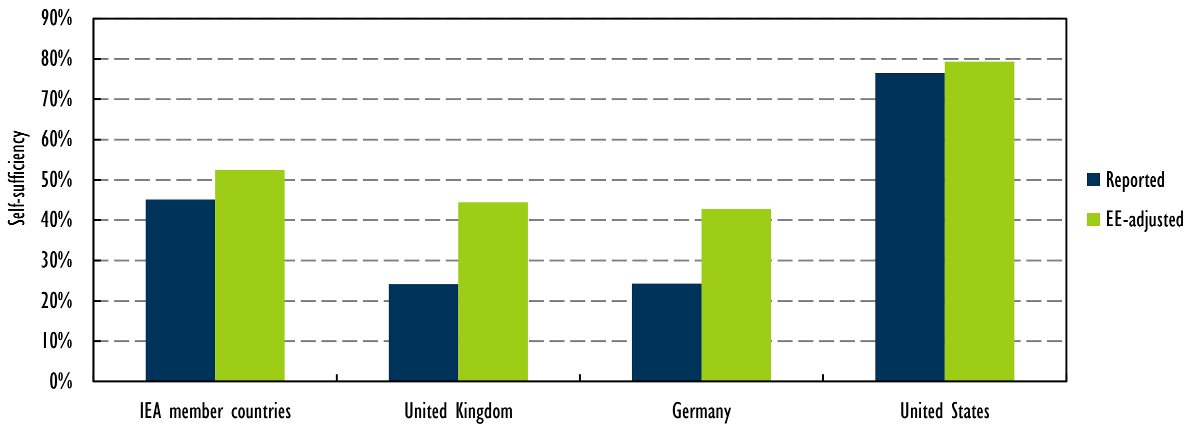
Virtual supply that increases domestic production

As described above, energy efficiency represents a domestically produced energy source that can boost energy security. Measuring the size of domestically produced energy (minus exports) relative to the size of TPES gives a metric of the volume of a country's total energy demand produced domestically, which can be used to calculate a "self-sufficiency" indicator. Incorporating the avoided energy consumption and corresponding delivered energy services (i.e. domestic production minus exports, plus avoided consumption, as a share of actual TPES plus fuel savings associated with the avoided consumption) arguably gives a richer sense of trends in the energy sector by taking into account the impacts of vehicle fuel economy and other similar programmes. This provides an adjusted self-sufficiency measure. Energy efficiency improvements since 1990 increase the share of TPES (in this case, EE-adjusted TPES) produced from domestic resources (including energy efficiency's contribution) by 16% (seven percentage points) in 2014. This pushes the domestic share across all IEA countries to above 50% (Figure 1.9).[15]

[14] TFC of electricity was converted to TPES using IEA data on the average efficiency of power generation associated with each primary fuel. The share of each primary fuel in avoided electricity generation was assumed to be the same as the share in actual electricity generation in each country. In reality, in any given year, nuclear and renewables would be much less likely to be avoided than coal and gas, which are more easily ramped up or down in the short term. However, over time and as efficiency improvements amass, investment decisions would be affected: i.e. with higher demand in each year, more nuclear and renewable plants may have been commissioned.

[15] Nuclear fuel imports are not accounted for in this analysis.

Figure 1.9 Proportion of TPES met by domestically produced fuels in IEA countries, in 2014, without ("Reported") and with ("EE-adjusted") avoided energy consumption from investments made since 1990



Source: IEA (2013a), "Energy balances", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 and 2 May 2015).

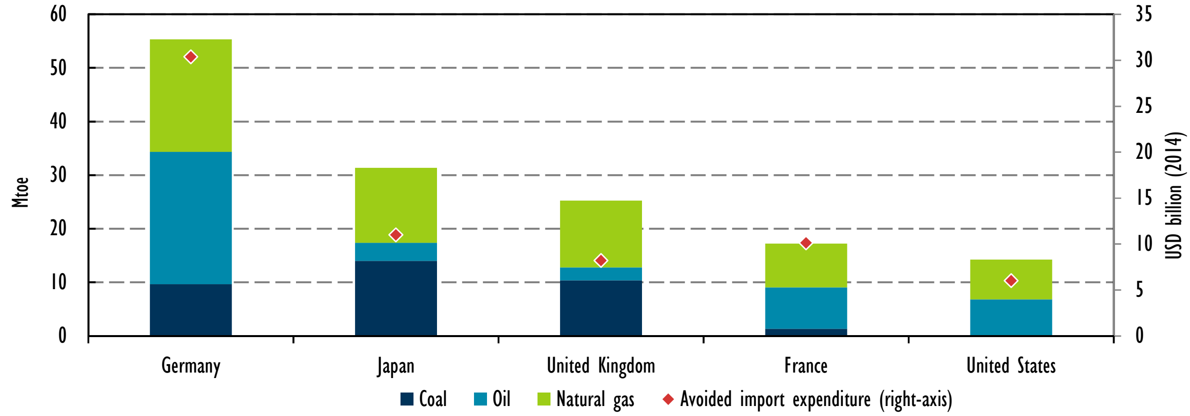
The proportion of EE-adjusted TPES met through domestically produced fuels varies among countries, with particularly strong impacts in the United Kingdom and Germany. In the United Kingdom, energy efficiency partly offset a long-term decline in energy independence, as the proportion of TPES produced domestically fell gradually in line with reductions in oil production. The UK ratio of domestically produced resources would have been 17 percentage points lower (at 24%) in 2014 without energy efficiency. In Germany, the ratio would have fallen to 24% as well. In the United States, including energy efficiency in adjusted TPES has a more modest impact of four percentage points in 2014.

Imports avoided through energy efficiency

Reduced fuel imports are, for many countries, a key return on energy efficiency investments. Avoided energy consumption leads to some reduction in imports for most countries, even for many exporting countries since they typically import some fuels. Across IEA countries, energy efficiency investments since 1990 have enabled countries to avoid 1 930 Mtoe (81 EJ) in primary energy imports over the period to 2014 (Figure 1.10).[16] This is broadly equivalent to the annual TPES of the European Union or the United States. In 2014 alone, IEA countries avoided 190 Mtoe (7.8 EJ) in primary energy imports. Germany achieved the greatest reductions in imports overall. Of the other countries with large reductions, Japan and the United Kingdom showed the highest volumes of avoided imports of coal and natural gas; in France and the United States, avoided imports were concentrated on oil and natural gas.

[16] To estimate the volume of avoided imports, this report assumes that avoided consumption would have been met through the same proportions of imports and domestic supply observed for actual TPES in each country in each year. These import ratios were applied to the estimates of avoided primary energy consumption to calculate the estimated volume of avoided imports.

Figure 1.10 Volume and monetary value of avoided imports in 2014, as a result of efficiency investments in selected IEA countries between 1990 and 2014



Source: IEA (2013a), "Energy balances", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 and 2 May 2015).

Applying import prices from the IEA Energy Prices and Taxes database to the volume of imports enables a calculation of the estimated value of avoided imports (Figure 1.10, right axis). In 2014 alone, several countries realised important benefits. Germany is estimated to have saved USD 30 billion as a result of energy efficiency gains that reduced consumption of imported oil, gas and coal. This equates to around 30% of the USD 80 billion savings to the IEA as a whole. These avoided imports boosted Germany's trade balance by 12%. Similarly, avoided imports of USD 11 billion reduced Japan's trade deficit by 8% while in France, energy efficiency led to avoided imports of USD 10 billion, reducing the country's trade deficit by 10%.

Energy efficiency and the attendant avoided consumption can also benefit exporting countries with limited imports, particularly by freeing up additional fuel volumes for sale on international markets.[17] The relevance of this warrants further examination in the cases of the Russian Federation (hereafter, "Russia") (Chapter 10) and Saudi Arabia (Chapter 11).

Helping to meet short-term supply challenges

Energy efficiency can also be used to tackle short-term energy challenges. In many crisis situations, natural disasters (such as earthquakes, landslides or droughts, the ability to deliver energy supply is dramatically reduced, leading governments to adopt various demand-side management and energy efficiency investments to try to adjust demand relative to lowered supply. In other cases, geopolitical and commercial stresses motivate action. This is currently true for Ukraine, where uncertainties surrounding short-term gas imports are motivating government action to actively manage consumption (Box 1.4).

[17] The extent to which exporting countries are able to take advantage of avoided domestic energy consumption to increase exports will depend upon a variety of factors, including market forces in other countries.

Box 1.4 Energy efficiency's role in making Ukraine more energy secure

Ukraine is facing unprecedented energy security challenges as a result of the ongoing crises in the realms of both geopolitics and energy contracts. The country is exploring means to strengthen its energy security by improving energy efficiency across the economy and thereby decrease its reliance on fossil fuel imports, particularly gas from Russia. In its draft National Energy Efficiency Action Plan, Ukraine has identified energy efficiency measures to achieve 6 500 kilotonnes of oil equivalent (ktoe) of energy savings in 2020. Capturing these savings would be equivalent in scale to decreasing Ukraine's natural gas imports by around 40%.

A large potential for energy efficiency investments can be found in the buildings sector. Almost 75% of the residential building stock in Ukraine was built before 1970; deep renovations on 70% of these buildings could generate significant energy savings. Only around one-third of residential buildings in Ukraine contains heat meters or control systems, even at whole-building level. Without control systems, occupants are able to counteract overheated rooms only by opening windows. Recognising the large potential for avoided consumption, the government has made it a priority to install meters and control systems, and has received financial support from the International Monetary Fund.

A recent IEA report[18] identifies priority areas for demand-side energy efficiency in Ukraine. The report recommends that Ukraine implement a package of measures that includes: widespread refurbishment of residential building envelopes; installation of building energy control systems and meters; replacement of inefficient appliances and equipment; information campaigns to reduce wasteful energy consumption; and other programmes across end-use sectors. Ukraine is currently working to develop and implement many of these measures (IEA, forthcoming).

In addition, Ukraine is working with multilateral development banks and other partners to design and implement energy efficiency programmes. For example, the European Bank for Reconstruction and Development (EBRD) is providing USD 111 million (EUR 100 million) for the Ukraine Sustainable Energy Financing Facility set up in 2014, and a loan of USD 88 million (EUR 79 million) to the manufacturer *EnergoMashSpetsStal* to improve energy efficiency and competitiveness through a comprehensive upgrade of all major production facilities and processes.

Programmes to mitigate the negative impacts of an electricity shortfall can employ a range of tools, such as technology replacement initiatives and information campaigns to encourage energy savings and investments, at times in tandem with non-energy efficiency measures, such as rationing (IEA, 2011). Effectively applied, these tools can stimulate and enable consumers to replace old technologies with more energy-efficient ones and to modify consumption patterns.[19]

Long-term impacts of energy efficiency on energy demand

Energy consumption has largely flattened in OECD countries since the mid-2000s (Figure 1.2). Moreover, a number of countries are adopting policies that expressly or implicitly aim to reduce future energy consumption while supporting increased GDP – in essence, not only decoupling GDP growth from energy consumption growth, but also striving to reach a "peak" in energy consumption

[18] The report was developed by the IEA with strong participation from the State Agency on Energy Efficiency and Energy Saving of Ukraine, the United Kingdom Foreign Office, the European Commission Support Group for Ukraine, the European-Ukrainian Energy Agency and more than 80 Ukrainian energy efficiency stakeholders.

[19] Countries implementing such programmes have achieved energy savings ranging from 3.6% (New Zealand, 2008 shortfall due to drought) to 25% (United States, Juneau, Alaska, 2008 shortfall due to avalanche cutting transmission line). Measures that led to electricity reduction in New Zealand included an information campaign targeting households. Juneau, Alaska also implemented an information campaign ("Juneau Unplugged") that provided end-users with advice on how to quickly and safely conserve electricity. Energy savings measures adopted as a result of that campaign included reducing lighting and appliance use, turning down thermostats, hanging clothes to dry and taking shorter showers.

in absolute terms. This trend, which is evident primarily in OECD countries that have attained certain incomes per capita, raises the question of whether "peak energy demand" may ultimately become an established and widespread policy objective – eventually on the global scale (Box 1.5).

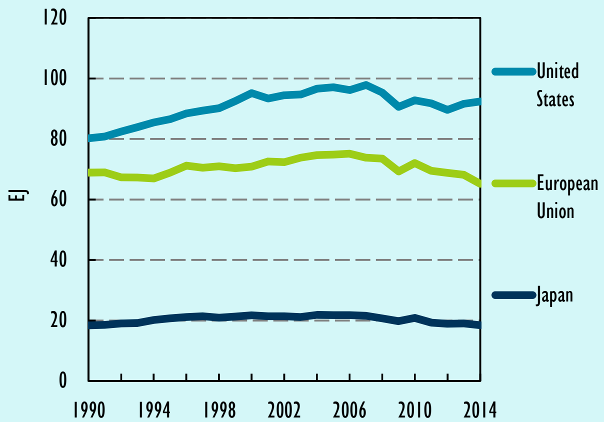
Box 1.5 From "peak supply" towards "peak demand"?

Nearly a decade ago, the "peak oil" theory, as it is often called, raised concerns that as inexpensive fossil fuel reserves were depleted, the price of energy would spike and constrain energy demand – with potentially significant negative consequences for industrialised economies. The development of the shale gas and oil industries has allowed for (at least) a temporary reprieve from the risk of fossil fuel shortages, while rapidly declining prices for solar photovoltaic energy cast further doubt over whether modern industrialised economies were indeed (or will be) energy-supply constrained.

Another trend has emerged more recently, relating to demand for energy. Either through explicit policies, or embedded implicitly in other policies, many countries are pursuing "peak demand" strategies – i.e. taking steps to limit the growth of total demand. Actions include focusing on the role of energy efficiency to improve living standards while delivering absolute reductions in actual energy consumption.

The European Union, for example, reached peak TPES in 2006 (Figure 1.11), and has put in place energy efficiency targets to reduce primary energy consumption in absolute terms relative to 2005 by 2020 and 2030 (EC, 2014). Germany has set particularly ambitious targets, aiming to reduce primary energy demand by 20% below 2008 levels by 2020 and 50% by 2050. Japan reached peak demand in 2004 and is aiming to further reduce consumption. It is assumed that Japan's TFC across all sectors will decrease by 13% by 2030 (compared to 2013) through energy efficiency measures (METI, 2015). Consumption in the United States has declined since a peak in 2007, and the government has a target to double energy productivity by 2030. If the productivity target is achieved, US energy consumption would continue to decline, even with robust economic growth of up to 3.5% per year to 2030.

Figure 1.11 TPES in the European Union, Japan and the United States, 1990-2014



Source: IEA (2013a), "Energy balances", Energy Projections for IEA Countries (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 and 2 May 2015).

A key point is that many OECD economies have grown even while energy consumption has flattened (see Figure 1.2), suggesting they have succeeded in decoupling GDP growth from energy consumption growth. As more countries put in place energy efficiency policies to further increase energy productivity, improve energy security and mitigate climate change, it is quite possible that the OECD as a whole has already reached peak energy demand.

Box 1.5 From "peak supply" towards "peak demand"? (continued)

In non-OECD countries, energy consumption is still increasing and expected to continue on the same trend (Figure 1.3) (IEA, 2014d). Many countries are now looking for ways to manage the drivers of energy demand. The Chinese government, for example, in its recently released INDC, states that it "will accelerate the transformation of energy production and consumption and … improve energy efficiency … with a view to efficiently mitigating greenhouse gas emissions." While formulated in the context of a climate objective, these actions will also affect China's energy demand pattern and should support decoupling of economic growth from energy consumption growth. This is a potentially important issue for China, which today consumes about 22% (127 EJ) of world TPES.

At some point, as other countries succeed in raising standards of living, they are likely to see turning points in their consumption – as is being demonstrated across the European Union. This begs the question: when will global energy demand peak?

Greenhouse gas emissions reduction through energy efficiency

The avoided TPES achieved through energy efficiency improvements also has a positive impact on carbon dioxide (CO_2) emissions, providing an environmental return on efficiency investments.[20] Energy efficiency affects CO_2 emissions directly by reducing the volume of fossil fuel combusted (e.g. natural gas in heating and industrial processes, and gasoline in transport) in final energy use, thus reducing associated emissions. An indirect effect arises when reduced use of fossil fuels in transformation processes leads to lower emissions (e.g. from avoided consumption of electricity generated from fossil fuels).

Annual CO_2 emissions from energy end-use sectors in IEA countries rose from 10.8 billion tonnes of carbon dioxide (10.8 $GtCO_2$) in 1990 to a peak of 12.5 $GtCO_2$ in 2007, after which they fell back to 11.6 $GtCO_2$ by 2014. Without efficiency investments between 1990 and 2014, CO_2 emissions in the IEA would have been a cumulative 10.2 $GtCO_2$ higher, effectively adding almost one year's worth of IEA energy end-use sector emissions to the atmosphere. In 2014 alone, emissions reduction of 820 $MtCO_2$ can be attributed to the effect of efficiency improvements made over the past 25 years (Figure 1.12).[21]

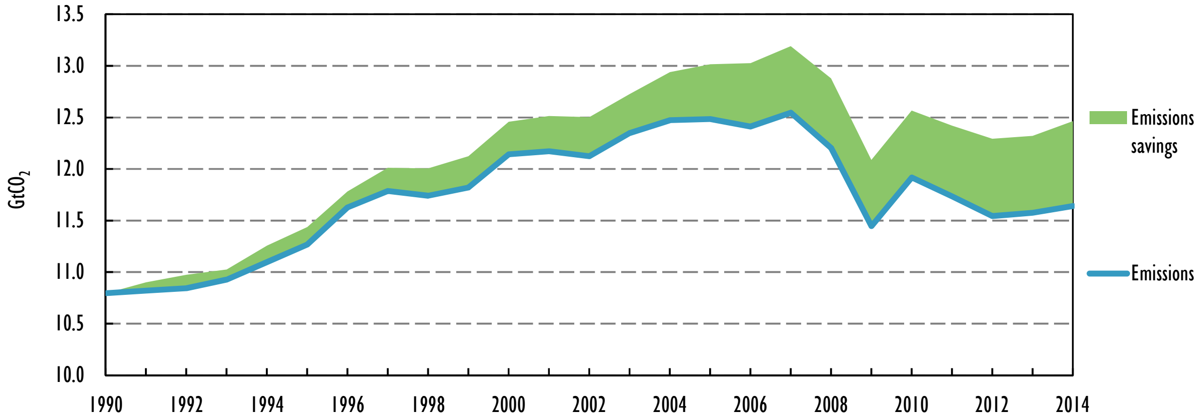
The impacts of avoided energy consumption on emissions are evident elsewhere in the world. In China, industry accounts for around half of TFC, the highest share among large economies. During the 11th Five-Year Plan (2006-10), a wide range of energy efficiency policies in the industrial sector are estimated to have avoided TFC of 13 EJ (322 Mtoe), with the related avoided emissions amounting to 760 $MtCO_2$ (Yu et al., 2015).[22]

[20] Another important "environmental return" from energy efficiency leading to avoided fossil fuel consumption is reduced air pollutants, such as nitrogen oxides, sulphur oxides and particulate matter.

[21] The volume of avoided emissions may be underestimated owing to the assumed fuel mix of avoided consumption, which includes both renewables and nuclear in proportion to their share in generation in each year (see above). It is also the case that the activity and structure effects estimated by the decomposition analysis will be influenced by efficiency gains; these second-round effects, often referred to as the "macroeconomic rebound effect" are likely to lead to the overestimation of avoided emissions. The *World Energy Outlook 2012* estimated the global macroeconomic rebound effect at 9% (IEA, 2012). Estimates of the macroeconomic rebound effect from a variety of studies range from 10% to 30% in OECD countries, while estimates in non-OECD countries tend to be higher (IEA, 2014a).

[22] The relatively large amount of emissions savings in China resulted primarily (90%) from avoided coal consumption, which is predominant in providing heat and electricity to the Chinese industrial sector.

Figure 1.12 IEA emissions from fossil fuel combustion, and emissions savings from energy efficiency investments, 1990-2014



Source: IEA (2014e), "CO_2 emissions by product and flow", *IEA CO_2 Emissions from Fuel Combustion Statistics* (database), available at http://dx.doi.org/10.1787/data-00430-en (accessed 1 June 2015).

Under IEA scenarios to limit the global temperature increase to 2°C or less compared to pre-industrial levels, energy efficiency plays the largest role (accounting for almost 40%) in reducing energy sector GHG emissions over the period to 2050. By comparison, renewables deliver the second-largest contribution at 30% (IEA, 2015a). Achieving this 2-degree objective will require an expansion of energy efficiency activity going forward, with attendant increase in investments. The *World Energy Outlook Investment Report*, for example, estimates that energy efficiency investments over the period to 2035 will need to total about USD 14 trillion (IEA, 2014f).

Medium-term prospects for the energy efficiency market

Recent policy developments suggest that energy efficiency investment is likely to increase, with primary examples being the US Clean Power Plan, the EU Energy Efficiency Directive and the Intended Nationally Determined Contributions (INDCs) countries are announcing as their commitments to tackling climate change under the UNFCCC.[23] Yet some unexpected events, such as the dramatic fall in oil prices in 2014, have dampened – at least for the short term – the economic incentives to invest. On balance, the effects of more stringent energy efficiency policy, even if primarily aiming to reduce emissions, are likely to outweigh the effects of lower prices.

Continued policy support for energy efficiency investment

Policy makers in some of the world's largest countries and economic regions have made important policy announcements that should drive energy efficiency investment in the medium term. Of note are recent energy efficiency targets set by the European Union, China, India, South Africa, Thailand, the United States (and many of its states), and the Economic Community of West African States.

In addition, 39 INDCs have been submitted to the UNFCCC Secretariat (as of 23 September 2015), representing 66 countries, covering about 70% of energy sector emissions. Several other countries

[23] The IEA maintains Policies and Measures databases on both energy efficiency and climate change, updated at least every six months based on submissions by national administrations (www.iea.org/policiesandmeasures/). See also the Energy Efficiency Market Snapshots in Part 2 of this report.

have indicated that they are in the process of preparing their INDCs. Energy efficiency is an important element of these INDCs, whether explicitly referenced (e.g. China and Japan), identified as an integral part of related policy packages (e.g. the European Union and the United States), or subsumed within underlying analysis on modalities to achieve the desired emissions reduction.

The United States, China and the European Union, the three largest energy consumers in the world, have all adopted a suite of policies – some targeting energy objectives, other targeting climate or other goals – that can be expected to support further energy efficiency investment. Other countries have also adopted or are planning policies that should promote investment, irrespective of the recent downward shift in oil prices.

In the European Union:

- Policy makers are putting “energy efficiency first”, treating it as an energy source in its own right so that it can compete on equal terms with generation capacity (EC, 2015). Member states were required to transpose the Energy Efficiency Directive into national laws by 2014 to help the European Union reach its target of 20% energy consumption reduction by 2020. Under the Directive, all EU countries are required to put in place key investment-driving policies, such as mandatory energy audits for large companies, incentives for small and medium enterprises to conduct similar audits, and requirements for governments to renovate the building stock they own or occupy (Council of the European Union, 2012). A number of EU member states are using energy supplier obligations as a way to achieve the energy savings required to meet the Directive's 1.5% per year savings target.
- In addition, the EU 2030 framework for climate and energy policies, which forms the basis of its INDC proposal, includes an indicative target of at least a 27% energy consumption reduction by 2030 compared to a projected reference level, to be reviewed by 2020 with the possibility of boosting the target to 30% (EC, 2014). This announcement paves the way for reviews of key energy efficiency policy Directives (such as the Energy Performance of Buildings Directive, the Energy Labelling Framework Directive and the overarching Energy Efficiency Directive) and should signal to the market that policy will continue to support investment levels in energy efficiency. Some EU member states may set more ambitious energy savings targets. France’s 2015 energy transition law, for example, sets a 2030 energy savings target of reducing energy consumption by 20% compared to 2012, which translates to a 34% efficiency improvement using the EU methodology and is close to the estimated cost-effective savings potential for France.

In the United States:

- The Clean Power Plan requires states to submit, by September 2016, plans to meet state-specific goals to reduce CO_2 emissions from the power sector (US EPA, 2015a). The US Environmental Protection Agency (US EPA) projected that by 2025, each state would be capable of reducing electricity demand by 1.5% each year (US EPA, 2014), in line with the rate leading states have already achieved through diverse mechanisms. For example, revenue decoupling or similar state-level policies reward utilities in 16 states for reducing customers’ bills. Additionally, in about three-fifths of the states, demand-side resources can bid into supply-side auctions and compete directly against supply (though suppliers have protested this to the Supreme Court). Energy efficiency offers states a low-cost compliance option when devising state plans; depending on the level of effort required and the methods by which states choose to comply with the federal Plan, annual expenditures on utility energy efficiency programmes could increase threefold (Pickles et al., 2014).

- The US EPA and the Department of Transportation have proposed tighter regulatory standards for heavy-duty vehicles (HDVs), due to be completed in 2016. These regulations will close somewhat the gap in efficiency between HDVs and lighter-duty trucks, and drive investment in more efficient freight. Under the proposed standards, the US EPA estimates that the fuel consumption of tractor trailers, for example, could drop as much as 24%. Overall, the programme would avoid consumption of around 250 Mtoe and save vehicle owners about USD 170 billion in fuel costs over the lifetime of the vehicles sold (US EPA, 2015b). National light-duty-vehicle (LDV) efficiency standards in the United States have tightened markedly, as in many other countries including China, India, Japan and across the European Union.
- Energy efficiency policies also play an important role across other end-use sectors. The Appliances and Equipment Standards programme of the US Department of Energy (US DoE) has issued or updated 29 product standards since the beginning of 2009, and now has standards covering around 90% of home energy use, 60% of commercial building use and 30% of industrial use (US DoE, 2015). By the end of 2016, as many as 20 additional or updated standards are scheduled to be introduced. A key standard was agreed in 2015 on commercial rooftop air conditioning, which is estimated to provide commercial building owners with net savings of nearly USD 50 billion (ASAP, 2015). Meanwhile, building standards in at least half of the US states, and in the two main agencies operating federal buildings, have tightened markedly in the past few years. Building retrofits are being significantly deepened and widely deployed through mechanisms such as Property Assessed Clean Energy (PACE) bonds, on-bill utility financing, green bonds, real-estate investment trusts and other financial innovations (see Chapter 3 for more details on buildings investment).

Other IEA countries are also strengthening policy support for energy efficiency investment.

- **Japan**'s Top Runner programme has been expanded to set efficiency standards for 31 different products, including vehicles, heaters and various electrical appliances, as well as building materials.
- **Canada** began enforcing, in 2015, stricter emissions standards for new and existing coal-fired power plants; its INDC underlines the establishment of more stringent emission standards for passenger vehicles and light trucks.
- **Korea** has tightened its vehicle fuel economy standards.

China is also putting in place polices that should encourage further energy efficiency investments.

- China submitted its INDC to the UNFCCC on 30 June 2015, containing goals to achieve peak CO_2 emissions by approximately 2030 (or sooner), and to reduce the emissions intensity of the economy by 60% to 65% by 2030 from 2005 levels. The list of actions includes higher efficiency in coal use, energy-efficient and low-carbon industrial systems, and cutting emissions from buildings and transport. Under the INDC, it has been estimated that energy per unit of GDP in China will be reduced by 32% in 2015 relative to 2005 with this trend expected to strengthen in subsequent decades. By 2030, energy intensity is estimated to drop by around 57% (Table 1.1) (Fu et al., 2015).

Table 1.1 Evolution of key indices in the implementation of China's INDC (2005 = 100)

	2005	2010	2015	2020	2030
Population	100	103	105	108	112
GDP per capita	100	166	235	321	517
Energy intensity per unit of GDP	**100**	**81**	**68**	**59**	**43**
Carbon intensity per unit of energy consumption	100	98	94	89	80
Energy-related CO_2 emissions	100	135	158	182	201

Note: Data for 2005 and 2010 are from China Statistical Yearbook, China Energy Statistical Yearbook and China's official review of target completion. Data after 2015 are developed based on INDC scenario study results calculated by the PECE model of NCSC and Renmin University of China.

Source: Fu et al., (2015) *An Analysis of China's INDC*, Translated by China Carbon Forum, China National Center for Climate Change Strategy and International Cooperation (NCSC), available at www.ncsc.org.cn/article/yxcg/ir/201507/20150700001490.shtml?from=timeline&isappinstalled=0.

- China's energy efficiency objectives and policies are set through the government's 12th Five-Year Plan (2011-15). The Plan put in place a package of policies and programmes, including the Ten Key Projects and Top 10 000 Enterprises programmes, to stimulate the industrial energy efficiency market. Under the Plan, China has introduced regulations to promote transformation and upgrading of traditional industries, as well as the closure of small and inefficient production facilities. In 2013, for example, China mandated the closure of facilities that generate 6.2 million tonnes (Mt) of iron, 8.8 Mt of steel, 270 000 tonnes of aluminium and 106 Mt of cement, while more than 2 000 small coal mines are to be closed by the end of 2015 (NDRC, 2014).
- More recently, China launched a *Strategic Action Plan for Energy Development, 2014-2020* which aims to boost investor confidence (People's Republic of China State Council, 2014). The Action Plan establishes the framework for tightly restricted expansion of high energy-intensive industries, and introduces a range of grants to drive up demand for energy efficient appliances and technologies. In parallel, China's central bank has issued guidelines for developing green finance, aiming to channel large-scale financial flows through innovative instruments such as green bonds, stocks, funds and insurance.
- Looking forward, China's urbanisation rate is expected to rise from around 50% today to around 70% in 2025, with 240 million people migrating to cities (Woetzel et al., 2009). Spurred in part by air quality concerns, this is making green building and transportation priority investment areas for achieving a sustainable urbanisation process. Annual investment in green industry could reach at least USD 320 billion in China during the 13th Five-Year Plan period (2016-20), and the annual output of energy-saving technologies and equipment manufacturing is estimated at USD 110 billion (PBC/UNEP, 2015). Much of the energy efficiency investments is expected to come from the private sector, with public-private partnerships, energy service companies (ESCOs), energy savings performance contracts (ESPCs) and other market innovations playing important roles in meeting financing needs.

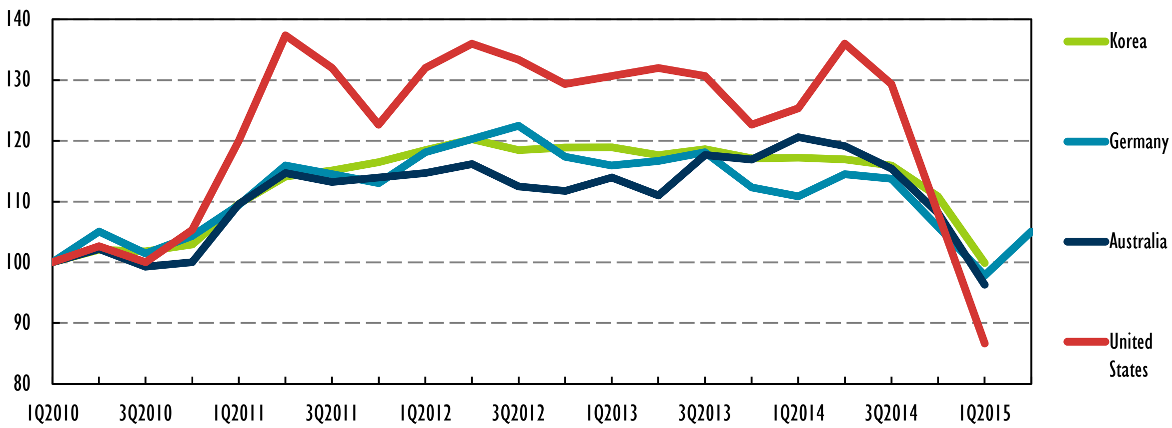
Will lower oil and gas prices affect energy efficiency investment?

Recent and pronounced declines in global oil prices and regional gas prices have affected incentives to invest in energy efficiency in some jurisdictions. However, a robust energy efficiency market can, for several reasons, still be expected in the medium term. The stronger and more widespread policies described above are a major driver, as energy efficiency measures remain the most cost-effective means of tackling increasing concerns over energy security, productivity, local air pollution and climate change.

Low oil prices: Impact on energy efficiency market for vehicles

Overall, lower oil prices have had only a moderate impact on the price end-users pay at the pump for gasoline or petrol in many jurisdictions (Figure 1.13). End-use price impacts have been more moderate where the tax component is high, where the fall in oil prices has triggered reductions in fuel subsidies, or where exchange rate fluctuations have dampened the change.

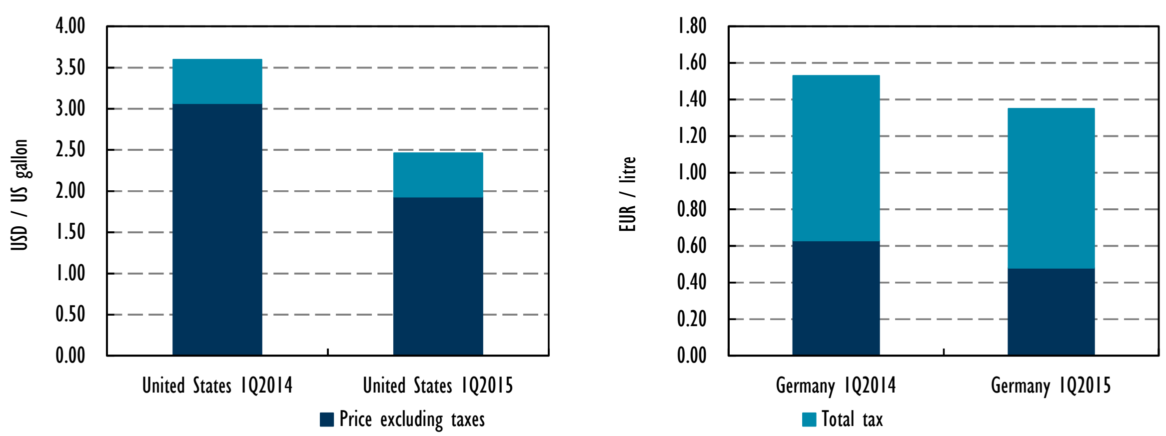
Figure 1.13 Indices of unleaded gasoline pump prices, 1Q 2010 = 100



Source: IEA (2015d), *Energy Prices and Taxes, Quarterly Statistics*, First Quarter 2015, OECD/IEA, Paris.

The impact of low oil prices on the end-user price at the pump has varied across the IEA. In the United States, gasoline pump prices have fallen by around one-third, from a high of just under USD 4.00 per gallon in 2012. In Europe, where gasoline prices are more heavily taxed (comprising as much as 65% of the pump price in 2015) and the Euro has fallen relative to the USD, declining oil prices have had a much weaker effect on end-user prices. German pump prices have fallen by only 12% year on year (Figure 1.14).

Figure 1.14 Unleaded gasoline prices in the United States and Germany



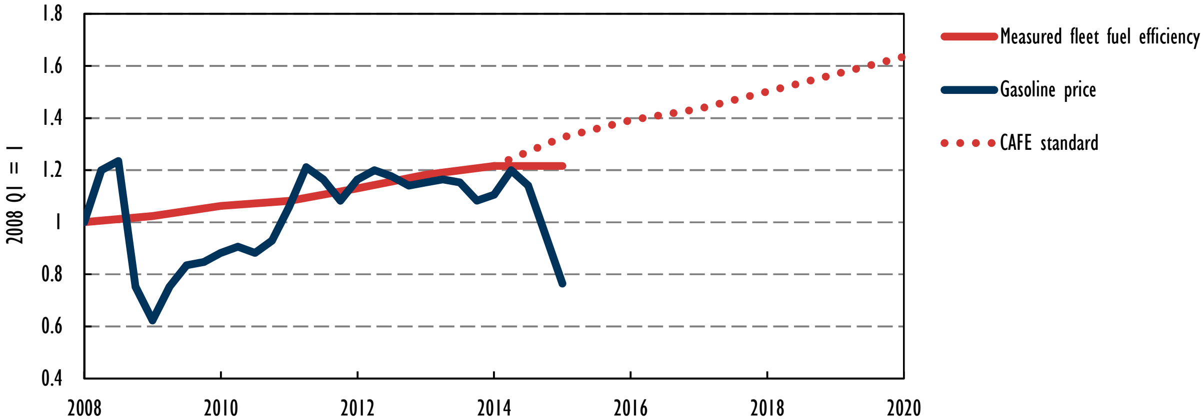
Source: IEA (2015d), *Energy Prices and Taxes, Quarterly Statistics*, First Quarter 2015, OECD/IEA, Paris.

In Germany, the new passenger vehicle fleet continues to become more efficient (using CO_2 emissions as a proxy). The average CO_2 emissions of new passenger vehicles sold in the first half of 2015 was 3%

lower than during the same period in 2014, with the reduction owing to improved fuel efficiency (KBA, 2015).[24] In Japan, the most fuel efficient vehicles continue to dominate new car sales (JADA, 2015).

Strong progress on vehicle efficiency has been made in recent years in the United States as manufacturers have invested in efficiency improvements to meet US Corporate Average Fuel Economy (CAFE) standards and consumers have purchased relatively fuel efficient vehicle classes. New LDV efficiency has increased steadily, including during the 2008-09 dip in gasoline prices, and stood 26% higher in 2015 than in 2007. Lower US gasoline prices, however, have prompted a shift in consumer purchasing patterns, with an increase in the sale of larger, less fuel-efficient vehicles. The share for sport utility vehicles (SUVs), for example, rose from 31.6% to 34.4% over the year to May 2015 (Ulrich, 2015). This trend towards bigger classes of vehicle appears to be offsetting the movement towards more efficient vehicles within product class. The average fuel economy seen so far in 2015 is 25.3 miles per gallon (mpg),[25] unchanged from the average seen in 2014 and down 0.3 mpg from its peak in August 2014 (Sivak and Schoettle, 2015). Low gasoline prices have had a negative impact on payback periods for energy efficient vehicles. The market share of electric vehicles (EVs) in new car sales has declined from 3.4% to 2.7% over the year to May 2015. A sustained period of lower gasoline prices may prompt the continuation of vehicle purchasing trends towards more passenger light-duty trucks. In turn, this could drive further investment to keep the new LDV fleet (as a whole) on track to meet the current US policy aims on fuel efficiency (Figure 1.15).

Figure 1.15 Indices of new US LDV fuel economy performance, CAFE standard and unleaded gasoline prices, 2008 = 100



Sources: IEA (2015d), *Energy Prices and Taxes, Quarterly Statistics*, First Quarter 2015, OECD/IEA, Paris, and Sivak and Schoettle (2015), "Monthly monitoring of vehicle fuel economy and emissions: Average sales-weighted fuel-economy rating (window sticker) of purchased new vehicles for October 2007 through July 2015", *Sustainable Worldwide Transportation,* Regents of the University of Michigan, Ann Arbor, available at www.umich.edu/~umtriswt/EDI_sales-weighted-mpg.html (accessed 12 August 2015).

Low fuel prices: Looking beyond transport

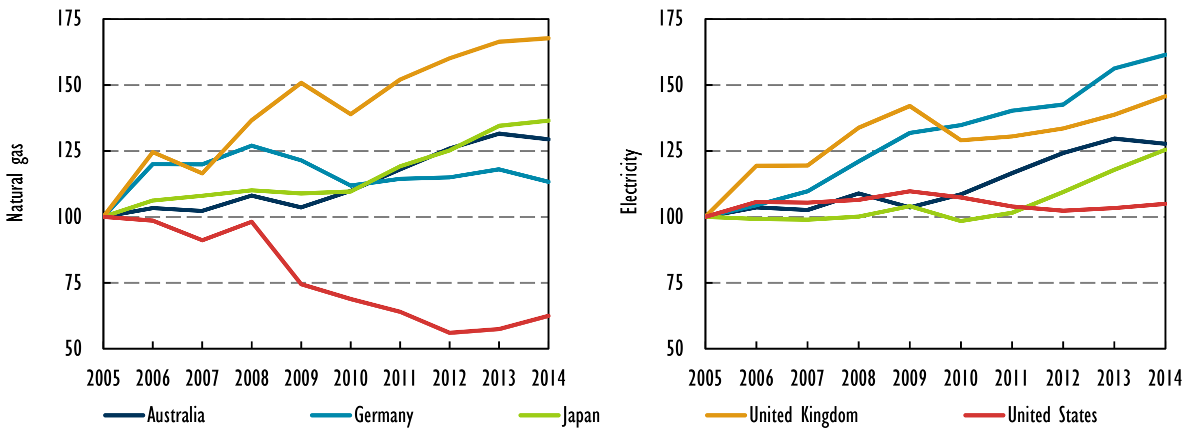
Recent oil price movements have had a minimal impact on incentives to invest in efficiency in other sectors (in sharp contrast to the effects noted in the transport sector) as electricity and natural gas

[24] Over 98% of the cars sold in Germany in June 2015 were either diesel or gasoline fuelled, and the relative shares of diesel (47%) and gasoline (51%) cars in the new passenger vehicle fleet did not change significantly between June 2014 and June 2015.

[25] "Window sticker" value.

are the predominant end-use fuels in IEA countries. Outside of the United States, wholesale natural gas prices have also softened over 2014/15, owing both to the link with oil prices (affecting many supply contracts) and relatively weak demand in Europe and Asia (affecting spot prices). In addition, a number of liquefied natural gas (LNG) export projects are expected to come on stream over the next two years, adding to global supply (IEA, 2015b). Lower wholesale prices have been feeding through to end-user gas prices in Europe during 2015, which is likely to make some energy efficiency projects in buildings and industry less economically attractive in the short run. Electricity prices have flattened in some jurisdictions during 2015, but remain high following increases seen over the last decade (Figure 1.16).

Figure 1.16 Indices of natural gas and electricity prices paid by industry and households, 2005 = 100



Source: IEA (2015d), *Energy Prices and Taxes, Quarterly Statistics*, First Quarter 2015, OECD/IEA, Paris.

The impact of natural gas price movements on the level of investment in efficiency will vary by sector and jurisdiction. Where projects remain cost-effective with lower prices, impacts should be minimal. Where projects are marginal in terms of their cost-effectiveness, the policy environment is vital, both in terms of the nature of policy instruments and their stringency. Quantity-based instruments, such as supplier obligations and white certificate schemes that are used in many European countries, will maintain investment through price changes. Regulations (on new buildings and products) negate the impact of price changes to a great extent in some markets. Where policies rely on market prices or subsidies to drive energy efficiency investment, however, the impact of prices is likely to influence decision making. With gas security concerns remaining paramount in many jurisdictions, particularly in Europe, policy drivers are likely to dominate price impacts overall.

Electricity prices have remained relatively firm at recent high levels, despite falling oil and gas prices. In fact, electricity is becoming more important to the energy system and to energy efficiency: electricity's share of TFC is rising in the IEA and, over the last 25 years, the volume of avoided electricity consumption has been greater than the reductions in the consumption of any other end-use fuel. Much of the energy efficiency market targets the reduction of electricity consumption. The factors that drive electricity prices are expected to continue to support the economics of energy efficiency investments geared towards this energy source, even though overall trends in electricity consumption, notably a flattening demand in OECD countries, will present new challenges (see analysis in Chapter 4).

Low oil prices and fossil fuel subsidies

The economics of energy efficiency investments for end-users are weakened in various jurisdictions through fossil fuel subsidies, which essentially allow consumers to purchase (use) such fuels for less than what it costs to produce them. The recent fall in oil prices has provided an opportunity for several economies to either cut or abolish fuel subsidies, including Egypt, India, Indonesia, Malaysia, Mexico, Thailand and the United Arab Emirates (Box 1.6). Subsidy reductions that offset underlying price reductions should have a minimal effect on efficiency investments in the short term. If prices rise in the future without subsidies being switched back on, however, the higher fuel cost to end-users would have a positive impact on the economics of energy efficiency investments, with a corresponding positive effect on the energy efficiency market. It should be noted that beyond the subsidy issue, the major driver of the economics of energy efficiency investments is the absolute level of prices, whether or not there are policy-driven distortions (i.e. higher energy prices resulting from ”natural” market forces will improve the economics of energy efficiency investments).

Box 1.6 Reduction of fossil fuel subsidies bodes well for future efficiency gains

Indonesia is faced with a considerable bill to finance subsidised end-consumer oil prices, which are a legacy of its times as a net oil exporter (IEA, 2015c). After price increases in 2013 and November 2014, the Indonesian government switched (in December 2014) from fixed pricing to semi-automatic pricing linked to world prices, resulting in a reduction of gasoline and diesel prices. Only smaller subsidies for liquefied petroleum gas (LPG), diesel fuel and kerosene remain in place. Fuel subsidies that had been earmarked to make up more than 13% of total government expenditure in the 2015 budget have now decreased to only 1% (OECD, forthcoming).

In **India**, energy prices have been highly regulated, with prices often kept below cost. Gasoline prices were partially deregulated in June 2010, and then fully deregulated in October 2014. The central government started reducing consumer subsidies for diesel fuel in late 2012. The savings realised amounted to USD 3 billion (INR 200 billion) between 2012 and 2014 – roughly equivalent to 10% of the annual revenues the country derives from its entire federal excise duties combined. Energy subsidies still represented over 2% of GDP in 2013-14 based on central government figures. The new budget for 2015/16 cut the petroleum subsidy estimate by 50% (OECD, forthcoming).

In July 2014, **Egypt** introduced long-awaited energy subsidy cuts, seen as a positive signal by external investors (IISD, 2015). The most significant step was a 64% hike in diesel prices but similar increases affected electricity and many other refined products (LPG being one exception). These initial reductions were set out as the first step in a five-year programme to eliminate entirely all energy subsidies (except LPG).

On 1 December 2014, the government of **Malaysia** took advantage of falling oil prices to put in place a "managed float" mechanism for gasoline and diesel (similar to that in Indonesia). Plans have been announced to cut more subsidies for petrol, LPG and cooking oil in the coming years.

Conclusions

The energy efficiency market has delivered remarkable returns over the last 25 years, with millions of end-use energy efficiency improvements contributing to a gradual improvement in energy intensity. Yet those returns have largely gone unnoticed, as little attention has been given to the value of the avoided energy consumption or of acquiring the same or higher levels of energy service with lower input. The avoided consumption produced by efficiency investments generates diverse returns. The multiple benefits of energy efficiency highlighted in this chapter are recognised in the increasing number of efficiency targets and policies now in operation across a wide range of countries, both within and outside the OECD. Even with the lower oil and gas prices seen in the first half in 2015, a large amount of untapped efficiency potential remains and strong policy drivers can be expected to continue to support a robust energy efficiency market in the medium term.

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2. TRACKING ENERGY EFFICIENCY PROGRESS

Summary

- **In 2014, energy intensity in OECD countries decreased by 2.3%, the fastest rate since 2011 and within range of the UN Sustainable Energy for All (SE4ALL) worldwide target of 2.6% annual improvement between 2010 and 2030.** Appliances, lighting and space heating showed the greatest reductions in energy intensity across the countries evaluated. World energy intensity since 2010 declined at an average annual rate of 1.1% and is down 14% over ten years.

- **Total final energy consumption (TFC) fell 7% between 2002 and 2012 across 18 IEA countries belonging to the International Energy Agency (IEA; IEA-18), with energy efficiency improvements playing the largest role, accounting for two-thirds of the reduction.** Energy efficiency has had the greatest impact in the residential sector, where the efficiency effect is estimated to have led to a cumulative TFC reduction of 19 exajoules (EJ) (463 Mtoe) between 2002 and 2012 in the IEA-18. This avoided consumption brings residential TFC back to below 2002 levels.

- **Improved data collection and analysis will help governments and other stakeholders to better track energy efficiency developments**, in turn supporting stronger policy design and better identification of market opportunities.

Introduction

Tracking energy efficiency progress is no small challenge. As demonstrated in Chapter 1, it implies measuring "avoided energy consumption", which requires finding ways to calculate the difference between "what is" (actual TFC) and "what might have been" (hypothetical TFC).

This chapter is structured to provide continuity with past editions of the *Energy Efficiency Market Report* (*EEMR*), with new content in 2015 providing more detail and analysis of changing trends as revealed through energy efficiency indicators. These new insights are possible because this year the IEA asked countries to report contextual information to explain changes in the intensity indicators when submitting data to the Energy Efficiency Indicators (EEI) database.

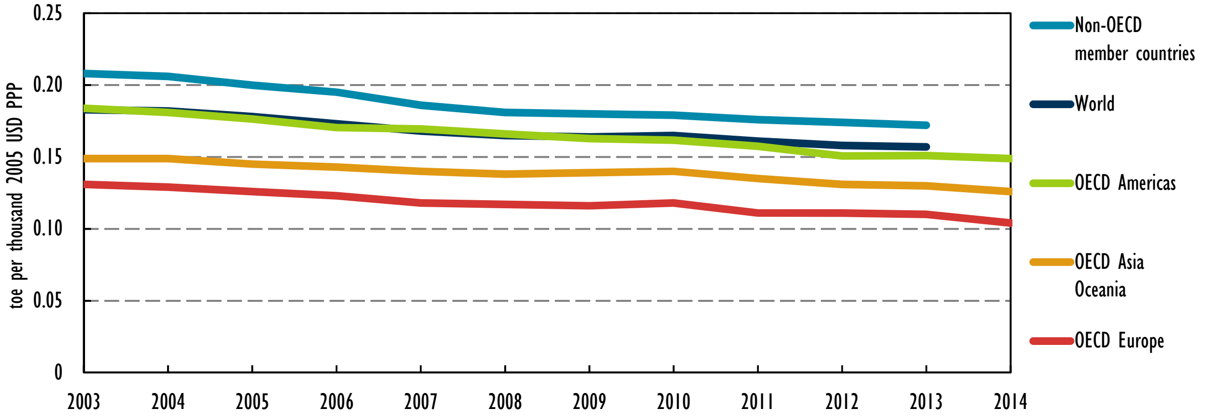
Global trends in energy intensity

At world level, overall energy intensity continues to decline, with the average annual reduction in total primary energy supply (TPES) per unit of gross domestic product (GDP) being 1.4% between 2003 and 2013 (Figure 2.1).[1] This reflects an increase in the productivity of energy, namely that each unit of energy consumed is generating more units of GDP. While this expansion is due to a variety of factors, including changes in economic structure, energy efficiency is playing its role.

[1] Although GDP remains the macroeconomic indicator of choice for governments, efforts still need to be made to better measure it. Additional metrics (such as well-being) should supplement, rather than replace it (OECD, 2015). To facilitate cross-country comparisons, the IEA uses US dollars (USD) and purchasing power parities (PPP). PPPs are rates of currency conversion that equalise the purchasing power of different currencies by eliminating the differences in price levels among countries. In their most basic form, PPPs are simply price relatives that show the ratio of the prices of identical goods or services in the national currencies of different countries. Note that when comparing long-term trends in absolute values of energy intensities, the values will be different when GDP is measured in different years (e.g. 2005 USD PPP and 2010 USD PPP).

From 2010 to 2013, the average change in energy intensity was 1.1%. This is well below the Sustainable Energy for All (SE4ALL) objective of 2.6% between 2010 and 2030.[2]

Figure 2.1 Energy intensity (TPES/GDP) by region, 2003-14



Notes: PPP = purchasing power parity; toe = tonne of oil-equivalent.

Sources: IEA (2014a), *Energy Statistics of OECD Countries 2014*, OECD/IEA, Paris, DOI: http://dx.doi.org/10.1787/energy_stats_oecd-2014-en, (accessed on [day month year]); IEA (2014b), *Energy Statistics of Non-OECD Countries 2014*, OECD/IEA, Paris, DOI: http://dx.doi.org/10.1787/energy_non-oecd-2014-en.

In 2014, the energy intensity reduction for the OECD as a whole was 2.3%, but with notable regional differences. Energy intensity in OECD Americas fell by 1.3%, in OECD Asia Oceania by 3.1% and in OECD Europe by 5.5%.[3] On average, OECD member countries have lower energy intensity than non-OECD countries, even though a range of intensities exists in both groups. Economies that have more resource extraction and heavy industry, longer transport distances and lower urban density tend to be relatively more energy intensive.

Isolating energy efficiency from other factors: The IEA decomposition analysis

Approach

Decomposition analysis quantifies how different factors – in this context called "effects" – within an economy influence energy consumption (see also Chapter 1, Box 1.2), typically distinguishing three main factors:

- **Activity** is the basic human or economic actions that drive energy use in a particular sector. It is measured by value-added output in the industrial and service sectors, by population in the residential sector, by passenger kilometres (pkm) for passenger transport, and by tonne kilometres (tkm) for freight.
- **Structure** reflects the mix of activities within a sector that can affect how energy is used, e.g. the share of production represented by each subsector of industry or services; floor area per person, number of dwellings per person and appliance ownership rates in the residential sector; and the modal share of vehicles in passenger and freight transport.

[2] See http://trackingenergy4all.worldbank.org/energy-efficiency.

[3] OECD Europe includes non-EU members Turkey, Switzerland and Norway, but excludes some central European countries that are members of the European Union.

- **Efficiency** is the amount of energy used per unit of different activities. This report uses the term "efficiency effect" to avoid confusion with the term "energy intensity". The decomposition analysis is undertaken at the most disaggregated level possible so that changes in energy intensity can be used as a proxy for energy efficiency.

The decomposition analysis typically examines six sectors: residential, passenger transport, freight transport, manufacturing, services and other industries, each having its own specific indicators (Table 2.1).

Table 2.1 Variables and metrics used for sectoral indicators in the decomposition analysis

Sector	Service/subsector	Activity	Structure	Efficiency (energy intensity) effect
Residential	Space heating	Population	Floor area/ population	Space heating energy*/ floor area
	Water heating	Population	Occupied dwellings/ population	Water heating energy**/ occupied dwellings
	Cooking	Population	Occupied dwellings/ population	Cooking energy/ occupied dwellings
	Lighting	Population	Floor area/ population	Lighting energy/ floor area
	Appliances	Population	Appliance stock/ population	Appliances energy/ appliance stock
Passenger transport	Car; bus; rail; domestic air	passenger-kilometre	Share of passenger-kilometres	Energy/ passenger-kilometre
Freight transport	Truck; rail; domestic shipping	tonne-kilometre	Share of tonne-kilometres	Energy/ tonne-kilometre
Manufacturing	Food, beverages and tobacco; paper, pulp and printing; chemicals; non-metallic minerals; primary metals; metal products and equipment; other manufacturing	Value-added	Share of value-added	Energy/ value-added
Services	Service	Value-added	Share of value-added	Energy/ value-added
Other industries***	Agriculture and fishing; construction	Value-added	Share of value-added	Energy/ value-added

* Adjusted for climate variations using heating degree-days.

** Adjusted for household occupancy.

*** The following International Standard Industrial Classification (ISIC) groups are not included in the analysis: mining and quarrying; fuel processing; and electricity, gas and water supply. Industries in category "Other industries" are analysed only to a very limited extent in this study.

Source: IEA (2014c), *Energy Efficiency Indicators: Fundamentals on Statistics*, OECD/IEA, Paris. Available at www.iea.org/publications/freepublications/publication/IEA_EnergyEfficiencyIndicatorsFundamentalsonStatistics.pdf.

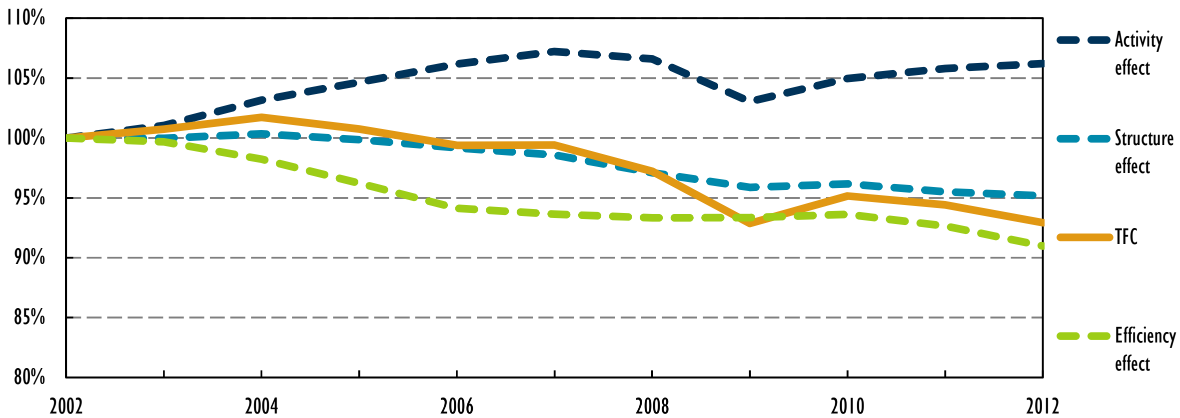
The IEA has comprehensive data for decomposition analysis of 18 IEA countries (IEA-18) for the period 2002 to 2012, allowing economy-wide analysis of the impacts of activity, structure and energy efficiency effect on energy consumption.[4] To analyse the role of energy efficiency in delivering end-use goods and services with less energy consumption, the appropriate metric is total final consumption (TFC) – the sum of direct energy consumption by end-use sectors (such as residential, industry or transport) – rather than TPES.[5] Accordingly, the analysis of the sectors presented in this chapter uses TFC.

Some caveats must be applied to the interpretation of the various effects identified by decomposition analysis. First, this approach relies on data availability and may not pick up more subtle real-world effects. Structural shifts within subsectors of standard industrial classification codes, for example, may not be discernible and may influence the reported intensity of production. It is also important to recognise that energy efficiency may have influenced the activity or structure of the economy. As efficiency changes the productivity of sectors, it can stimulate change in the relative share of different sectors and hence explain part of the overall structural effect. Similarly, the returns from cost-effective efficiency investments will drive new economic activity, which is likely to explain at least some of the GDP growth associated with the activity effect. The most limiting aspect of decomposition analysis for assessing the impact of energy efficiency, however, is data availability: most countries do not yet track detailed disaggregated energy efficiency indicators.

Results

Overall, TFC peaked in the IEA-18 in 2004 then declined to 7% below 2002 levels by 2012, with the rate of decline being relatively steady over the period, except for the dip during the 2008-09 recession. Energy efficiency improvements played the largest role, accounting for two-thirds of the reduction, with structural changes playing a significant albeit secondary role (Figure 2.2).

Figure 2.2 TFC in IEA-18 decomposed by factor, 2002-12



Notes: Values are indexed to 2002 levels. Decomposition results are multiplicative rather than additive.

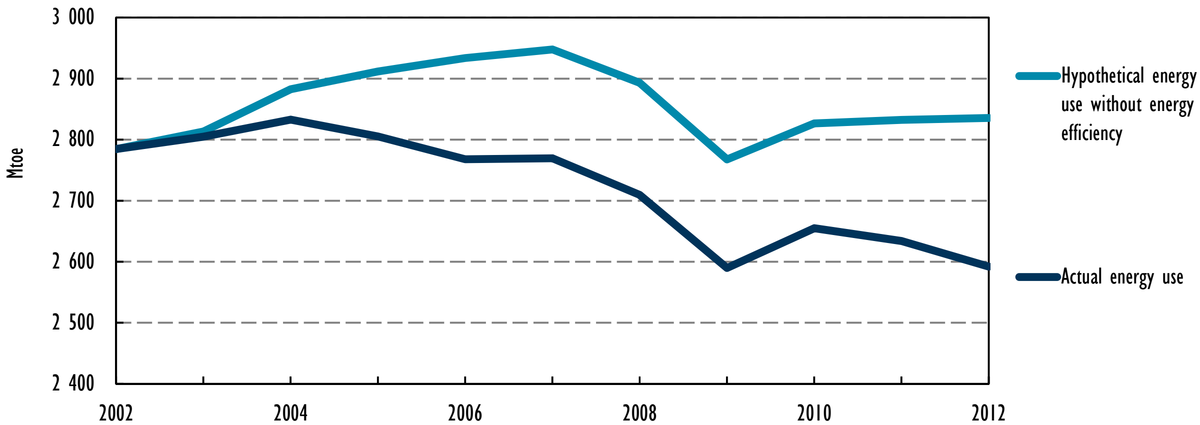
[4] As in *EEMR 2014*, the decomposition methodology is the Log Mean Divisia Index (LMDI). The IEA-18 countries were selected based on the completeness and consistency of their energy efficiency indicator data. They are Australia, Austria, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Japan, the Netherlands, New Zealand, Spain, Sweden, Switzerland, the United Kingdom and the United States. For purposes of comparison, the sectoral decomposition analyses presented keep this sample of countries, although there may be greater data availability in some sectors. Decomposition analysis can also be carried out at country level, as is done for five countries in the Energy Efficiency Market Snapshots in Part 2.

[5] Generally, TPES is used to represent energy used in an economy as a whole because it captures the total amount of energy used, including the efficiency (or indeed inefficiency) of conversion of primary energy sources into useful energy for consumers (end users).

Across the IEA-18, energy efficiency improved significantly between 2003 and 2006, more than counteracting the increasing activity levels, but then plateaued between 2006 and 2010.[6] Between 2010 and 2012, efficiency began improving again, at a rate similar to the 2003-06 period. The impact of the economic recession is clearly evident in the drop in activity between 2007 and 2009.

While efficiency improvements slowed between 2006 and 2010, structural changes (e.g. changes in the relative economic importance of industries, the shares of transport modes, or in the floor area, number of dwellings, or number of appliances per person) continued to reduce TFC. However, structural effects have been less important than energy efficiency in driving changes in energy use over the past decade. By 2012, hypothetical energy use without efficiency would have been 10 EJ (240 Mtoe), or 9% higher relative to 2002 levels of efficiency (Figure 2.3).[7]

Figure 2.3 Actual and hypothetical energy consumption in IEA-18, had efficiency not improved, 2002-12



Energy intensity and energy efficiency performance by sector

Residential

Analysis of the residential sector breaks down the main end-uses as space heating, water heating, lighting, cooking and appliances.[8] This section outlines changes in the energy intensity of these end-uses while also decomposing the energy use to show how efficiency has contributed to changes in TFC in the sector.

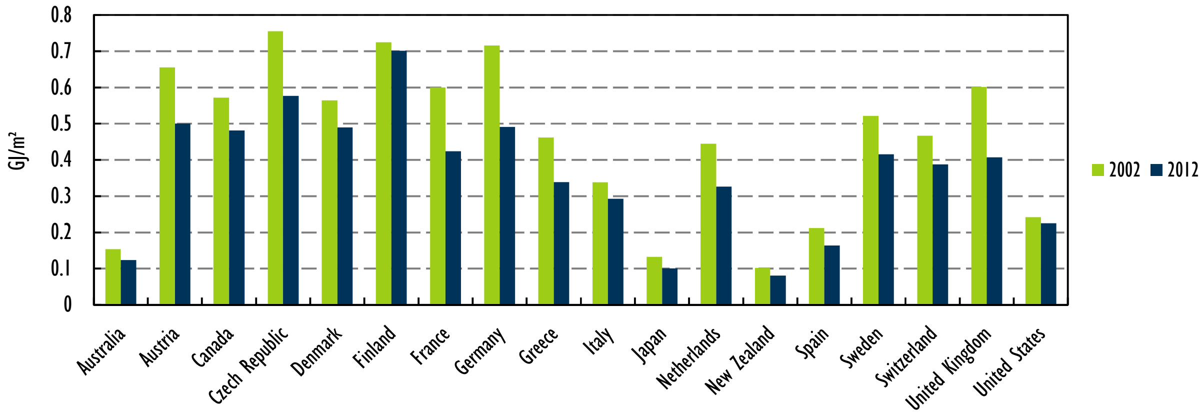
The energy intensity of **space heating** is a function of the building floor area, climate, building shell efficiency, heating system efficiency and the behaviour of building users. Space heating energy intensity decreased over the period in all countries (Figure 2.4), with the biggest decreases in both absolute and percentage terms in the United Kingdom and Germany. Trends in some IEA countries, notably larger homes and fewer inhabitants per home, undermined these intensity improvements such that they have not led to reduced TFC for these end-uses in those countries. TFC for space heating rose in Australia, Canada, Denmark, Finland, Italy and Spain between 2002 and 2012.

[6] The efficiency effect is measured by the change in energy intensity to deliver energy services. In many sectors service levels declined while energy consumption remained the same.

[7] The hypothetical case accounts for all changes in activity and structure across all countries but assumes no energy efficiency improvements since 2002.

[8] Space cooling is important in a number of countries but is not included as a separate section here due to insufficient data.

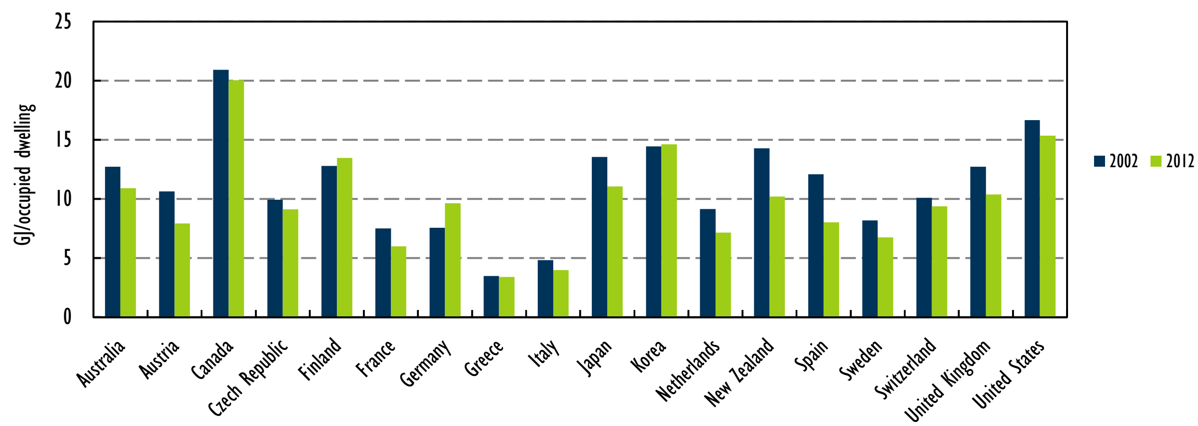
Figure 2.4 Energy intensity of residential space heating, 2002 and 2012



Notes: GJ/m^2 = gigajoules per square metre. Space heating is adjusted for heating degree days. Energy is measured as TFC for space heating, and floor area is measured as total residential floor area in the country. In Denmark space heating includes water heating. United States energy efficiency indicators are estimated by the IEA Energy Data Centre.

Steady improvements in **water heating** energy intensity are evident in all 18 countries, with New Zealand and Spain showing particularly strong progress over the period (Figure 2.5). In many cases, reductions in the energy intensity of water heating coincide with policy measures directed at efficiency in the residential sector.[9] In Germany, the share of electricity and district heating in residential heating fell between 2007 and 2012 while use of natural gas and biomass increased, resulting in an increase in intensity.

Figure 2.5 Energy intensity of residential water heating, 2002 and 2012



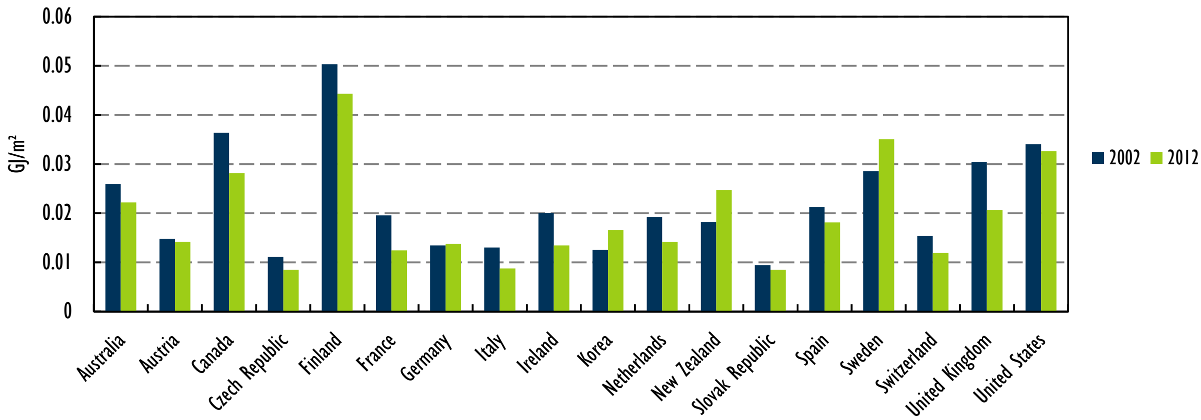
Notes: Water heating is adjusted for household occupancy. Denmark's water heating is included in space heating (see Figure 2.6). Data for recent years for the Netherlands have been revised. Oil and gas water heating in Germany jumps in 2008, possibly as a result of a data revision, leading to an intensity increase.

Improvements in the energy intensity of **lighting** have been achieved as many countries introduced regulations to phase out incandescent lamps during the period 2002 to 2012 (Figure 2.6). The EU Ecodesign requirements on household lamps, which came into force in 2009, aimed to phase out

[9] Energy consumption is also affected by the fuels used, some systems being more efficient than others.

the sale of incandescent lamps by 2012. The pace of stock turnover leads to delayed improvements in the efficiency of lighting at a national level; intensity increases are the result of more lighting per unit of residential floor area.

Figure 2.6 Energy intensity of residential lighting, 2002 and 2012

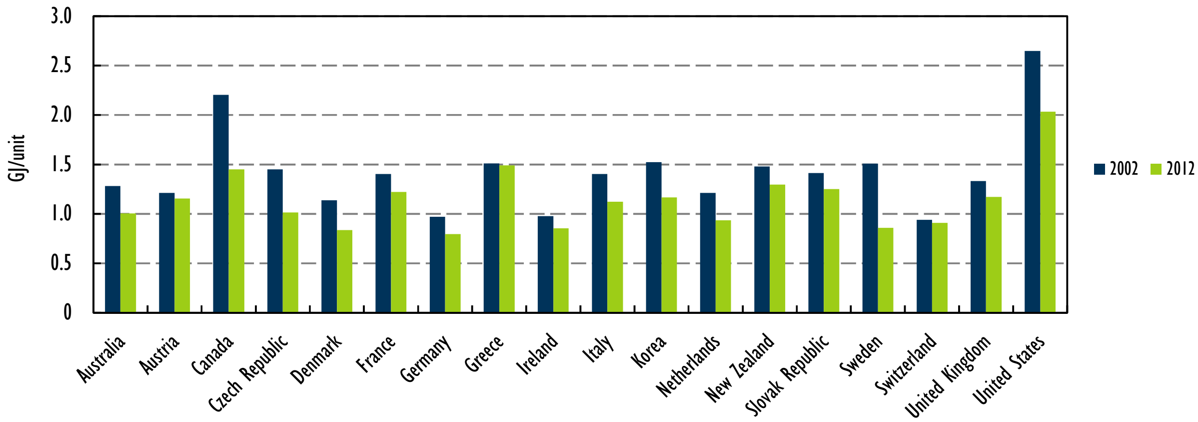


Notes: Data for Finland and the United States for 2002 are estimates; data for Denmark, Greece and Japan are unavailable.

The United Kingdom has seen particularly large improvements in its lighting efficiency: between 2001 and 2010, the average efficiency of new lamps sold more than doubled from 13.2 lumens per watt to 27.4 lumens per watt (IEA 4E, 2011). This was achieved primarily by a voluntary agreement with major retailers to remove the most inefficient products from sales prior to mandatory EU regulation and the inclusion of energy-efficient lamps in the UK's energy supplier obligation.

Growing use of **appliances and consumer electronics** is a source of rising household energy consumption, particularly networked devices that provide such end-uses as entertainment and communication (e.g. game consoles and personal computers). In most of the 18 countries evaluated, demand for white goods (e.g. refrigerators and washing machines) is no longer growing significantly, but their efficiency is increasing: the net result is reduced total energy consumption. Particularly rapid progress in the United States and Canada in recent years brings both countries more into line with the appliance and consumer electronics efficiency levels of other IEA countries considered (Figure 2.7).

Figure 2.7 Energy intensity of large household appliances, 2002 and 2012

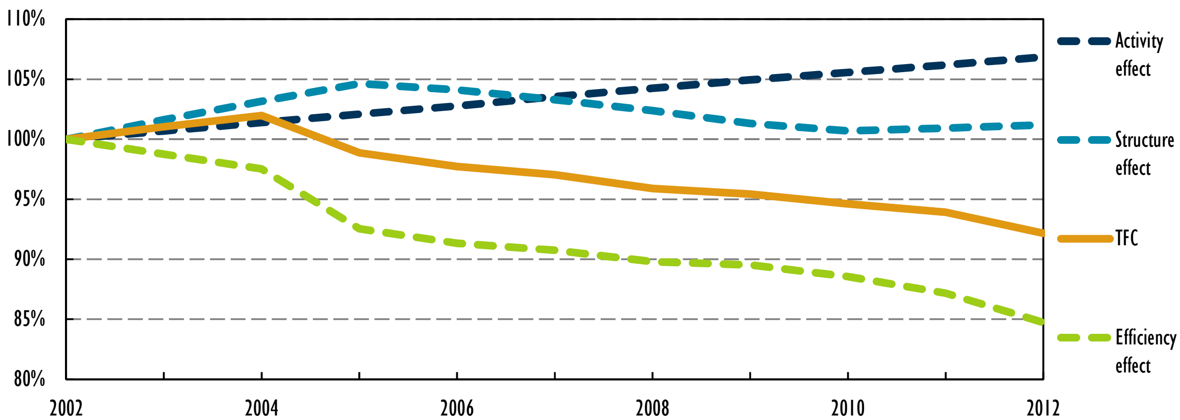


Notes: Large household appliances are refrigerators, freezers, dishwashers, clothes washers and clothes dryers. Data for Finland, Japan and Spain are unavailable; data for the United States for 2002 are estimated.

By contrast, energy demand is growing for televisions, which are increasing in screen size, and personal computers and other networked devices, which are increasing in number. As a result, energy consumption by these devices is growing despite efficiency gains. The energy intensity of televisions as a product group (total energy consumption divided by stocks, in GJ per unit), for example, rose by more than 50% in Australia, Canada, Denmark, France and the Netherlands between 2002 and 2012.

Overall, residential energy consumption fell in absolute terms between 2002 and 2012 in the IEA-18, owing specifically to the efficiency effect (Figure 2.8). The residential sector has been the focus of many efficiency policies and programmes, partly because it is a sector in which relatively inexpensive efficiency improvements can be regulated or incentivised (such as the phasing out of incandescent bulbs). The efficiency effect is estimated to have led to a cumulative TFC reduction in the IEA-18 of 19 EJ (463 Mtoe) between 2002 and 2012. It should be noted that from 2006 to 2010, structural effects reduced energy consumption, largely because of a decrease in overall residential floor area in the United States and an increase in occupancy. Elsewhere, the move to larger homes and the subsequent need for more heat, lighting and appliances drove structural changes.

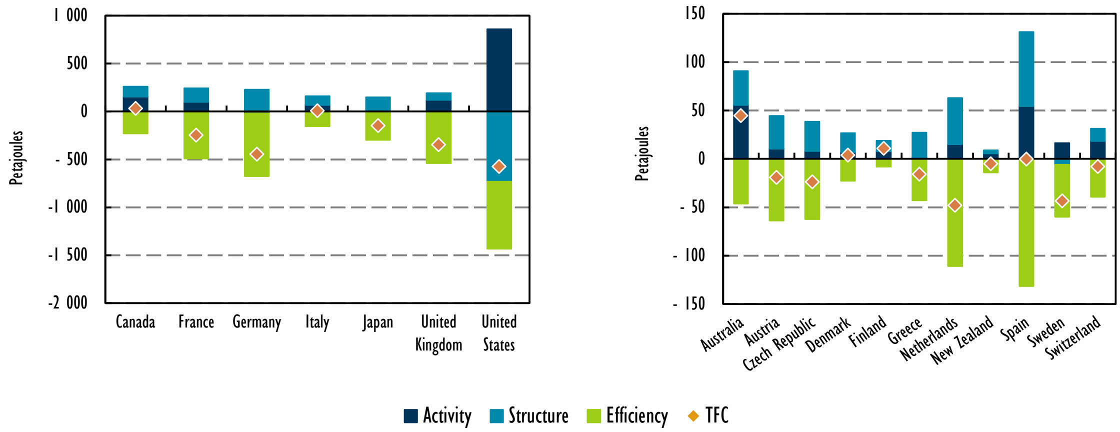
Figure 2.8 Residential TFC in IEA-18 decomposed by factor, 2002-12



Notes: Values are indexed to 2002 levels. Decomposition results are multiplicative rather than additive.

All 18 countries analysed have made energy efficiency improvements in the residential sector (Figure 2.9); in 12 countries, these efforts have been the primary driver reducing TFC to below 2002 levels. With the exception of Germany, the IEA-18 countries had an increasing activity effect due to population growth. Most of the countries experienced structural effects – largely through increases in floor area and the number of dwellings per person, as well as higher appliance ownership rates, which drove up energy demand. The United States and Sweden show structural changes that reduced total energy consumption. This was due to a decrease in floor area per person, which was particularly strong in the United States (-12%, or -1.3% per year) but less aggressive in Sweden (an overall change of -2%).

Figure 2.9 Residential energy consumption, decomposed for IEA-18, 2002-12

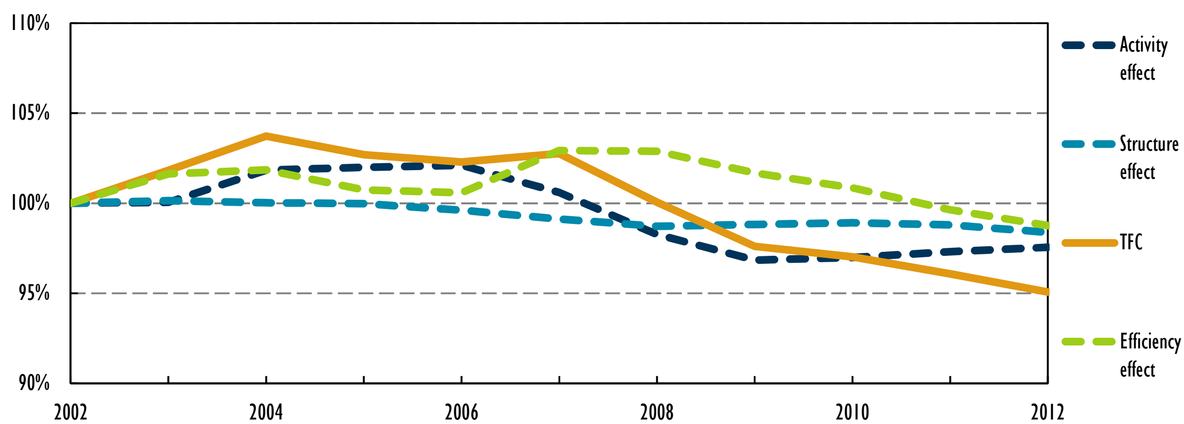


Transport

Passenger transport

Energy efficiency in passenger transport has lowered energy consumption. Decomposing passenger transport energy use across the IEA-18 reveals how efficiency, structural change and declining activity levels are working together to reduce energy consumption (Figure 2.10).

Figure 2.10 Passenger transport TFC in IEA-18 decomposed by factor, 2002-12

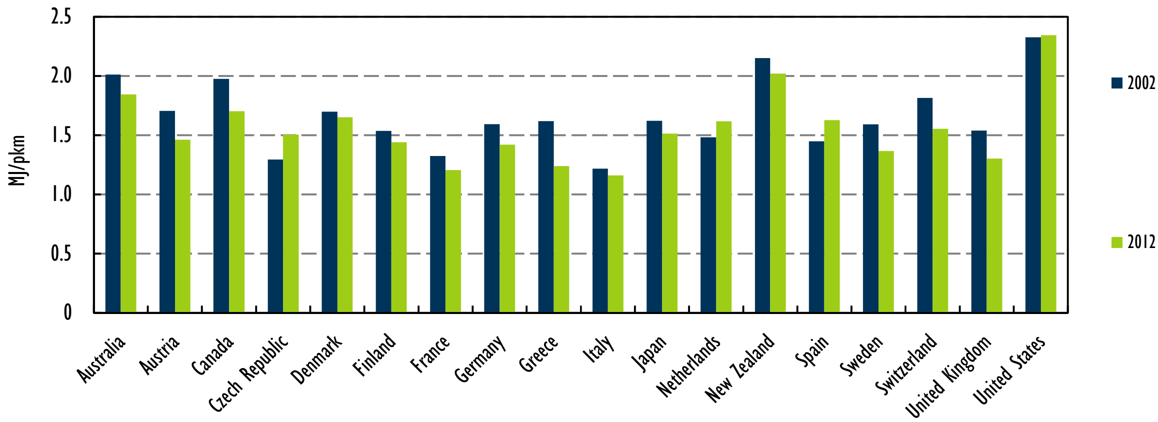


Notes: Values are indexed to 2002 levels. Decomposition results are multiplicative rather than additive.

A proxy for energy efficiency in the passenger transport sector is the energy intensity of a passenger-kilometre (pkm), i.e. the energy used to move one passenger a distance of one kilometer, whether as a result of modal shift or improvements in passenger vehicle efficiency. This intensity metric (energy/pkm) decreased in the majority of the IEA-18 countries over the decade 2002-12 (Figure 2.11).

In the United Kingdom, rail (among the least energy-intensive modes of passenger transport) increased strongly (up around 45%) while pkm by other modes were largely unchanged. Trains were also the fastest-growing mode in absolute terms in France, Japan and the Netherlands, while passenger air transport was the fastest-growing mode in Australia and the United States. In Italy, bus use grew the most quickly, adding 7 billion pkm/year over the decade. In all other countries, cars and light-duty vehicles (LDVs) added the most pkm. Total pkm declined in only five countries: the Czech Republic, Italy, Japan, the Netherlands and the United States, with Italy having the most significant drop (14%) in activity, primarily due to a 20% decrease in total pkm in private road transport.

Figure 2.11 Energy intensity of passenger transport, 2002 and 2012



Notes: MJ/pkm = megajoules per passenger-kilometre. Passenger cars, buses, passenger trains and passenger aircraft are included; (exceptionally, the Netherlands and Switzerland do not include passenger aircraft). For air transport, only domestic flights are included (except for Canada, which includes international flights). The United States includes light commercial vehicles.

Eight of the IEA-18 (Denmark, France, Germany, Greece, Italy, Japan, Spain and the United Kingdom) had a decrease in energy consumption for passenger transport, of which all but one (Spain) also had a decrease in pkm energy intensity. In total, 14 of the 18 had a decrease in transport energy intensity. The United States and the Netherlands were exceptions, with decreases in total pkm but increases in intensity, with the key difference that the decline in activity did not reduce TFC in the Netherlands. Two other countries also had an increase in intensity: the Czech Republic and Spain. In the Czech Republic, the increase in intensity also drove up overall consumption.

Modal shift, i.e. changing from one type of transport to another, is the primary structural change in the passenger transport sector. When the shift is towards a less energy-intensive mode (such as passenger road to rail), the structural effect causes a decrease in overall energy consumption. Of the IEA-18 countries, 15 show that such structural changes decreased overall energy consumption. Of the three countries (Denmark, Greece and New Zealand) in which structural change had an increasing influence, the most significant modal shift was in Greece, from public transit to private vehicle road transport. As both Denmark and the Netherlands have a strong bicycle culture, the shift in structure may reflect cycling pkms, which are not measured in the dataset available for analysis (Box 2.1). *EEMR 2014* contains an extensive discussion on the transport sector.

Box 2.1 The market for energy efficiency in transport: vehicle efficiency and modal shift

Efficiency in transport can be assessed under narrow and broad scopes. Under the narrow scope, energy efficiency commonly refers to increasing the technical efficiency of each mode of transport and is often measured by the amount of fuel it takes to move a passenger or a tonne of freight one kilometre. This approach provides straightforward improvement benchmarks for regulators and vehicle manufacturers.

Box 2.1 The market for energy efficiency in transport: vehicle efficiency and modal shift (continued)

Under this narrow scope, fuel economy standards are the predominant tool for achieving efficiency gains in transport in light of rising adoption of passenger LDVs and increasing mobility demand. Such standards covered more than 50 million vehicles sold in 2011, or 70% of the world vehicle market, and provide a strong signal for markets to deploy efficient technologies and services. Recently, there is also a growing focus on achieving efficiency improvements in heavy-duty vehicles (HDVs), with the United States, Japan and Korea implementing efficiency-based standards. Growth in energy use in the transport sector is in large part driven by HDVs, while HDV efficiency gains have lagged behind those of passenger LDVs.

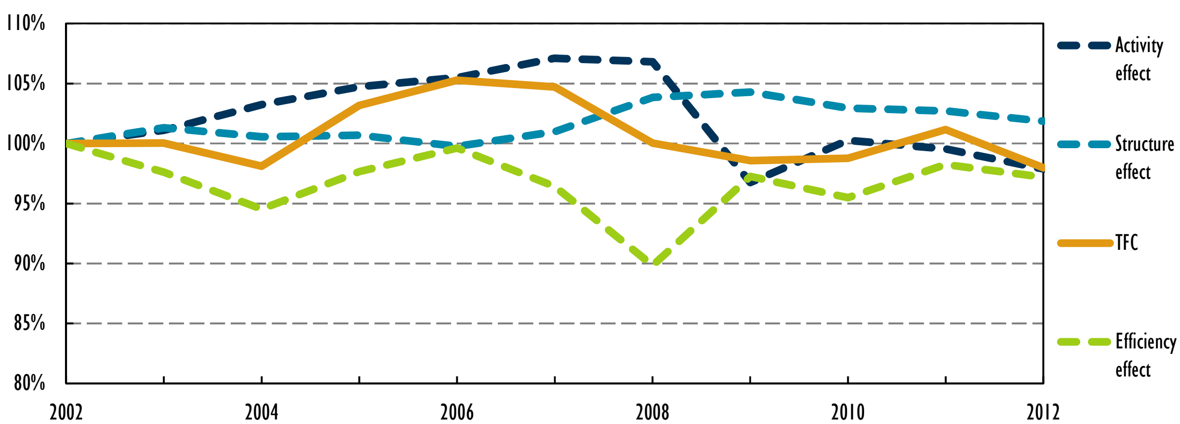
Using a wider lens, transport efficiency can be examined as the average energy required to move a person or tonne of goods one kilometre in a given jurisdiction. This approach accounts for the fact that different modes of transport move passengers or payloads with different energy requirements, and different vehicles or modes have different technical efficiencies. For example, passenger vehicles move a person with 80% more energy than a bus; rail moves a tkm of freight with 90% less energy than road freight. Thus, shifting transport across modes can reduce total energy consumption while maintaining the benefits and utility of the transport itself, and the share of different transport modes affects the total energy intensity of the transport system.

A shift in transport by mode, considered a structural change in the transport system, can have large energy consumption impacts. If a significant amount of transport shifted from small cars to light-duty trucks, total energy consumption could increase faster even if the efficiency improvements for light-duty trucks were greater. Investments that support a shift to more efficient modes constitute energy efficiency investments. As more attention is directed towards modal shift as a method to improve the efficiency of transport systems, increased investment is likely to follow. For more information see Chapter 3 of *EEMR 2014*, "The Market for Energy Efficiency in Transport: A Focus on the Land-Based Sub-Sector".

Freight transport

Energy efficiency in freight has also lowered energy consumption. The economic crisis after 2007 resulted in freight vehicles operating at lower capacity factors, which had a negative impact on energy efficiency in the sector (Figure 2.12). The share of more energy-intensive freight transport modes (structure effect) also rose during the financial crisis.

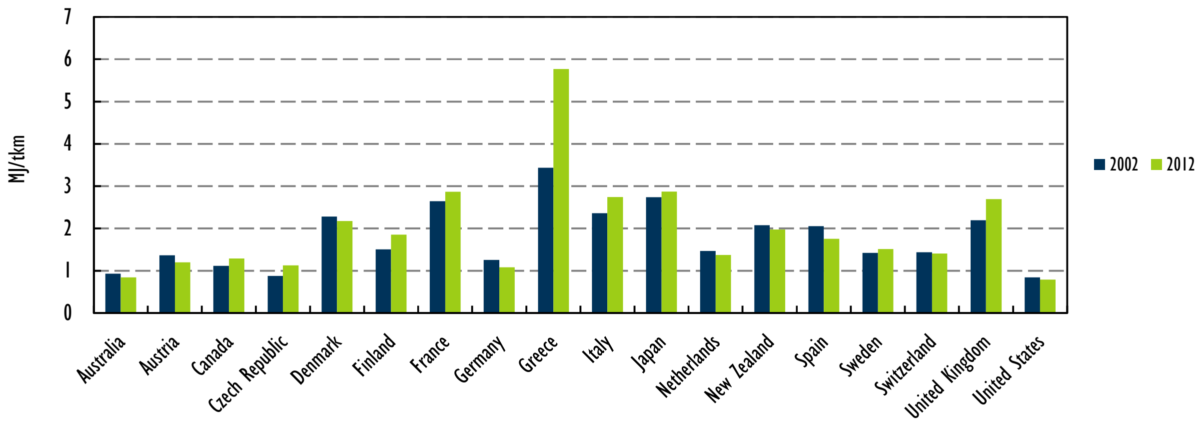
Figure 2.12 Freight TFC in IEA-18 decomposed by factor, 2002-12



Notes: Values are indexed to 2002 levels. Decomposition results are multiplicative rather than additive.

The overall energy intensity of the freight transport sector in terms of MJ per tkm increased in nine of the selected countries between 2002 and 2012, with a quite dramatic increase in the case of Greece (Figure 2.13). An increase in freight intensity likely reflects declining load factors in freight vehicles during the economic downturn.

Figure 2.13 Energy intensity of freight transport (MJ/tkm), 2002 and 2012



Notes: MJ/tkm = megajoules per tonne-kilometre. Freight transport includes road, rail and water transport. Exceptionally, Denmark, Finland, Greece and Switzerland exclude water transport, which – if there are significant volumes – has the effect of increasing freight transport energy intensity relative to other countries. The United States excludes light commercial vehicles.

Eight of the IEA-18 had a decrease in overall energy consumption for freight transport, largely due to a decrease in overall activity (tkm) rather than an intensity improvement (with the exception of the United States). Canada and the Czech Republic had increases in freight transport energy intensity combined with growth in activity. In Canada, the share of water transport in total freight dropped from 30% in 2002 to 23% in 2012, with most of the shift transferring to more energy-intensive road freight. In the Czech Republic, the shift was from rail to road transport.

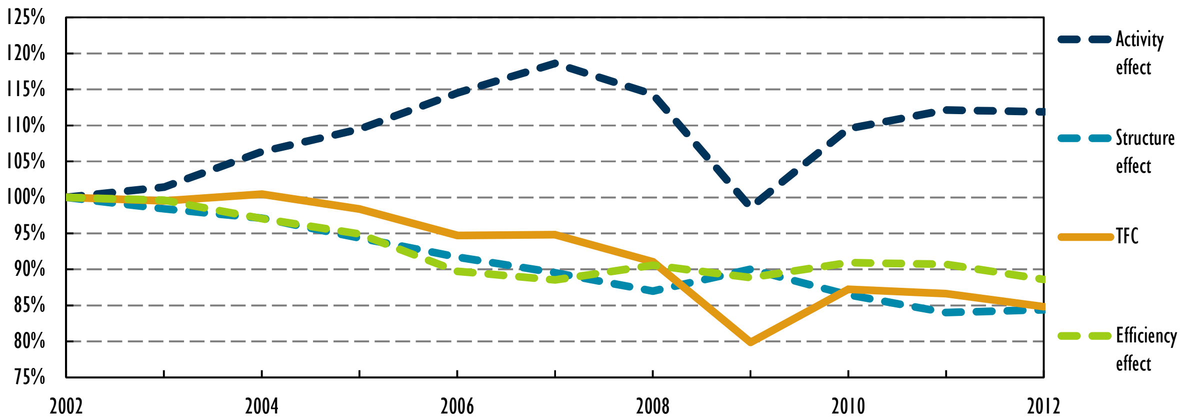
Industry (manufacturing)

IEA countries have seen a decrease in the share of energy-intensive industries (e.g. pulp and paper, cement and basic metals production) in total manufacturing value-added.[10] In parallel, the machinery and equipment ISIC sector, which includes high-tech information and communications devices, emerged as an important subsector. Since machinery and equipment manufacturing requires relatively less energy consumption, this structural change had a significant impact on the sector's overall energy intensity.

Decomposing trends in the IEA-18 for the industry sector shows that strong activity growth was counteracted by both intensity improvements and structural effects. The impact of the global economic recession can be clearly seen in the dip in activity between 2007 and 2010-11. The increase in the structure effect over that period is more likely due to changes in the relative value-added associated with subsector output, as opposed to a relative shift to more physical production in energy-intensive subsectors, which would take longer. This assumption is corroborated when individual countries are examined.

[10] Manufacturing is made up of pulp and paper, chemicals, non-metallic minerals, iron and steel, non-ferrous metals, and other manufacturing. Agriculture, refining and coal conversion are not included with the exception of Australia, where manufacture of coke and refined petroleum products is included, and Canada where bitumen extraction from oil sands is accounted for in the mining sector.

Figure 2.14 Industry (manufacturing) TFC in IEA-18 decomposed by factor, 2002-12



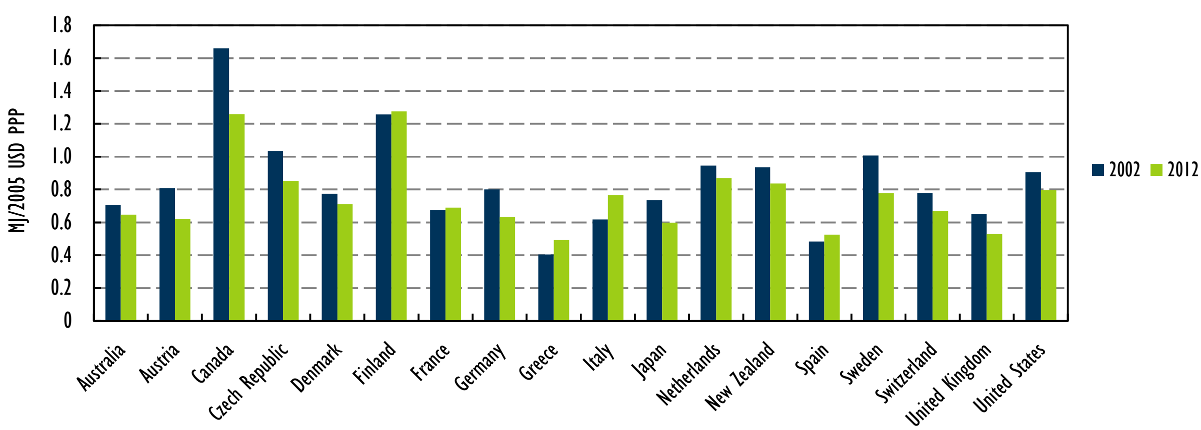
Notes: Values are indexed to 2002 levels. Decomposition results are multiplicative rather than additive.

All but four of the IEA-18 had an overall decrease in industrial energy consumption over the period 2002-12. For three of the four that show an increase (Austria, Germany and Switzerland), increased activity was the underlying factor; Australia saw a shift towards more energy-intensive industry subsectors (non-metallic minerals, metals and machinery) that drove up overall industry energy use. The Netherlands was the only other country to display a shift towards more energy-intensive subsectors (chemicals and petrochemicals, metals and machinery) but it did not lead to an overall increase in industrial energy consumption. Austria, Canada, Finland and Germany saw a worsening of energy intensity over the period. This is most likely a result of a shift to biomass fuels, which are less energy efficient but use waste material for fuel and reduce carbon emissions, energy expenditure and dependence on imported fuels.[11]

Services versus manufacturing: A major driver of energy intensity, independent of energy efficiency

Energy intensity in the services sector declined between 2002 and 2012 in 13 of the 18 countries, most noticeably in Canada (24%), Sweden (23%) and Germany (21%) (Figure 2.15).

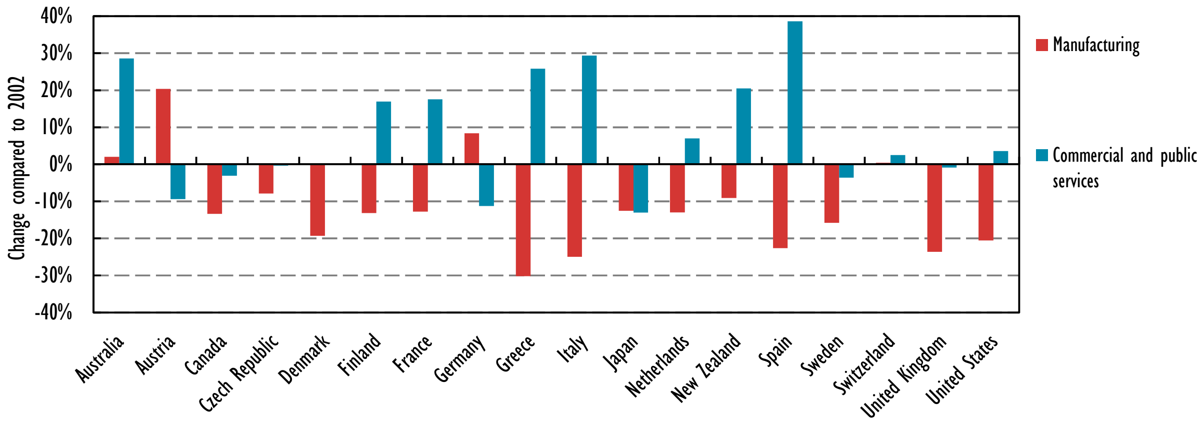
Figure 2.15 Energy intensity (gross value-added) of services in IEA-18, 2002 and 1012



[11] This highlights that more disaggregated data are required to fully analyse energy efficiency trends in the industry sector. Where data availability allows it, physical production data could also be used, together with specific fuel-use data.

Shifts in the relative shares of manufacturing and services provide insight into how structure affects TFC. As a general trend across the countries analysed, energy use in industry decreased between 2002 and 2012, while it increased in commercial and public services (i.e. services) (Figure 2.16).[12] Services TFC increased in Australia, Finland, France, Greece, Italy, the Netherlands, New Zealand, Spain, Switzerland and the United States. In Spain, this increase was more than one third.

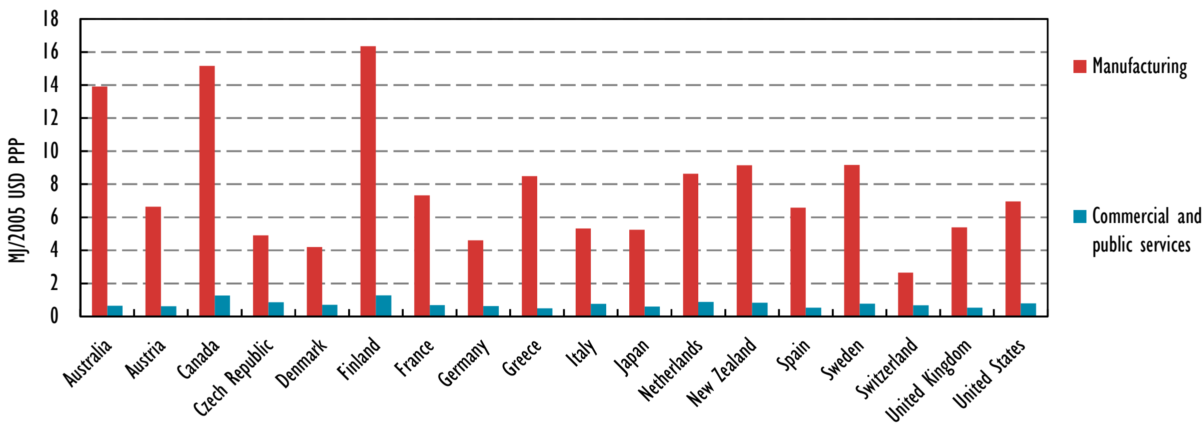
Figure 2.16 Changes in TFC in the services and manufacturing sectors by country, 2002-12



Note: Refinery is excluded from manufacturing.

The creation of one unit of value-added in the manufacturing sector requires 4 to 22 times as much final energy input compared to the services sector (Figure 2.17). Accordingly, changes in the energy used in the economy reflect changes in economic structure (i.e. shares) between manufacturing and services.

Figure 2.17 Energy intensities of the manufacturing and services sectors (value added), 2012

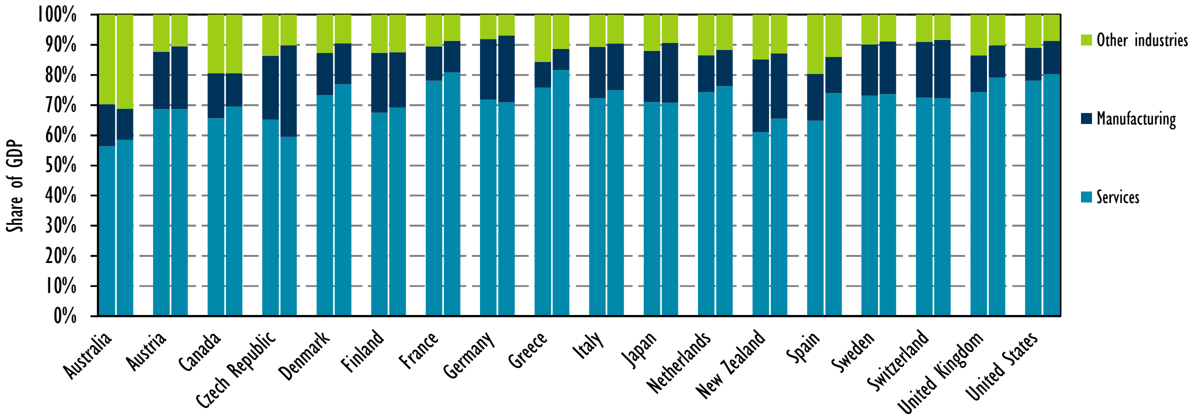


Ultimately, changes in economic structure can have a large impact on the overall balance of energy used per unit of GDP: an increase in the share of GDP generated by services (instead of manufacturing)

[12] Manufacturing data are presented here as a proxy for all industry. IEA indicators do not include TFC in the upstream energy conversion sectors, but it is acknowledged that these are significant sources of energy consumption and value-added in some countries and as a result have considerable potential for energy efficiency investment.

generally stimulates a corresponding decline in energy intensity. The share of GDP generated by the services sector rose in 12 of the IEA-18 countries between 2002 and 2012 (Figure 2.18).

Figure 2.18 Shares of manufacturing and services sectors in GDP value-added, 2002 and 2012



Conclusions

Energy intensity has been decreasing at world level, meaning that less energy is being used for every unit of GDP output. In addition, TFC is decreasing in many IEA countries for individual consumers, businesses and public services – with most of the decline being linked to energy efficiency measures. In the case of individuals, this can largely be attributed to efficiency improvements in the residential sector and passenger transport. Businesses and public services had a reduction in absolute energy consumed for manufacturing, services and freight transport in ten out of the 18 countries. Freight remains a sector with significant potential for energy efficiency, but structural trends towards less efficient modes are raising the energy intensity of the sector.

The same groups, i.e. consumers, business and public services, recently benefiting from efficiency gains are key players in the growing energy efficiency market. Indicator analysis shows the positive impacts of investments in energy efficiency to date, thereby highlighting the potential for policy makers to stimulate greater participation and increased investments in the energy efficiency market to generate greater gains. These results also show the value of digging deeper than highly aggregated metrics (such as TPES or TPES per unit of GDP) when tracking energy efficiency progress. Greater efforts are needed to improve data collection in order to support policy makers in developing stronger efficiency policies and programmes, and company decision makers and others in identifying and better exploiting market opportunities.[13]

References

IEA (2014a), Energy Statistics of OECD Countries 2014, OECD/IEA, Paris, DOI: http://dx.doi.org/10.1787/energy_stats_oecd-2014-en, (accessed on [day month year]).

[13] In 2014, the IEA published two manuals that aim to help countries improve their data collection and analysis, which is critical to this analysis. *Energy Efficiency Indicators: Fundamentals on Statistics* provides information on priority areas for data collection and interpretation of indicators to best support energy efficiency policy. *Energy Efficiency Indicators: Essentials for Policy* Making suggests a hierarchy of indicators, with the most detailed indicators at the bottom of the pyramid and more aggregated indicators at the top (IEA, 2014a, 2014b).

IEA (2014b), Energy Statistics of Non-OECD Countries 2014, OECD/IEA, Paris, DOI: http://dx.doi.org/10.1787/energy_non-oecd-2014-en.

IEA (International Energy Agency) (2014c), *Energy Efficiency Indicators: Fundamentals on Statistics*, OECD/IEA, Paris.

IEA 4E (2011), *Benchmarking Report: Impact of "Phase-Out " Regulations on Lighting Markets*, Benchmarking Report, International Energy Agency Energy Efficient End-use Equipment, OECD/IEA, Paris, http://mappingandbenchmarking.iea-4e.org/shared_files/668/download (accessed 29 June 2015).

3. EFFICIENCY MARKET FOR BUILDINGS

Summary

- **Global energy efficiency investment in buildings (excluding appliances) is estimated to have been USD 90 billion (+/- 10%) in 2014, with significant potential for additional profitable investments.** Investment in three countries alone – the People's Republic of China ("China"), Germany and the United States – is estimated to have been USD 59 billion. As energy efficiency codes, standards and programmes are improved and more widely implemented, per-building investment is projected to increase across most building markets in countries belonging to the Organisation for Economic Co-operation and Development (OECD).

- **Investment in energy efficiency in buildings globally is growing more rapidly than overall growth of building construction.** In the United States, investment in energy efficiency in buildings represents about 2.4% of construction investment, an increase from 1.9% in 2009; investments increased by USD 6 billion over the same period. In Germany, the investment share has doubled from 3% in 2009 to 6% in 2013.

- **New building construction is driving most of the investment in building energy efficiency in China (with its construction boom) and in the United States.** Investment in new buildings is particularly high in China (70%) and the United States (60%). In contrast, 60% of energy efficiency investment in Germany is directed to existing building retrofits, with government policies and funding playing an important catalytic role.

- **Global energy efficiency investment in buildings is projected to increase to over USD 125 billion (excluding appliances) by 2020.** This level, however, falls far short of the estimated USD 215 billion needed by that time to achieve the climate change mitigation goals set out in the 2-Degree Scenario (2DS) of the International Energy Agency (IEA).

- **Government investment is catalysing significant additional investments from industry and consumers.** Germany invested USD 2.4 billion in 2013 for a residential energy efficiency programme that stimulated almost USD 14 billion in energy efficiency investment and a total of USD 45 billion in residential construction.

- **A key challenge for the future is that the global buildings market is large and highly disaggregated.** Decisions on energy efficiency are taken by multiple players – governments, industry and consumers – based on different needs and goals, and reflect diverse incomes, climate conditions, habits, etc.

Introduction

The buildings sector is a large energy-consuming sector, accounting for more than 30% of global total final energy consumption (TFC). The sector is highly disaggregated, with many actors making operational decisions every day. The same is true for energy efficiency investment decisions: multiple players take decisions that drive investments, for both retrofits and new construction.

Energy efficiency investment, for the purpose of this chapter, includes all expenditures that support specific measures to make a building more energy efficient, notably the building envelope and systems for heating, ventilation and air-conditioning (HVAC), water heating and lighting. It also includes all expenses incurred to enable the energy efficiency investment, such as policy development and support for research, development, demonstration and deployment (RDD&D). Expenditures on appliances and electronic devices (such as refrigerators, televisions, microwaves and computers) are not included.[1]

Consumers, industry (e.g. construction companies, the energy efficiency supply chain, utilities) and governments are all investors in the current market for energy efficiency in the buildings sector. Most investment by consumers (building owners and occupants) and building construction companies is through the purchase of energy efficiency technologies and services. The supply chain investment generally includes technology research and development (R&D), and supply chain development. Utilities typically invest in utility-based energy efficiency programmes and the establishment of energy service companies (ESCOs). Government investment supports the development and implementation of codes and standards, and the provision of economic incentives (such as tax credits and rebates).

Globally, it is estimated that owners and occupants will spend USD 4.6 trillion on construction in 2015, with only a small portion (2%) dedicated to energy efficiency (Global Industry Analysts, 2012). A lack of available data makes it difficult to separate, quantify and analyse the energy efficiency investments within broader construction investments (even on projects that receive funding for energy efficiency). Some data are available from certain jurisdictions, however, and are used to inform the estimates in this chapter.

This chapter examines various aspects of buildings energy efficiency investment, including the market background and current market investments. It then explores the influence of policies, technologies, and business opportunities and models. Each section examines factors that impact energy efficiency investment, both nationally and globally.

Buildings energy use: Defining the context for the energy efficiency market

The buildings sector accounts for one-third of TFC globally; the share can be as much as 80% in some regions that depend on traditional use of biomass as an energy source (IEA, 2013). At the subsector level, residential buildings account for three-quarters of buildings sector energy use and non-residential[2] buildings for one-quarter. At the end-use level, the combination of space heating, space cooling and water heating are estimated to account for nearly 60% of global energy consumption in buildings.

Based on current policies, technologies, services and projected economic trends, energy use per end-use in buildings is expected to change dramatically: some changes will reduce energy use (e.g. for space heating), others will drive it up (e.g. for appliances). Considering the factors that influence energy

[1] Energy demand from these appliances is counted within a building's energy use and is distinct from energy efficiency investments, which are best tied to a building.

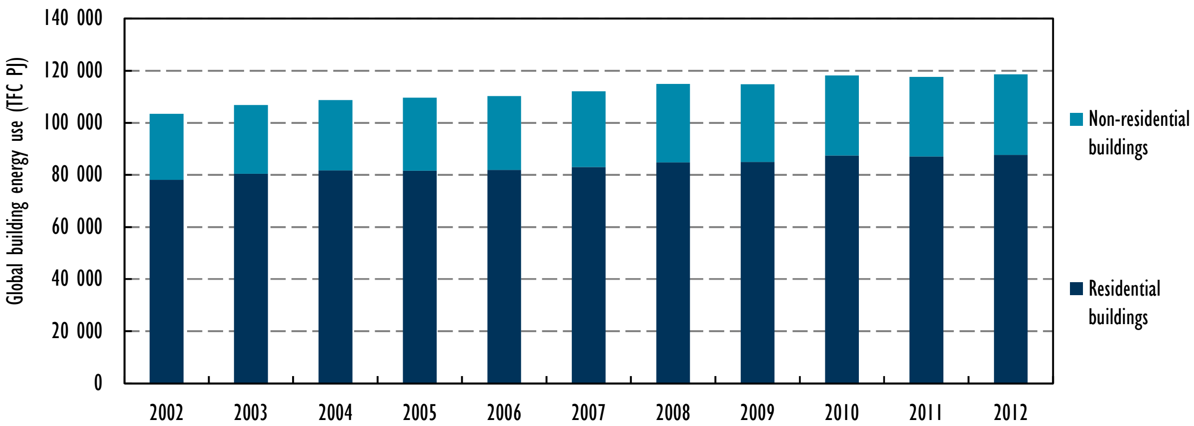
[2] Non-residential buildings refer to commercial and public services buildings with non-residential uses such as offices, hospitals, schools, public administration, mercantile and hospitality. Non-residential buildings exclude industrial buildings and residential buildings.

end-use in buildings – population growth, market shifts, economic prosperity, etc. – efforts to strategically align new policies, technologies and services within the buildings energy efficiency market could deliver significant energy savings.

Building energy use by building type

Residential buildings account for 74% of global building energy use and non-residential buildings (notably commercial buildings) for 26%. From 2002 to 2012, however, energy use in non-residential buildings grew at a faster rate (22%) than in residential buildings (12%) (Figure 3.1). Non-residential buildings often provide a good opportunity for energy efficiency investment, as the commercial activities undertaken typically require more active management of revenues and expenses, and decisions about per-unit energy consumption are more centralised.

Figure 3.1 Global buildings energy use by subsector, 2002-12



Energy efficiency in the residential buildings subsector improved by 15% from 2002 to 2012, resulting in 10 800 petajoules (PJ) of energy savings relative to annual final energy in 2012 (see decomposition analysis in Chapter 2). The value of these savings is USD 164 billion, based on an average weighted price for energy of USD 14/gigajoule (GJ).[3] Although the IEA does not conduct a decomposition analysis on non-residential buildings (largely because of data insufficiency), common elements with the residential sector provide some insights. If similar energy savings could have been achieved in the core end-uses (i.e. excluding all services energy consumption such as data centres or healthcare treatment) of non-residential buildings, this subsector could have saved 3 800 PJ of annual final energy in 2012, representing a value USD 53 billion (based on the same average weighted price). The opportunity for energy savings is particularly interesting in urban buildings (Box 3.1)

[3] This assessment draws on a published estimate of 2010 world energy expenditure as USD 6 400 billion (in constant 2005 USD expressed in PPP) (Desbrosses, 2011). Using IEA energy price data, the 2010 price is converted into a 2014 price equivalent of USD 13.85/GJ.

Box 3.1 Energy use in urban buildings

Energy use in urban buildings reflects the country context.

In industrialised countries, urban buildings typically use less energy per person compared to suburban or rural buildings, due to a combination of factors. For example, urban buildings are often attached to surrounding buildings, which reduces the need for space conditioning (i.e. heating or cooling). Additionally, as urban buildings are more expensive to build per square meter (m^2), the floor area per person is typically smaller. In a residential scenario, for instance, for the same budget, a family may be able to acquire a 300 m^2 detached home in a rural location, a 200 m^2 semi-attached home in a suburban location, or a 100 m^2 apartment in an urban location.

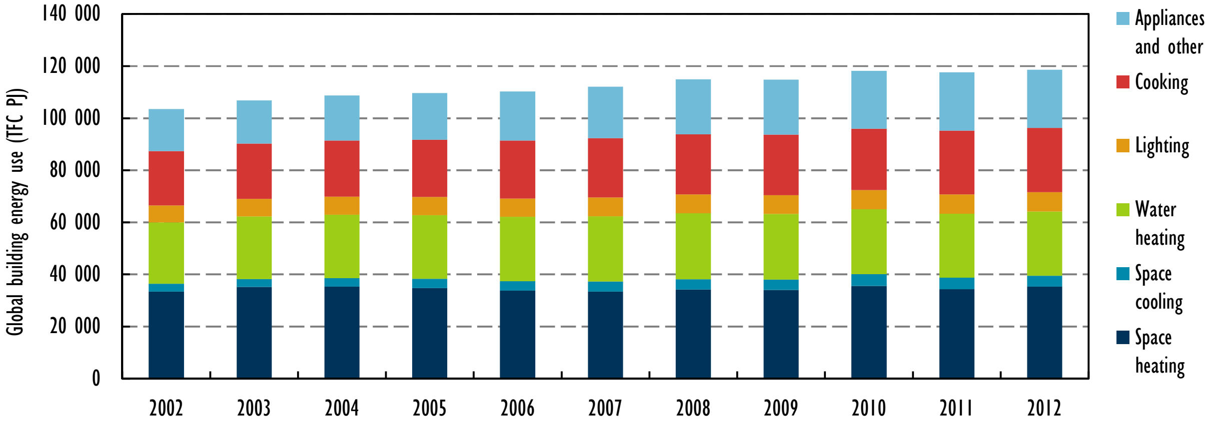
In developing countries, the energy consumption pattern is often reversed, with urban buildings using more energy per person compared to suburban or rural buildings. This is due to urban buildings having full (or substantially better) access to energy, and urban populations having higher income and higher comfort expectations that require increased energy use. Rural populations, by contrast, may have very limited access to energy, and very low energy use per person.

Population estimates to 2050 project a significant increase in urban population globally, with much of the growth in developing countries. This will drive up the number of new urban buildings in such regions, and increase energy use at the national level, leading to the need for increased attention on energy efficiency policy in the urban areas in developing countries to manage the expected energy demand growth.

Building energy use by end-use

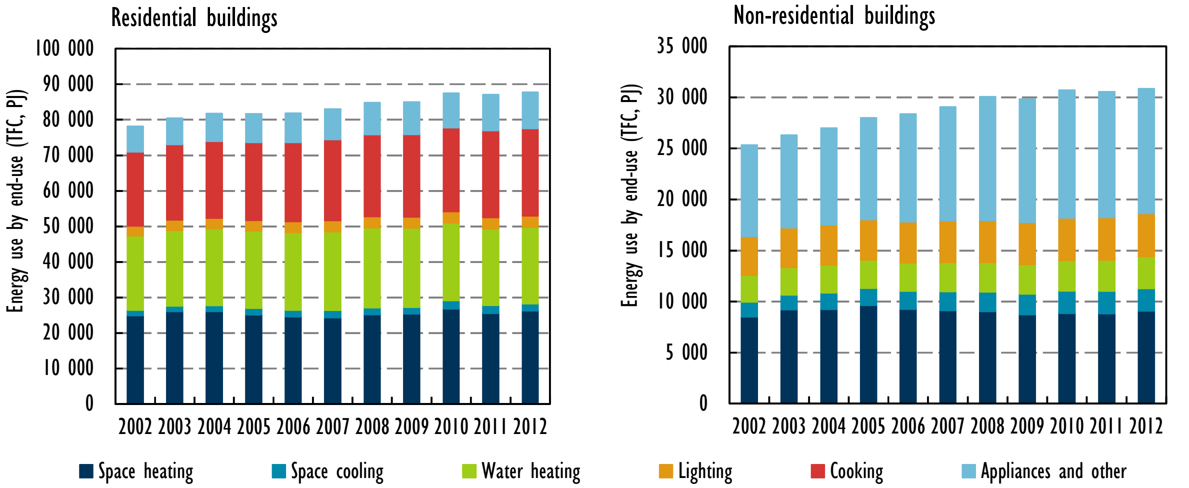
Building energy end-uses include space heating, space cooling, water heating, lighting, cooking and appliances (including large appliances and small appliances). Building energy efficiency investment includes expenditure in all of these end-uses except small appliances, which are typically considered a service more than a building end-use. Historically, the largest end-uses globally are space heating, water heating and cooking; more recently, the appliances category is growing to become one of the largest end-uses (Figures 3.2 and 3.3). Unless specifically stated, this section discusses end-uses for both the residential and non-residential building sectors jointly.

Figure 3.2 Estimated global building energy use by end-use, 2002-12



Note: A large portion of energy demand for residential space heating, water heating and cooking is met with biomass (particularly in developing countries), resulting in significant additional energy use in residential buildings compared to non-residential buildings (Figure 3.3).

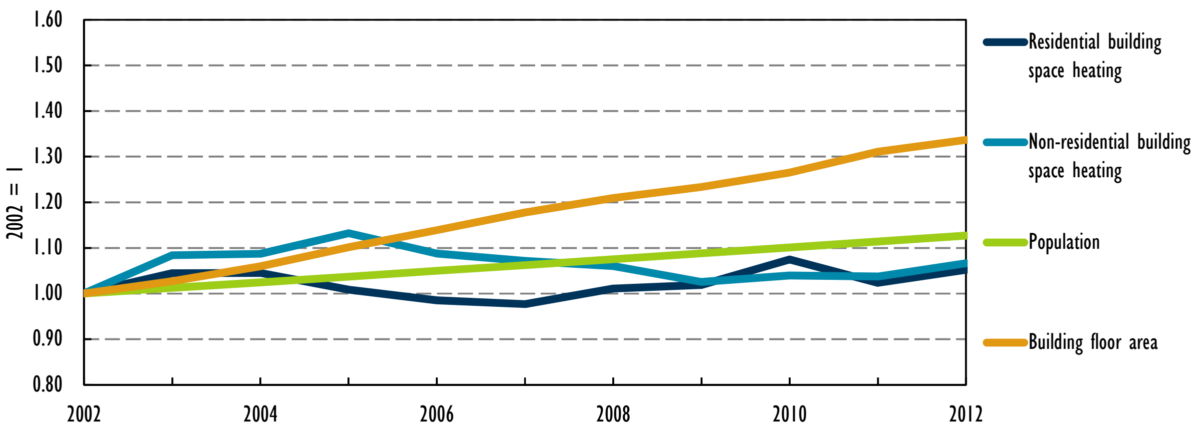
Figure 3.3 Estimated global building energy use, by building type and by end-use, 2002-12



Notes: Electricity end-uses (including space cooling, lighting and appliance energy use) appear as a small portion of building energy use when normalised by global final energy. However, when compared in primary energy or purchased energy, the electricity end-uses are a larger portion of the global building energy use. Space heating, water heating and cooking energy use are a larger portion of the global final energy due to being primarily gas or biomass energy.

Space heating: In many countries with cold climates, the energy requirements for space heating at the building level are decreasing as a result of policies that call for improving the energy efficiency of the building envelope and of heating equipment technologies. However, the number of people and the number of buildings that require space heating are rising, and with rising incomes (particularly in developing countries) people often expect a higher level of comfort which drives up the energy demand for space heating. Ultimately, building space heating demand growth is moderating: from 2002 to 2012, global population grew by 13% and floor area by 34%, yet space heating demand growth was much lower – just 5% in residential buildings and 7% in non-residential buildings (Figure 3.4).

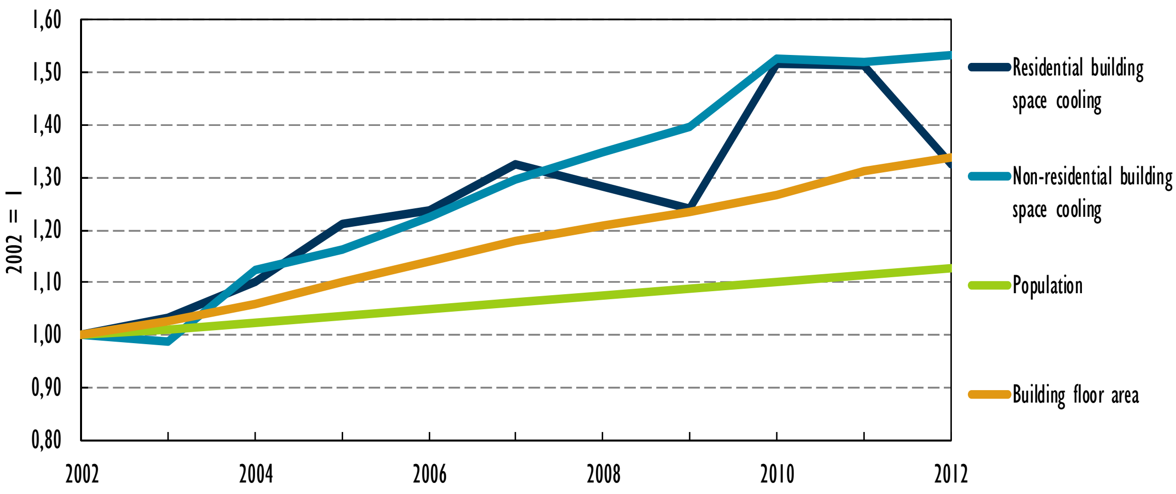
Figure 3.4 Estimated global energy use for building space heating, relative to population growth and building floor area (indexed to 2002), 2002-12



Energy efficiency investment in space heating, primarily in industrialised countries that have cold climates, has resulted in a decoupling of space heating energy use from growth in both population and building floor area. At the national level, OECD countries have had decreasing overall space heating energy use. The trend is opposite in non-OECD countries, where increased development and population growth led to an increase in energy use for space heating. However, as most of the non-OECD developing nations are in hot climates, global growth in building space heating is minimal compared to energy consumption growth for other end-uses.

Space cooling: In some countries, the market for space cooling equipment is largely saturated. In such contexts, policy and supply chain improvements targeting the energy efficiency levels of building envelopes and cooling equipment technologies are helping to drive down the energy requirements for space cooling at the building level. By contrast, in countries where the space cooling equipment market is not yet saturated (including numerous large and growing emerging economies), the building level energy use for space cooling is rising. Population growth, floor area expansion, rising incomes and climate figure significantly in the case of space cooling: the number of people and the number of buildings that require space cooling is increasing, particularly in the hot climate, developing countries. Energy efficiency improvements in space cooling equipment have not kept pace with increased penetration of and the associated rise in demand for mechanical air conditioning energy use. This has resulted in a growth rate of 43% for space cooling energy[4] over the last decade, which exceeds by far the growth in both population (13%) and building floor area (34%) (Figure 3.5).

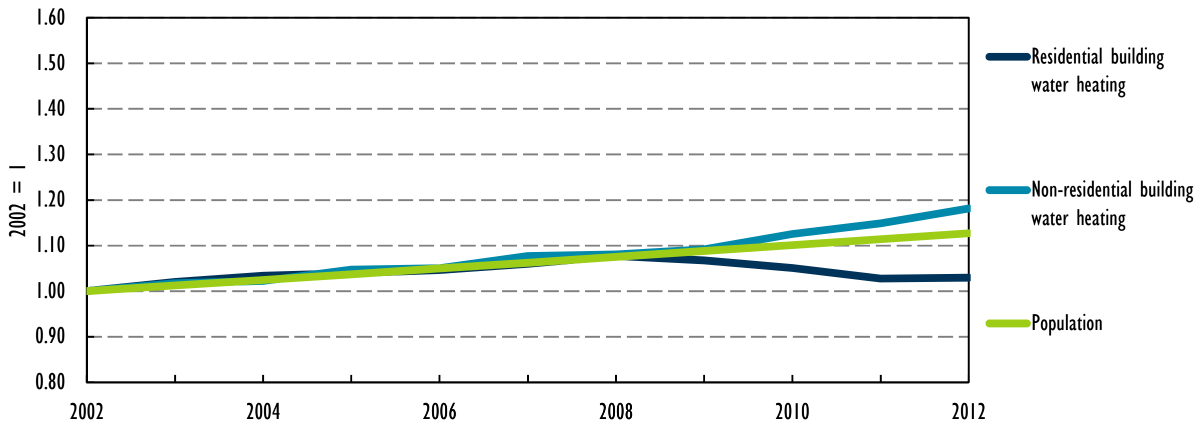
Figure 3.5 Estimated global energy use for building space cooling (indexed to 2002), 2002-12



Water heating: At present, inefficient technologies dominate the water heating market in almost all countries, making energy demand for this end-use high at the building level. Current government policies and industry investment make it challenging for consumers to adopt highly efficient technologies at reasonable prices, including heat pumps or solar water heaters. Recent trends for residential buildings show a small increase (3%) in energy use for water heating from 2002-12, notwithstanding a larger growth in population (13%). Non-residential buildings show a much larger increase (18%) in energy use (Figure 3.6).

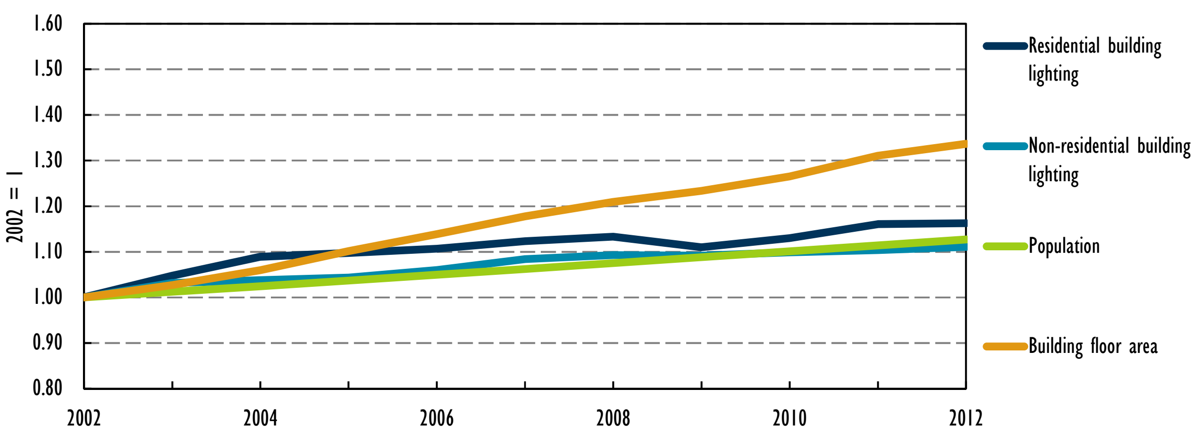
[4] These figures have not been adjusted for changing climate (e.g. mild summer periods versus hot summers). However, the ten-year data set reflects the larger trend of increasing energy use for space cooling in buildings.

Figure 3.6 Estimated global energy use for building water heating (indexed to 2002), 2002-12



Lighting: The efficiency of lighting in buildings is improving due to a continued shift over the past decade from incandescent bulbs (including halogen) to compact fluorescent lamps (CFLs) and now to light-emitting diode (LED) technology. Adoption of advanced lighting controls and sensors, along with more strategic use of natural daylight, has enabled a portion of the buildings market to avoid additional lighting energy use even as building floor area has increased. Lighting energy use shows an increase of 10% to 15% while building floor area has grown by 34% (Figure 3.7), reflecting a decoupling of lighting energy use from floor area. In developing countries, where energy use for lighting is rising due to increasing population (a portion of which also represents rising incomes and comfort expectations) and increase in building floor area, early adoption of CFL technologies has paradoxically minimised the opportunity for additional energy savings from newer technologies. For the purposes of estimating the energy efficiency market of lighting for buildings, only the physically connected system hardware (light sensors, fixtures and controls) are included, but not the bulbs (as with the categorisation of appliances being beyond the buildings energy efficiency investment).

Figure 3.7 Estimated global energy use for building lighting (indexed to 2002), 2002-12

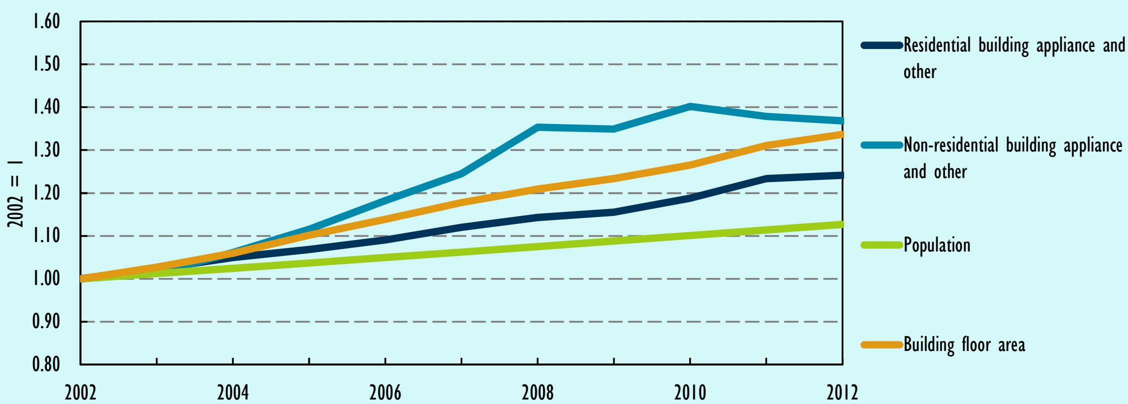


Appliances: A large portion of the energy load in buildings is from appliances. Historically, appliance use represented about one-third of the total energy, but the share is growing in recent years. This is due in part to the increasing number of appliances per home (i.e. including consumer electronics, dishwashers, etc. – see discussion in Chapter 4), appliances per office (including computers and office equipment) and the increased use of appliances in daily life. Appliances typically are part of what is often referred to as the "plug-load": i.e. they continually draw some energy through electrical outlets. While this analysis does not take account of spending for appliances as building energy efficiency investment, data on appliances reveal interesting trends that will affect future energy use in buildings (Box 3.2).

Box 3.2 Appliances: Becoming a bigger player in building energy demand

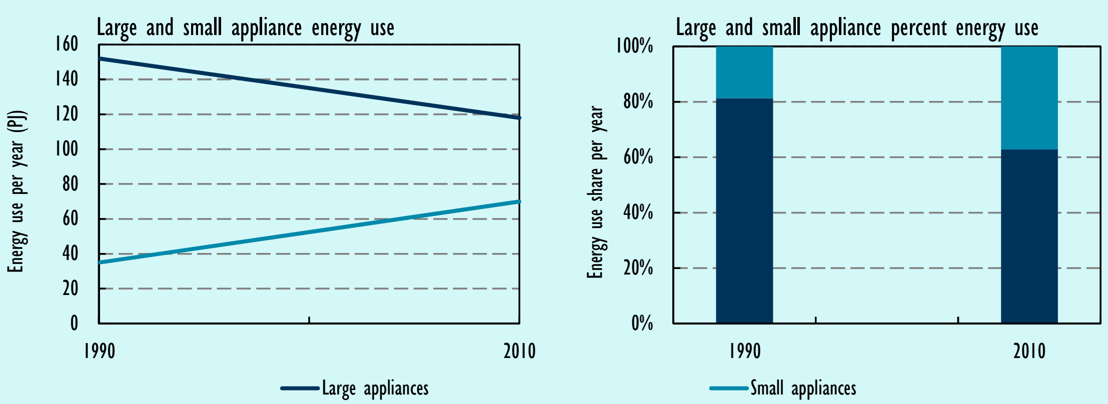
Improvements in technology efficiency are reducing the energy requirement of some large, widely used appliances such as refrigerators and dish-washing and clothes-washing machines. At the same time, however, increased sales of products with lower market saturation (particularly dish-washing machines and clothes dryers) are driving up overall appliance energy use. In developing countries at the national level, the efficiency gains in large appliances are offset by the increasing penetration associated with rising income and growing population. Globally, the growth rate of energy demand of appliances in both the residential (24%) and non-residential (37%) sectors outpaced that of population growth (13%). In the non-residential sector, this growth has also outpaced the increase in floor space (34%) (Figure 3.8).

Figure 3.8 Estimated global energy use for building appliances (indexed to 2002), 2002-12



The relative shares of large and small appliances are also shifting in many places, in part driven by the growth of small appliances. In Canada, for example, between 1990 and 2010 the share of energy use from small appliances in total appliance energy use increased from 20% to 38% (Figure 3.9) (Natural Resources Canada, 2013). The combination of improved energy efficiency in large appliances and wider market saturation of small appliances has already resulted in a noticeable change in energy use trends.

Figure 3.9 Transitions energy use of large and small appliances in Canada, 1990-2010

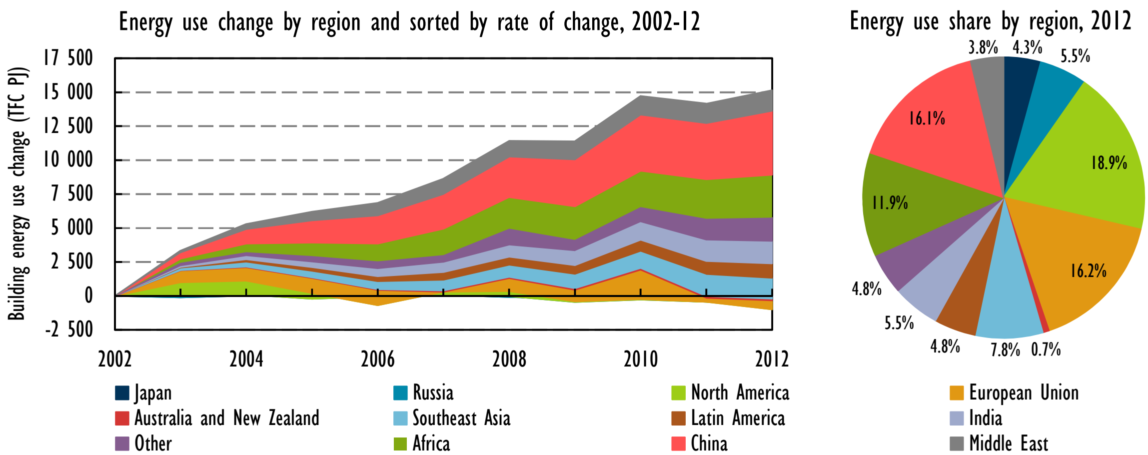


Source: Natural Resources Canada (2013), *Energy Efficiency Trends in Canada, 1990-2020*, Natural Resources Canada, Ottawa, http://publications.gc.ca/collections/collection_2014/rncan-nrcan/M141-1-2010-eng.pdf (accessed 3 July 2015).

Building energy use by country/region

Building energy use by country and region is following other energy use trends, with OECD countries exhibiting relatively flat energy use while use in non-OECD regions (particularly developing countries) is increasing in line with large population growth and economic development (Figure 3.10). From 2002 to 2012, some regions saw rapid increases in building energy use including the Middle East (55%), China (35%) and Africa (30%).

Figure 3.10 Building energy use change and building energy use share, by region, 2002-12



Estimating investments in buildings energy efficiency

In the face of uneven data on energy efficiency investments in the buildings sector, several top-down and bottom-up approaches have been used to estimate the size of this market. Through these methods, the IEA estimates that global annual investment in buildings energy efficiency is more than USD 80 billion (Table 3.1).

Building energy efficiency in the United States, Germany and China: Growing markets in diverse contexts

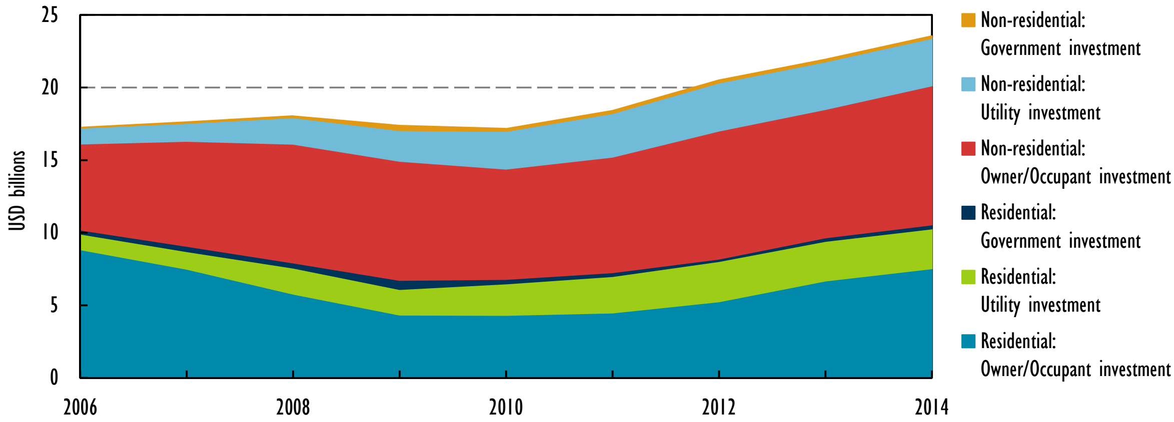
The IEA was able to collect significant market data from the United States, Germany and China to set a starting point for bottom-up analysis, including a combination of investment costs from consumers, industry, utilities and government. While this dataset is incomplete, it reveals interesting insights into energy efficiency investment per country, per energy use and per GDP.

United States

In the United States in 2014, USD 960 billion was spent in the residential and non-residential building construction market (United States Census Bureau, 2015), of which around 2.4% was invested in energy efficiency – a total of more than USD 23 billion. This represents an increase of nearly one-quarter since 2009, when the efficiency investment share was 1.9%, and an increase of 37% from the USD 17 billion invested in 2006. Of the 2014 total, an estimated USD 10.5 billion was invested in residential energy efficiency and USD 13 billion in non-residential (Figure 3.11). Non-residential investment by building owners and occupants saw the largest growth, with investment almost doubling in just seven years – from USD 7 billion in 2006 to USD 13 billion in 2014.[5]

[5] Analysis is based on data collected in an IEA database on energy efficiency investments that include a variety of sources, such as government statistics, industry statistics and building sector reports.

Figure 3.11 Estimated building energy efficiency investment in the United States, 2006-14



Germany

In Germany, government and bank programmes have been set up to promote energy efficiency investment, including the KfW residential programme. In 2014, more than USD 17 billion was invested in building energy efficiency in Germany, almost USD 13 billion of which was directed towards residential buildings. Considering that annual building construction investment in Germany is one-third of the US market and one-fourth of the market in China, this amount is relatively large. While the US and Chinese markets show steady growth, building energy efficiency investment in Germany has fluctuated having been, for example, more than USD 20 billion in 2013. Still, over the last ten years, efficiency investment in buildings has risen by 26%. Similarly, the share of construction costs allocated to energy efficiency investments has increased, doubling from 3% in 2009 to 6% in 2013.[6]

China

Energy efficiency investment in China has continued to grow in step with the pace of investment growth in the building construction market. In 2014, more than USD 18 billion was invested in building energy efficiency in China, with more than USD 11 billion of that invested in residential buildings. The market for energy efficiency in China has been driven by a combination of ESCO investment, consumer spending, and voluntary and mandatory government programmes (such as building codes and retrofit programs). More than 70% of energy efficiency investment occurred in new buildings.[7]

Estimating the global market for building energy efficiency investment

Working with an admittedly limited data set, the IEA is able to apply standard methods to derive estimations of the global market for building energy efficiency investment.

[6] Analysis is based on data collected in an IEA database on energy efficiency investments that include a variety of sources, such as government statistics, industry statistics and building sector reports.

[7] Analysis is based on data collected in an IEA database on energy efficiency investments that include a variety of sources, such as government statistics, industry statistics and building sector reports.

Extrapolation of bottom-up data, based on share of global construction investment

Bottom-up data collected for China, Germany and the United States, which includes the shares of energy efficiency investment within the total construction investment, is used along with global construction investment data to estimate the global building energy efficiency investment. Annual global construction investment (limited to only building construction activities) has been estimated to range from USD 4 trillion to USD 5 trillion. Using a global building construction market size of USD 4.6 trillion, along with the data for China, Germany and the United States – namely the USD 59 billion in building energy efficiency investment and their 64% share of global construction market – the global annual investment for energy efficiency in the buildings sector is estimated to be USD 93 billion (Table 3.1).[8]

Top-down estimation, based on sector payback periods

Global building energy use in 2014, excluding appliances and other plug-loads, was 73.5 EJ. Using an energy efficiency improvement of 1.3% per year from 2002 to 2012 (Figure 2.8), building energy efficiency savings equals an estimated 0.96 EJ in 2014. Although energy efficiency generates benefits beyond savings (Box 3.3), the value of savings relative to expenditures on investment provides a useful guide in evaluating what investments in energy efficiency are being made. Using an average weighted price for energy (USD 14/GJ[9]) and payback periods of five years for residential buildings and ten years for non-residential building decisions on core building end-uses,[10] global investment in building energy efficiency is estimated to be USD 82 billion (Table 3.1).

Table 3.1 Estimates of annual investment in energy efficiency in buildings (USD billion, 2014)

Method	Total
Investment in China, Germany and the United States (bottom-up data)	59
Global investment based on extrapolation of bottom-up investment and construction data	93
Global investment based on top-down estimation using sector payback periods	82

[8] This methodology of extrapolating from the construction data for the United States, Germany and China can be modified to use share of buildings use as the relevant factor, as this may drive interest in investments, or GDP, as a proxy for overall economic activity:

- If annual energy use in the buildings sector (excluding appliance energy use) is used to extrapolate, the calculation of 30.2 EJ in China, Germany and the United States compared to 73.5 EJ globally, gives an, estimated global annual investment of USD 146 billion.
- These three countries represented 39% of total global GDP in 2014. Applying this factor to their combined building energy efficiency investment of USD 59 billion yields an estimated global annual investment of USD 151 billion.

[9] This assessment draws on a published estimate of 2010 world energy expenditure as USD 6 400 billion (in constant 2005 USD expressed in PPP) (Desbrosses, 2011). Using IEA energy price data, the 2010 price is converted into a 2014 price equivalent of USD 13.85/GJ.

[10] The longer payback period for the non-residential building sector reflects greater capacity for decision makers to analyse and assume longer payback periods than most households can exercise. The payback periods are longer for core building measures that have a long useful life and are shorter for appliances and other measures that have less years of useful life.

Box 3.3 The multiple benefits of energy efficiency investment

Until recently, the calculated return on investment for energy efficiency in buildings was limited to the energy saved and associated cost savings. More effort is now underway to understand and monetise a wider range of benefits (collectively referred to as "multiple benefits") of energy efficiency. The capacity to attach additional values is starting to impact investment decisions in the buildings sector.

For building owners and occupants, the multiple benefits of energy efficiency often include some or all of the following: improved durability, reduced maintenance, greater comfort, lower costs, higher property values, increased habitable space, increased productivity, and improved health and safety.

The multiple benefits of energy efficiency to governments often include reduced societal health costs, improved air quality, an improved tax base and lower budget variation, higher GDP and enhanced energy security. Utilities benefit from cost and operational benefits due to reduced customer turnover, reduced emissions and reduced system capacity constraints.

Source: adapted from IEA (2014a), *Capturing the Multiple Benefits of Energy Efficiency*, OECD/IEA, Paris, available at www.iea.org/bookshop/475-Capturing_the_Multiple_Benefits_of_Energy_Efficiency (accessed 17 August 2015).

Influencing investment growth in energy efficiency markets

Investments in energy efficiency in new buildings

Energy efficiency investments are most cost-effective when incorporated into new buildings at the schematic design phase. From a regulatory policy perspective, it is much easier for jurisdictions to implement energy efficiency standards and codes that will apply to subsequent new buildings than to apply new regulations to existing buildings. A wide range of highly energy-efficient technologies and design techniques, which are often applied on a voluntary basis, can make buildings significantly more energy efficient than a typical code-compliant building.

In anticipation of the need to comply with EU Directive 2010/31/EU, many EU countries are proactively adopting zero-energy building (ZEB) policies for all new construction. The Directive stipulates that all new buildings owned or occupied by public authorities must be nearly zero energy by 2019; the legislation will apply to all new buildings (regardless of who owns and occupies) by 2021. The US Department of Energy (US DoE) Building Technologies programme set a goal of achieving cost-effective, market-viable zero-energy residential homes by 2020, which extends to services subsector buildings by 2025. This goal was recently replaced by one to achieve 50% savings across the entire buildings sector by 2030 (IEA, 2013). Similar programmes and activities are underway in other countries (Box 3.4)

Box 3.4 Global green building construction activity

Dodge Data and Analytics defines a green building as one built to Leadership in Energy and Environmental Design (LEED) or an equivalent standard, or one that is energy and water efficient while also providing improved indoor environmental quality and/or resource efficiency. In this definition, all green buildings would include some level of energy efficiency.

In 2012, green building construction in the United States was worth USD 85 billion (Dodge Data and Analytics, 2012). Globally, 20% of residential and 44% of non-residential building projects qualified as green building activity (Dodge Data and Analytics, 2012), with total global green building project activity at 38% of total construction investment (McGraw-Hill Construction, 2013). With USD 4.6 trillion of global construction activity (Global Industry Analysts, 2012), these estimates would indicate that USD 1.7 trillion of global construction activity includes some portion of energy efficiency investment.

Investments in energy efficiency in existing buildings

Energy efficiency investments undertaken in existing buildings are fundamentally different than those built into new construction. Typically, projects for existing buildings imply higher costs to upgrade but have less access to finance, and the work itself causes disruption of existing building uses. These factors are often enough to stall many otherwise cost-effective building energy efficiency projects.

To achieve the level of energy savings possible in new buildings, owners and operators of existing buildings need comprehensive energy efficiency upgrade packages that include financial solutions. Otherwise, they are likely to undertake only minor upgrades and low-cost or no-cost energy efficiency measures that improve building operation but fall far short of delivering the substantially higher savings potential that could be achieved through deep energy retrofits.

Even though cost-effective energy efficiency retrofits to existing buildings are inherently more challenging, the sheer market size can result in significant energy savings at the country level. In the United States, 3.5 billion m^2 of non-residential building floor area – i.e. less than 40% of the potential market – is currently using the ENERGY STAR Portfolio Manager to measure and track energy use. The US Environmental Protection Agency (US EPA), which launched and oversees the ENERGY STAR programme, estimates the energy cost savings for existing buildings at USD 3.4 billion since programme's inception (US EPA, 2015). Yet 60% of buildings have not yet applied it.

Investments in energy efficiency by building component

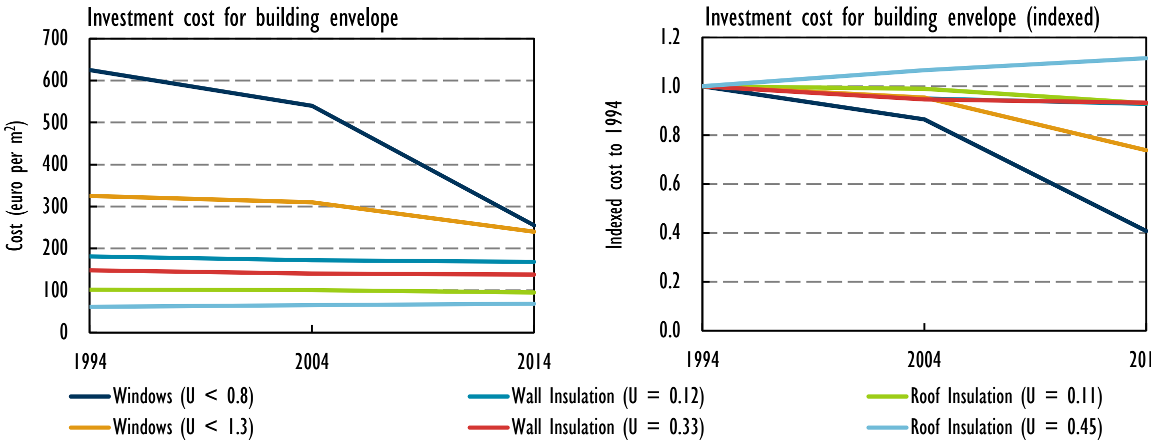
Improvements in the energy efficiency of building components enable designers and consumers to more easily invest in building energy efficiency. With government and industry support, such improvements are being achieved within each of the building component types, as shown below. At present, however, energy efficiency investment at the building component level is poorly tracked globally.

Building envelope: The building envelope determines, to a large extent, the overall efficiency of a building over its entire lifespan. High efficiency building envelope measures are often core elements of energy efficiency programmes for new buildings and of deep energy retrofit programmes for existing buildings. In reality, upgrading the envelopes of existing buildings is a major undertaking that is infrequently pursued. Some building envelope measures (e.g. attic insulation, air sealing and window films) are low-cost investments that can be carried out at any stage of the building lifecycle. Other building envelope measures (e.g. wall insulation, foundation insulation or installation of new windows) are more likely to be carried out only when the component is due for replacement (i.e. not earlier, as purely an energy saving activity). In many places, the costs of such components have been dropping, which boosts their uptake (Box 3.5).

Box 3.5 Lowering the cost of building energy efficiency in Germany

Energy efficiency buildings investments are becoming more cost-effective in various locations as cost decrease. In Germany, a general trend is evident of building envelope technology costs declining from 1994 to 2014, with the cost of windows falling most dramatically. Roof insulation, commonly the lowest-cost building envelope measure, has not shown any significant cost changes; as a result, when indexed it shows only the increasing cost trend (Figure 3.12).

Figure 3.12 Cost of building envelope measures in Germany, 1994-2014



Note: Investment costs for building envelope in 2014 EUR.

Source: Ecofys Germany (2014), "Preisentwicklung Gebäudeenergieeffizienz Initialstudie", Ecofys website, Berlin, www.ecofys.com/de/veroeffentlichung/preisentwicklung-gebaeudeenergieeffizienz (accessed 3 July 2015).

HVAC equipment: HVAC equipment often has a relatively short lifespan (10 to 20 years) compared to the building structure and building envelope (40 to 100+ years), and is generally easier to replace, retrofit or upgrade. With this regular turnover, significant energy savings potential can be achieved through equipment minimum energy performance standards (MEPS), which encourage building owners, occupants or operators to pursue HVAC system energy-efficient upgrades on a more frequent basis.

Water heating equipment: Water heating equipment also has a short lifespan compared to the building structure and building envelope. It is typically replaced every 10 to 20 years, again allowing for substantial energy savings through MEPS to improve efficiency of equipment.

Energy meters: Accurate data on actual energy consumption is important on multiple levels: at the building level, it allows better consumer decision making; at the national or regional level, it supports strategic policy making or business planning. Smart meters are being deployed widely in many countries; however, the building sector will need to continue to evolve to enable energy efficiency investment decision makers to use meter data in more effective ways.

Lighting: Lighting systems in buildings are defined as comprising fixtures, controls and sensors – but do not include lamps and similar displaceable items (which are not viewed as part of the buildings market). Following a shift from incandescent bulbs to CFLs, future trends project a significantly increased market share for LED lighting, as retailers phase out both incandescent and CFL lighting. The shift may also involve the deployment of advanced fixtures, controls and sensors that are better adapted to these different lighting systems.

Appliances and other: As noted above, appliances represent a major part of the energy load in buildings but are not considered in this chapter as an integral part of the building structure (rather as part of the plug load).[11] Emerging information and communications technologies (ICTs) being

[11] The equipment and appliances used by building occupants have a high impact on overall energy consumption. For some items, such as refrigerators, the purchase price is based on the size and options of the appliance; however, the level of efficiency is not reflected in pricing (or is reflected with a lower weighting). As a result, consumers may pay more for technology that is less energy efficient, which means they pay more up front and also more for the higher amount of energy consumed by the appliance throughout its lifespan. A similar trend can be seen in the prices of windows, light fixtures, cooking appliances, TVs, etc.

deployed will support better energy management within buildings by enabling increased control of equipment (including HVAC and other building components) and other products (Box 3.6).

Box 3.6 Energy use and the "internet of things"

The internet of things (IoT), a term used to describe the growing network of physical objects or "things" embedded with electronics, software, sensors and network connectivity to enable objects and devices to transmit and receive data, will play a vital role in future energy use in buildings. The IoT will enable some technologies to use improved information and controls to reduce energy use and waste, but connected devices and objects will have an increased energy demand due to the need to establish and maintain network connectivity. Globally, more than 14 billion network-connected devices are already operating, with the number expected to grow to 50 billion over the next decade. With future plans to connect almost every person and every device, the potential for the IoT to affect energy use could be very large.

Policy drivers and emerging trends for building energy efficiency

At the most basic level, policy drivers – including economic instruments – have a strong influence on the markets for building energy efficiency investment. Effective policy options can range from building codes and product standards that stimulate technology innovation and create new markets, to financing tools (e.g. low interest rates for energy efficiency loans) that assist consumers or taxes by which governments recoup the return on their investment. Policy action can also create additional employment benefits.[12]

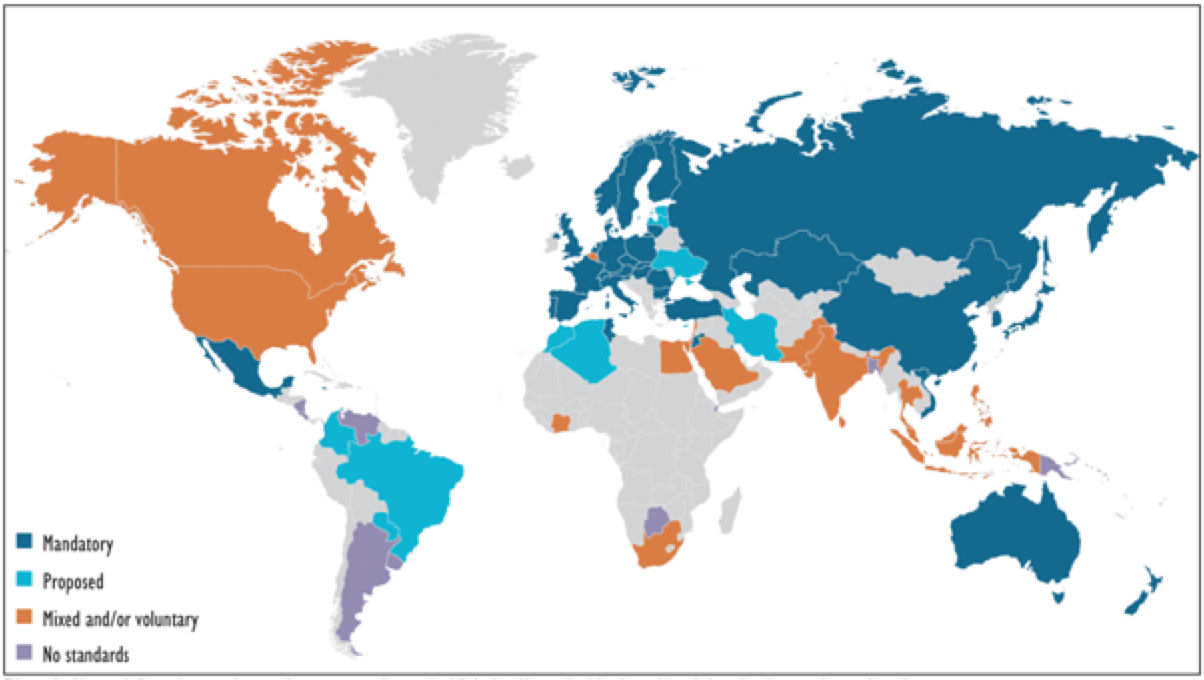
Building codes and regulations

The development, adoption and enforcement of codes and standards (at local, national or regional levels) are important for creating and sustaining energy efficiency markets. Often, these are used in combination with government-issued targets for improved energy efficiency, which are updated regularly to maintain momentum as progress is achieved (or to recalibrate targets that proved overly ambitious).

In many countries, the investment in establishing building codes and/or product standards becomes a significant driver of energy efficiency for decades. The non-residential building code status map, generated by the Building Codes Assistance Project (BCAP), shows that many countries have adopted some form of building codes and standards (Figure 3.13). The power of building targets can be seen in the European Union, where the Energy Performance of Buildings Directive (EPBD) was revised in 2010 with tougher requirements for buildings. Under the revisions, EU member states are required to ensure, by 2018, that all new buildings owned by public agencies will be nearly zero-energy buildings (ZEBs); the ZEB target will be extended to all new buildings by the end of 2020 (IEA, 2013b).

[12] In Germany in 2010, the KfW bank group invested USD 103 billion (EUR 1.37 billion) in building energy efficiency programmes, creating over 197 000 new jobs (KfW Bankengruppe, 2011). In British Columbia, Canada, the green building and energy efficiency sector is estimated to have contributed roughly USD 8.4 billion (3.9%) to the provincial GDP in 2011 (USD 5.5 billion direct and USD 2.9 billion indirect) (Natural Resources Canada, 2013), and to have stimulated 76 450 full-time equivalent (FTE) jobs (46 290 direct and 30 160 indirect) (Globe Advisors, 2012).

Figure 3.13 Non-residential building code status



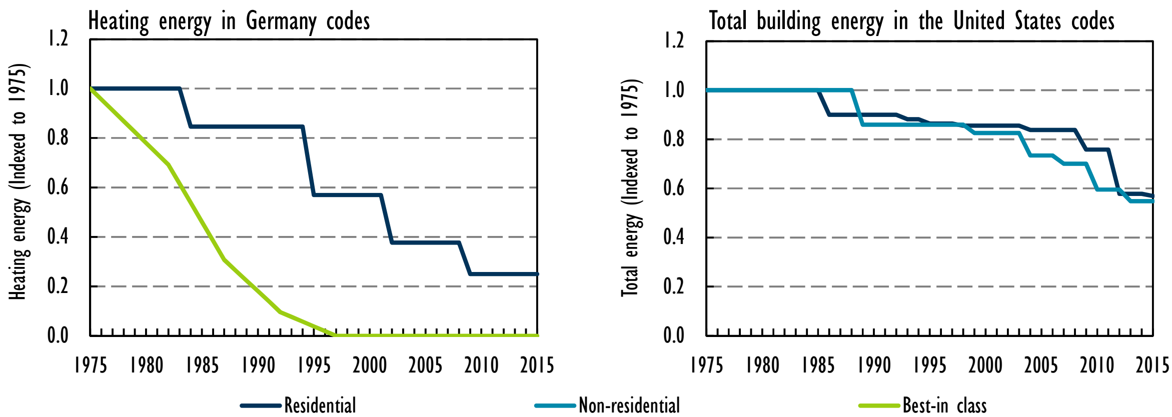
Source: BCAP (Building Codes Assistance Project) (2015), "Code Status: International Non-Residential", Online Code Environment and Advocacy Network website, Washington, available at http://energycodesocean.org/code-status-international-non-residential (accessed 27 June 2015).

The International Code Council (ICC) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recently undertook to develop a new generation of building energy codes that, if adopted and enforced, would achieve 30% energy savings while also providing positive 30-year life-cycle cost savings to consumers. In a 30-year perspective, residential consumers achieve increased value for their buildings from these new energy codes, ranging from USD 2 000 to USD 9 000 for the 2009 International Energy Conservation Code (IECC) and from USD 5 500 to USD 33 000 for the 2012 IECC, across the eight climate zones in the United States (US DoE, 2012). While the upfront investment cost is higher for each of the new, more stringent building energy codes, the payback is attractive in that the investment significantly drives down lifetime energy use and associated costs.

Recent improvements in building energy codes extend a longer term trend. The average energy impact of code-compliant buildings indexed to 1975, when the initial building energy codes were created during the energy crisis, shows steady progress towards greater efficiency. In fact, action in the building code arena means that residential buildings that are code-compliant in 2015 are 43% more energy efficient than comparable code-compliant buildings from 1975 through to the mid-1980s. For non-residential buildings, the efficiency gain is 45% (Figure 3.14).

Targeted policy actions have led to similar trends in countries throughout Europe. Germany, for example, shows a long-term trend of increased regulation and increased technical potential from technology R&D leading to reduced space heating energy use in building codes by 75% since 1975. In addition to code-compliant buildings being significantly more energy efficient, the "best-in-class" residential building line has continually improved ahead of the building standards (Figure 3.14). While this finding is limited to space heating (i.e. not total building energy use), it represents significant improvement in the largest energy end-use in many existing residential buildings.

Figure 3.14 The impact of codes on heating energy demand and total building energy demand (indexed to 1975)



Notes: The Germany best-in class curve shows research projects that introduced increased energy efficiency to the market.

Sources: Mendon, V., R. Lucas and S. Goel (2013), *Cost-Effectiveness Analysis of the 2009 and 2012 IECC Residential Provisions – Technical Support Document*, report prepared for the US DoE, Pacific Northwest National Laboratory, Richland, www.energycodes.gov/sites/default/files/documents/State_CostEffectiveness_TSD_Final.pdf (accessed 3 July 2015); US DoE (2008), *Energy Efficiency Trends in Residential and Commercial Buildings*, U.S. Department of Energy, Washington, http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/bt_stateindustry.pdf (accessed 3 July 2015); Fraunhofer Institute for Building Physics (2014), *What Makes an Efficiency House Plus?*, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), Berlin, www.ibp.fraunhofer.de/content/dam/ibp/en/documents/Areas-of-Expertise/heat-technology/2014-08_Broschuere_Wege-zum-Effizienzhaus-Plus_engl.pdf (accessed 17 August 2015).

Policy innovation for building energy efficiency

Governments at various levels (national, state or local) in many countries are implementing policies to support a range of strategic codes and standards in the buildings sector that enable greater energy efficiency. All of the following examples deliver some degree of improved efficiency when applied in isolation; many have a much higher impact when applied in combination.

Stipulated funding sources: The American Recovery and Reinvestment Act of 2009 (ARRA) in the United States introduced a national level approach to boost adoption of the 2009 IECC (or equivalent) building energy codes. The US DoE tied distribution of funding to states and local government agencies to their demonstrated intent to adopt and enforce the standards in support of national goals.

Density approval for efficiency improvement: Some jurisdictions have begun to link building approval processes to energy efficiency goals: developers that want to increase the density of buildings must meet the requirement to increase energy efficiency or green building standards.

Fast-track approval for efficiency improvement: In another approach to linking approval processes and energy efficiency goals, some jurisdictions will accelerate the paperwork process for developers that meet the requirement to increase energy efficiency or green building standards.

Building operational energy disclosure: In a move that both rewards participants and puts pressure on non-participants, some jurisdictions are launching programmes that require building operators to disclose the energy consumption of their assets. In European Union, for example, the Energy Performance Buildings Directive (EPBD) requires that public buildings display energy performance certificates that show actual energy use. This approach aims to increase both energy efficiency and information sharing about how goals can be achieved.

Building retrofit regulations: Current building energy codes often apply only to new construction and/or major retrofits. In recognition of the large amount of energy used by existing buildings, a recent trend focuses on opportunities to stimulate more activity in retrofits. In some cases, the new requirements are triggered by the sale or purchase of existing buildings. This is currently most commonly done through an energy performance certificate, which rates the current level of efficiency and requires either the seller or the buyer to commit to improving the ranking before the transaction is approved. Some jurisdictions have tried to develop enforceable code language for this approach, similar to existing building codes; such regulations are difficult to apply, but very important given the highly inefficient nature of the existing building stock.

Increased diagnostics/performance testing: Many of the newer building codes and standards require increased testing of buildings, stipulating that the testing must be carried out by third-party inspectors and/or local code inspectors.

Beyond code/standards guidelines: Guidelines that seek to achieve energy efficiency beyond what is stipulated in base code are increasingly common. They enable jurisdictions to write locally relevant regulations that aim to exceed the minimum requirements set out in base code. Often, this is carried out through energy efficiency programmes or financing mechanisms that adopt the language of the code or programme requirements. In Denmark, multiple future versions of regulations are developed and made publicly available; this helps the supply chain adopt increased energy efficiency and lead the market into "beyond base code" requirements in advance of more stringent requirements being legislated.

Technology drivers and emerging trends

A number of market drivers exist to stimulate technology innovation for energy efficiency and deployment of effective solutions, including investment in research, development and demonstration (RD&D) and in business development (e.g. technology demonstration to promote commercialisation and deployment through a well-developed supply chain).

Research, development and demonstration

Investment in RD&D often aims to meet new standard requirements as cost-effectively as possible for the manufacturer, or to help manufacturers go beyond new standards and influence even more energy-efficient future standards. Ultimately, the RD&D investment is a survival and growth investment for companies, which provides downstream benefits to consumers through improved products and increased energy efficiency.

Box 3.7 Product interventions continue to transform the cost-effectiveness of energy efficiency

Technology breakthroughs have fundamentally changed markets in many different sectors, with prime examples including the combustion engine (which enabled the industrial revolution), the computer (which enabled the digital revolution) and the internet (now enabling the information revolution).

Within the building energy efficiency industry, technology RD&D has led to product breakthroughs in many areas of the market. Low-emissivity (low-e) windows, for example, are much more efficient at allowing light to pass without accompanying heat gain – thus avoiding the additional layers of glass or dark window tinting that was common in buildings constructed in the 1980s – and have revolutionised the capabilities of the building envelope. Aerosol-based building and duct sealants are now enabling more cost-effective approaches for renovating existing buildings that have high air leakage; they address the leakage problem without the need for traditional air sealing, which is very labour-intensive and incurs high labour costs. LED lighting is also a market-changing breakthrough as highly efficient lighting is becoming more cost-effective.

These and many other examples of product type innovations have enabled higher energy efficiency than was possible before their invention, and will enable continued cost-effective investment in energy efficiency.

Getting products from research and development through to successful commercialisation is a substantial challenge. This stage in the product commercialisation cycle is where investment in demonstration is often key to ensuring that the best technologies become trusted by market players and also priced to achieve market penetration. In addition to the traditional product demonstration carried out by product manufacturers to gain market acceptance, governments can "invest" in this phase through “innovation procurement policies” (COWI, 2009). Examples of such policies include bulk purchase by government agencies of products that are technically viable, but not yet market viable due to high production costs at existing levels of market demand (Box 3.8). Governments can also support demonstration by enabling testing of the products under controlled, government-approved conditions.

Box 3.8 Building energy efficiency investment by a non-traditional investor

The US Department of Defense (US DoD), the largest single energy consumer in the United States, recently undertook to support energy efficiency innovation for buildings (among others). The Department's Environmental Security Technology Certification programme has facilitated demonstration of a range of energy technologies including cold climate heat pumps, advanced LED lighting, controls and sensors, thermal storage, building air sealing, auto-optimising HVAC systems, dynamic glazing and other new technologies (US DoD, 2015).[13]

Mass procurement programmes by large organisations or governments can expedite product adoption in a market and also underpin the scale-up needed to bring product pricing down for the mass market. Governments in many countries have adopted this type of programme, including South Africa and Mexico which have made mass purchases of energy-efficient products such CFL lighting, water heaters and refrigerators. In the European Union, Article 6 of the Energy Efficiency Directive requires public organisations to procure only energy-efficient products.

[13] Product subsidies are another government intervention that can expedite development of the supply chain for energy efficiency technologies. China, for example, recently invested USD 2 billion in energy-efficient home appliance subsidies, which led to high consumer uptake. In just one year (June 2012 to June 2013) the subsidy – in the form of cash rebates ranging from USD 16 to USD 64 per appliance purchased – stimulated consumer purchases of over 65 million energy-efficient home appliances, with total spending of USD 41 billion (IEA, 2015b).

Business models

An energy efficiency market requires a diverse supply chain that includes developers, designers, manufacturers, distributors, retailers, builders and ESCOs, and ultimately the consumer – who may interact with businesses across this matrix or only with those near the end of the supply chain. For many of these players, the concept and aims of energy efficiency requires adoption of new business models. Moreover, the relationships among these businesses often determines whether a given energy efficiency market is active or stagnant.

For consumers, the price of energy efficiency measures is a key factor in the decision to invest. Different aspects of the supply chain business influence the final cost seen by the consumer. For manufacturers, the size and scale of the operation – which determines pricing strategies – often dictate how cost-effective technologies and services are in the market. For distributors, relationships with manufacturers and retailers can enable product distribution at scale and can improve product pricing to the consumer. For the retailer, product advertising, placement and pricing help determine whether the consumers are able to perceive a value that will prompt them to purchase the energy-efficient products or services. Energy efficiency can also have positive synergies with renewable energy investments, allowing more efficient buildings to be powered more easily by renewable technologies independent of the grid (Box 3.9).

Box 3.9 Combining energy efficiency with renewables to support low-energy communities

Drake Landing is a community with 52 homes in Okotoks, Canada that combines energy efficiency and renewable energy to significantly reduce grid energy use. The community-scale system optimises diverse energy efficiency measures with solar energy, thermal storage, heat recovery and other technologies. Drake Landing is the first community in the world to have over 90% of residential space heating needs being met by solar thermal energy. It is also the largest subdivision of high energy efficiency (R-2000) single-family homes in Canada, with each home being 30% more efficient than standard, code-compliant homes (Drake Landing Solar Community, 2015). It is worth noting that Okotoks is located in Southern Alberta, where winters are long and temperatures can plummet to -40ºC.

ESCOs, builders and developers all have business models that rely on the manufacturer-to-retailer business relationship. The ESCO business model is as a one-stop shop for energy efficiency products and energy efficiency services that enable builders, developers, owners, operators and occupants of buildings to purchase energy efficiency. An ESCO might also offer single-point access to a full range of services from product sourcing to design, financing and installation. ESCOs often conduct business through energy performance contracts, thereby helping to minimise the out-of-pocket cost to the buyers of products and services. However, the focus on profit often creates market limitations for ESCOs. Some ESCOs seeking to limit their own financial risk target products and services that deliver a high profit margin or offer a quick payback on technologies. With ESCOs selecting only those measures that are cost-effective in the short term (i.e. would pay back in 2 to 4 years), many of the long-term measures needed to achieve the full potential of deep energy retrofits are omitted from standard ESCO contracts.

Box 3.10 A business model for mass deployment of deep energy retrofit

In the Netherlands, effort is underway to take deep energy retrofit of existing buildings from a craft trade to an industrialised model that enables mass deployment.

Energiesprong, is a Dutch government funded programme that has developed an approach by which it can complete onsite refurbishment of small single-family houses in just one day on site, or of very large multi-family residential buildings within ten days This has enabled large-scale retrofits in the Netherlands, leading to a project in which Energiesprong will refurbish 111 000 houses to net-zero energy levels (Energiesprong, 2015). This industrialised approach to delivering energy efficiency reduces risk for builders, financers and end-consumers. If this emerging business model proves cost-effective, its replication in other countries could address the issue of improving the existing residential building stock.

Financial models

Financial models play an important role in enabling increased market penetration of energy efficiency products or services, with different models fitting different purposes and contexts. For large-scale projects, large development banks often use their strong credit rating and ability access to money to assist markets that have lower credit ratings and limited access to money. The Energy Efficiency Guarantee Mechanism (EEGM), offered by Inter-American Development Bank (IDB), is an example of a programme that uses the IDB's high credit rating to bring finance to the energy efficiency market for buildings in Brazil (Atla Consultoria, 2015).

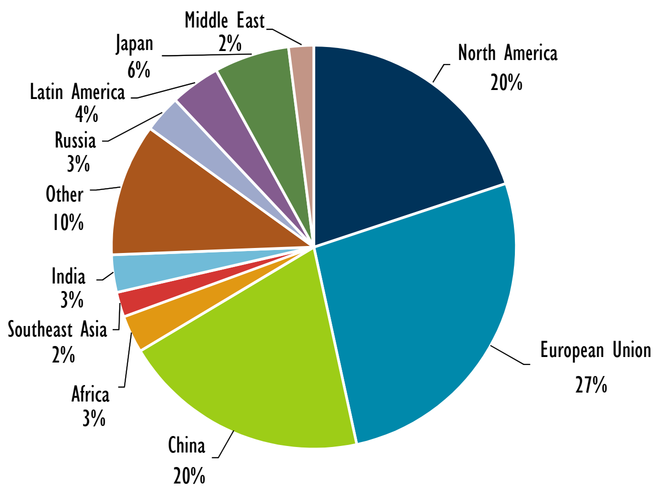
Cash-flow payments through utility bills or directly from energy savings are another financial model available. This approach may be delivered through mechanisms such as "on-bill" financing and energy performance contracting. On-bill financing allows consumers to directly access funding available from utilities or governments to complete building energy efficiency improvements, with the repayment added to their regular monthly billing. Energy performance contracting allows consumers to access financing and services from a business that makes its profit from selling energy efficiency goods and services, often by taking a "cut" of the energy savings realised. It is typically delivered through ESCOs.

Prospects for energy efficiency in buildings

The market for energy efficiency in buildings is anticipated to grow, driven by diverse factors including government policies targeting energy consumption (e.g. in the European Union) and the recently announced INDCs, some of which contain specific actions regarding energy efficiency in buildings. Japan, for example, lists "Energy efficiency and conservation in (sic) buildings (remodelling)" and "promotion of compliance with energy savings standards for newly constructed buildings" as two activities. Recent trends in the world's two largest economies, the United States and China, show continued government and industry support for increasing buildings energy efficiency investment. Projections based on recent trends point to a global market that would expand from the current USD 80 to USD 100 billion of investment in 2014 to USD 125 to USD 150 billion in 2020. By comparison, the IEA 2DS projects a funding requirement of USD 215 billion by this time (excluding appliances), suggesting actual investment shortfall of almost 50% unless current growth rates for energy efficiency investments are ramped up considerably.

Looking beyond to 2035, the IEA estimates, based on current policies and expected market activity, that a large portion of the overall energy efficiency investment over the 2014-35 period would occur in the European Union (27%), North America (20%) and China (20%). In each case, the projected share of energy efficiency investment is larger than the current share of energy consumption represented by the country or region. This is also true for Japan's estimated investment of 6% of global buildings energy efficiency investment compared with 4% of global building energy use (Figure 3.15).

Figure 3.15 Projected global building energy efficiency investment shares by region, 2014-35



Source: IEA (2014b), *Special Report: World Energy Investment Outlook*, OECD/IEA, Paris, www.iea.org/publications/freepublications/publication/WEIO2014.pdf (accessed 29 June 2015).

Conclusions: Medium-term prospects for efficiency markets in buildings sector

Clearly, trends in recent years show significant growth across all stages of the building energy efficiency investment cycle. Still, substantially more investment is needed globally to realise the potential for energy efficiency in the buildings sector – and, of note, for buildings to meet their role in achieving the 2DS target mapped out by the IEA. The market for energy efficiency in existing buildings represents huge untapped potential and warrants specific attention. This requires an efficient investment chain, which is developing but needs to be strengthened.

The global investment in energy efficiency for buildings is estimated using multiple methods, including extrapolation of bottom-up data and with top-down calculations. This analysis estimates the current global market for energy efficiency investment in buildings to be USD 90 billion (+/- 10%) annually. Following on significant growth over the past five years, and reflecting current policies and market trends, the market for energy efficiency in buildings is expected to expand substantially in the next five years. If current trends continue, by 2020, energy efficiency investment in buildings would be over USD 125 billion.

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4. ENERGY EFFICIENCY IN THE ELECTRICITY SYSTEM AND THE OUTLOOK FOR UTILITY EFFICIENCY INVESTMENTS

Summary

- **Energy efficiency investments have successfully slowed growth in electricity demand in countries belonging to the Organisation for Economic Co-operation and Development (OECD).** Energy efficiency improvements since 1990 drove savings of 2 200 terawatt hours (TWh) in 2014 in International Energy Agency (IEA) member countries, equalling about 24% of total electricity demand. Growth in electricity consumption has flattened across OECD countries, from a peak of 9 385 TWh in 2007 to 9 355 TWh in 2013. Total electricity demand in the OECD is projected to increase by an average of 0.8% per year through 2020.

- **Efficiency improvements in appliance energy performance across OECD countries since 1990 saved a total of 430 TWh in 2014**, about 25% of total energy efficiency savings and helped to flatten demand, despite a 130% increase in the appliance stock to 3.2 billion units.

- **In addition to delivering electricity, utilities are important players in energy efficiency markets, spending over USD 13 billion in 2013 on end-use energy efficiency improvements.** End-use investments are often driven by policy mandates. Utilities also invest in generation, transmission and distribution (T&D), and metering infrastructure that improves efficiency and reliability of the electricity grid.

- **Lower electricity demand growth challenges the traditional utility business model, which is based on revenue from electricity sales.** Governments and utilities are examining new policy and business models that will help sustain investments while also keeping on track with bigger, longer term climate change and energy demand challenges. Electricity utilities in several markets are increasingly turning to opportunities in energy efficiency and energy services provision.

- **In non-OECD regions, electricity demand is still increasing; utilities in these regions have opportunities to generate value from energy efficiency investment at both the supply-side and end-use levels.** As urbanisation increases, incomes rise and more people gain access to electricity, electricity demand for specific end-uses is expected to rise dramatically, putting additional strain on already overloaded electricity systems. Investments to improve T&D infrastructure to reduce losses (particularly technical ones) will enable more reliable supply to more customers. Utilities are increasingly aware of how investments in end-use efficiency can support development goals and reduce the cost of expanding electricity access.

Introduction

Energy efficiency investments have had, and are projected to continue to have, a marked impact on electricity consumption in many countries around the world. The form of the impacts and their effects differ from country to country, based on factors such as economic development, structure of the economy and overall access to electricity.

In OECD countries, energy efficiency investments in industrial production, large appliances, lighting, heating and cooling equipment, building thermal envelopes and building energy control devices are reducing the amount of electricity needed to satisfy energy service demand for manufacturing, cooking and cleaning, lighting, heating and cooling, media entertainment, etc. While improving energy efficiency is a positive outcome, increased efficiency has weakened the growth outlook for electricity consumption in the OECD challenging some incumbent electricity market actors. This trend is expected to continue over the next five to ten years.

A key set of actors within the electricity-related energy efficiency market is electricity providers or utilities, which include integrated generators, transmission companies, distributors, wholesalers and retailers. Often spurred by policy mandates, these companies pursue energy efficiency investments to meet their own business needs (e.g. supply-side investments) and also encourage and even finance end-use energy efficiency expenditures by their consumers.

This chapter assesses the ways in which energy efficiency investments in OECD countries have slowed the historical growth in electricity consumption and thus present new challenges to electricity utilities. With lower income from electricity sales, many utilities are looking to diversify their revenue streams to areas beyond electricity generation and delivery – often by providing energy efficiency services.

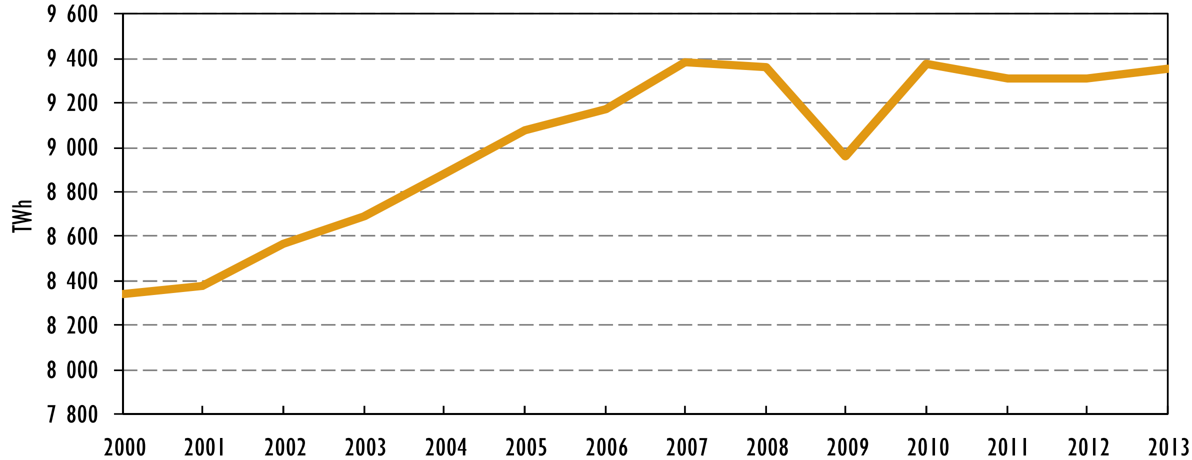
The situation for electricity demand and efficiency investment in non-OECD countries is quite different. Electricity consumption in non-OECD countries more than doubled between 2002 and 2012 to 9 623 TWh and exceeded electricity consumption in the OECD for the first time in 2012. This rapid growth is straining the reliability of electricity systems, to the point of impeding economic development. Governments across many non-OECD countries are looking to energy efficiency investments to serve a variety of objectives, most importantly to ensure system reliability (that the "lights stay on") as their economies continue to grow at a rapid rates.

Energy efficiency is flattening electricity consumption in the OECD

Growth in electricity consumption has stagnated across the OECD over the past decade. After peaking in 2007 at 9 385 TWh, the global recession – which hit OECD countries particularly hard – instigated a 4% decline in consumption between 2008 and 2009. Electricity consumption rebounded in 2010, then essentially flattened between 2010 and 2013 (Figure 4.1), even as gross domestic product (GDP) grew 4% higher than 2007 levels.

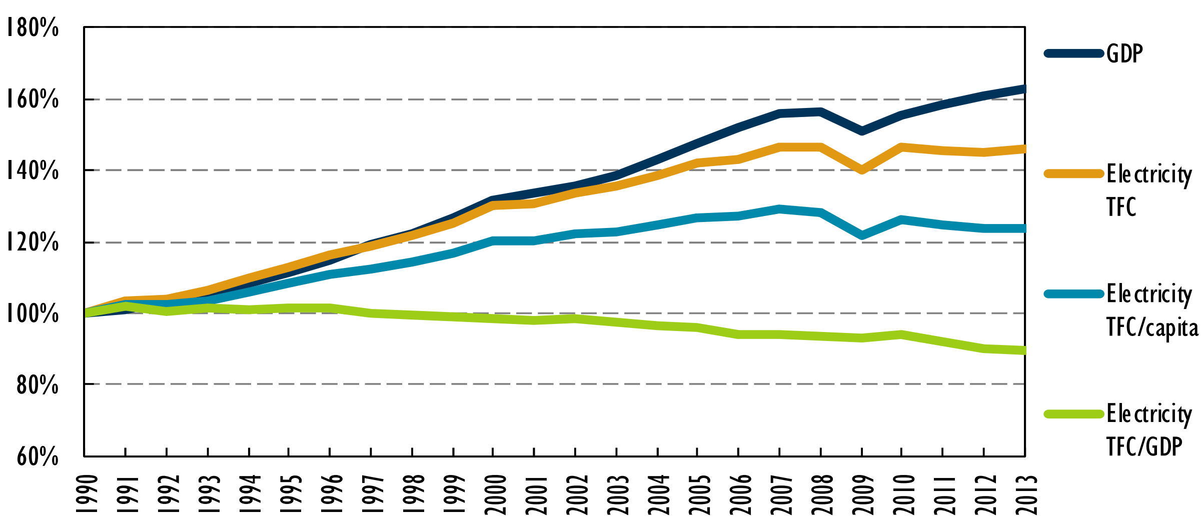
The traditional, parallel relationship between electricity consumption and GDP in the OECD diverged after 2000. Between 1990 and 2000, electricity consumption and economic growth in the OECD increased in lock-step, with no material change in the electricity intensity of GDP (the amount of electricity required to produce a unit of GDP) (Figure 4.2). The electricity intensity of economic output began to decline noticeably between 2000 and 2007, at an average rate of 0.7% per year. This weakened relationship pre-dated the shock of the recession in 2008. Even though GDP in the OECD reached a high in 2013, absolute electricity consumption was down since 2010. Electricity consumption per capita grew between 2000 and 2007, though at a slower average rate than in the preceding decade. Between 1990 and 2000, growth in electricity consumption per capita was 1.9% per year; between 2000 and 2007, it was almost halved to just 1.0% per year. Since 2008, it has declined by 0.9% per year. Trends within some countries belonging to the IEA are also worth noting (Box 4.1).

Figure 4.1 Electricity consumption in the OECD 2000-13



Source: IEA (2013a), "Energy balances", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 May 2015).

Figure 4.2 Index of key indicators related to electricity consumption for OECD countries



Source: IEA (2013a), "Energy balances", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 May 2015).

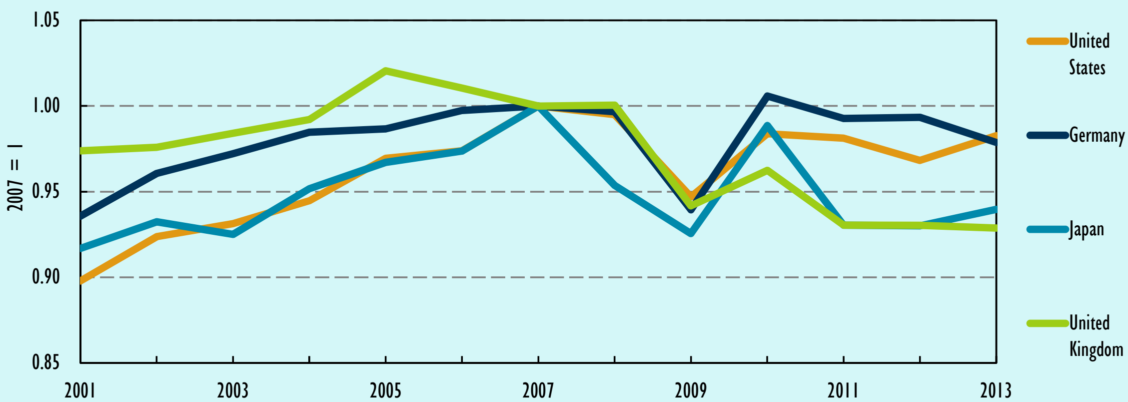
Box 4.1 Spotlight on electricity consumption in individual OECD countries

In four IEA countries – Germany, Japan, the United Kingdom and the United States – indexing of electricity consumption prior to and after the OECD peak in 2007 illustrates the slowing trend in slightly different time frames and to different degrees (Figure 4.3). What is common to all four countries is that electricity consumption in 2013 is lower than in 2007.

Box 4.1 Spotlight on electricity consumption in individual OECD countries (continued)

The United Kingdom saw consumption peak before 2007, then decline quickly after the recession such that consumption is lower in 2013 than it was in 2001. German electricity consumption has declined to 2004 levels. Even though the United States experienced the strongest post-recession economic recovery, electricity demand has remained 2% to 3% lower than 2007 levels each year since 2010. Japan was impacted by both the recession and the 2011 earthquake and nuclear shutdown, explaining why it had the strongest reduction in electricity consumption since 2007. Still, Japanese electricity demand was down significantly in 2008, pre-dating of the acute effects of the recession in 2009.

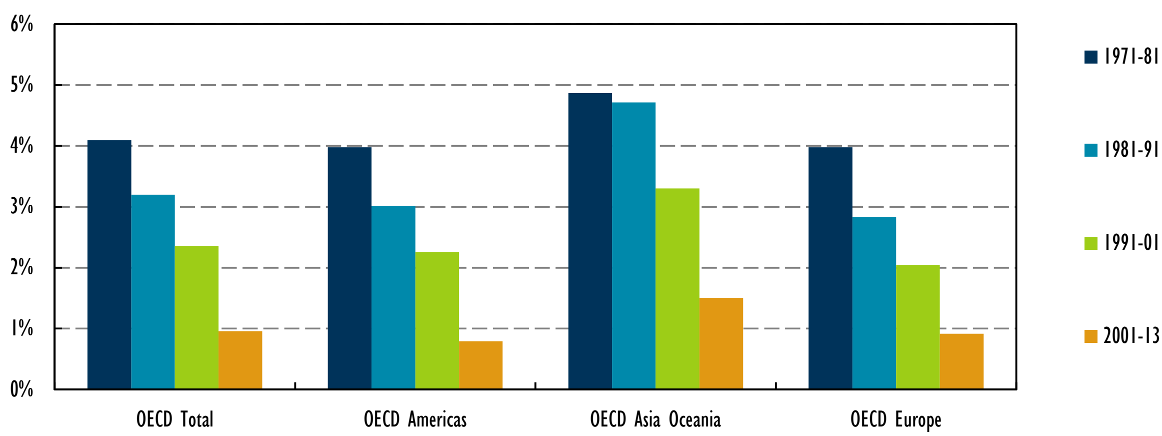
Figure 4.3 Electricity consumption in four OECD countries, before and after the 2007 OECD peak



Source: IEA (2013a), "Energy balances", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 May 2015).

Since the 1970s, growth in electricity consumption in each decade has been slower than in the preceding decade (Figure 4.4). The slowing growth (or absolute decline in some countries) in electricity consumption is, in fact, part of a 40-year average trend.

Figure 4.4 Average annual growth in electricity consumption by OECD region

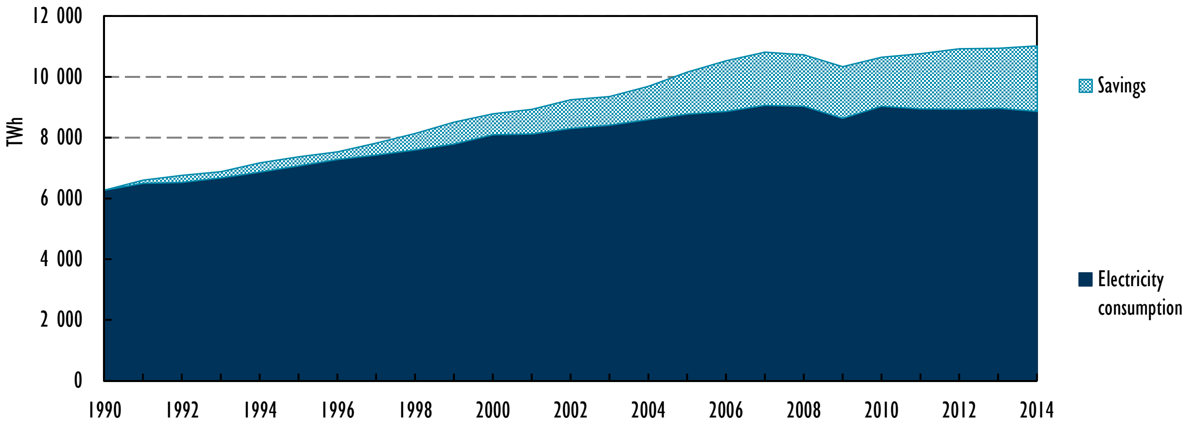


Source: IEA (2013a), "Energy balances", *Energy Projections for IEA Countries* (database), available at http://dx.doi.org/10.1787/data-00473-en (accessed 1 May 2015).

Energy efficiency's role in reducing the growth of electricity demand

Decomposition analysis carried out the by the IEA (covered in Chapters 1 and 2) provides insight into how efforts to improve energy efficiency and decrease energy intensity are helping to reduce electricity consumption. Assuming that the no energy efficiency improvements had been made since 1990, total final consumption (TFC) of electricity would have been 2 200 TWh higher overall – i.e. 24% above the actual consumption (Figure 4.5). Between 2010 and 2014, electricity consumption would have grown by 3% without energy efficiency improvements; instead, it declined by 2%. Energy efficiency improvements deliver ongoing and cumulative benefits which, when taken together, are much larger their annual incremental impact. Over years or decades, these improvements chip away at total energy demand until they fundamentally alter the outlook for future consumption growth.

Figure 4.5 Hypothetical savings in electricity consumption from energy efficiency improvements in IEA countries, 1990-2014



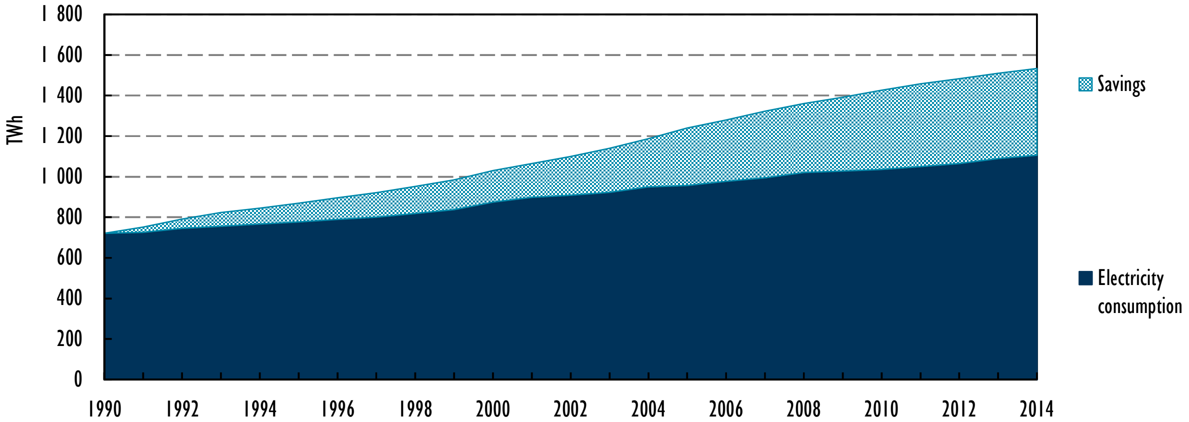
Appliance efficiency improvements have been central to reducing electricity consumption

The last several decades have seen a marked increase in the numbers of major appliances[1] being used in households in the OECD, with the total stock having grown by 130% between 1990 and 2014. At the same time, major appliance energy efficiency improvements have had a major impact in electricity consumption patterns in the residential sector. The improved efficiency stems from a combination of technological improvements, government-mandated efficiency standards and adoption programmes, and normal stock turnover and investment by consumers.

Had there been no efficiency gains over the past 25 years, electricity consumption by major appliances would have been 39% higher in 2014, given the increase in stock. The avoided electricity consumption from major appliances efficiency improvements since 1990 was 430 TWh in 2014 (Figure 4.6) or 5% of total electricity consumption in IEA countries.

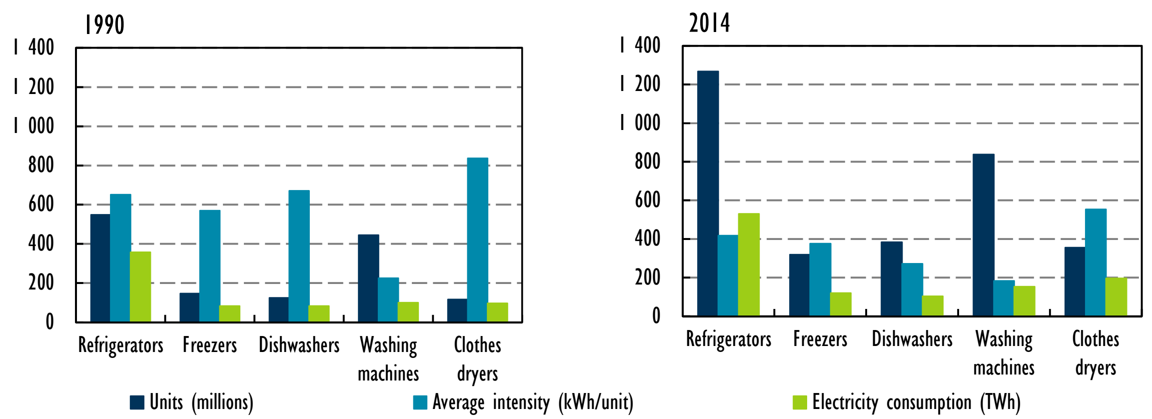
[1] Major appliances include refrigerators, freezers, dishwashers, clothes washers and clothes dryers.

Figure 4.6 Electricity consumption of major appliances and savings from appliance efficiency improvements in IEA countries



The important role of energy efficiency improvements to offset the OECD increase in appliance stock is well illustrated by dishwashers. The stock of dishwashers increased by 208% between 1990 and 2014, from approximately 120 million units to 380 million, but the related total electricity consumption increased by only 25%. This decoupling of stock increases and electricity consumption was facilitated by a 59% improvement in the average energy efficiency of the dishwasher stock. Other major appliances types have followed similar patterns over the same period (Figure 4.7).

Figure 4.7 Stock size, energy intensity and energy consumption of major appliances in the OECD



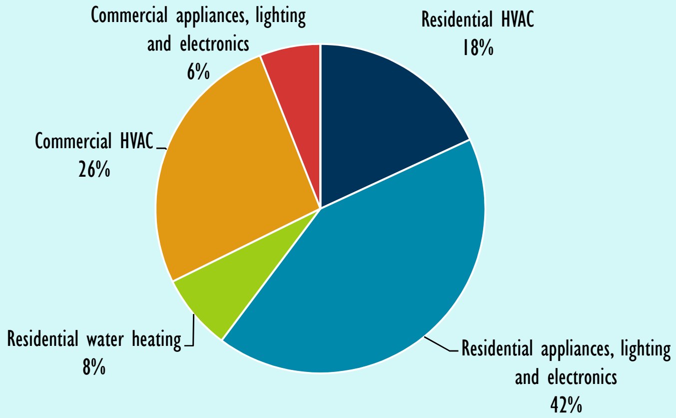
The largest energy savings from appliance efficiency improvements in the IEA have been achieved in refrigerators, which were one of the earliest appliance-types targeted for efficiency standards. In the United States, refrigerators have been subject to increasingly stringent state-level and national standards since 1972, which had an important role in reducing refrigerator unit energy consumption across the OECD. While the stock of refrigerators has increased by 131% since 1990, refrigerator energy use in the OECD has increased by only 48%, driven by a 36% average efficiency improvement of the stock. Had the energy efficiency remained at 1990 levels, refrigerator energy use would have been 31% or 168 TWh higher (equivalent to over half of Italy's total electricity consumption). Updated efficiency standards in 2014, such as those in the United States, are expected to drive a further 25% efficiency improvement.

Box 4.2 Appliance standards achieving electricity savings

Minimum energy performance standards (MEPS) for appliances, used since the 1970s to improve the energy efficiency of appliances, are being more widely adopted by policy makers (CLASP, 2014). More than 3 600 standards had been implemented in 81 countries in 2013 (up from 50 countries in 2004), across 55 product types with the most commonly regulated products being refrigerators, air conditioners and lamps (EES/Maia Consulting, 2014). This represents a threefold increase during the decade beginning 2004. The United States and the European Union lead in terms of the number of standards and the relative ambition levels.

Efficiency standards announced in different countries for all end-use devices (i.e. all commercial and residential electrically-powered equipment) are expected to save an additional 238 TWh of electricity consumption by 2025 in the OECD (approximately the current total electricity consumption of Mexico). Most of these savings (42%) are made through standards for residential appliances, lighting and electronics (Figure 4.8). Together, energy savings from standards across the residential and commercial sectors make up 8% of total final energy savings from energy efficiency improvements by 2025 in the IEA 6 Degree Scenario.[2]

Figure 4.8 Share of projected energy savings in 2025, by sector and technology category, from announced efficiency standards in the OECD



Source: IEA (2015), "Tracking Clean Energy Progress 2015", *Energy Technology Perspectives 2015*, excerpt: IEA Input to the Clean Energy Ministerial, OECD/IEA, Paris, www.iea.org/publications/freepublications/publication/Tracking_Clean_Energy_Progress_2015.pdf (accessed 9 August 2015).

In the coming years, the relative importance of standards will shift to products not previously subjected to efficiency targets. Increasingly ambitious standards to reduce the energy consumption of major appliances, along with the fact that ownership levels in most OECD countries are saturated, leaves less (but still significant) opportunity for further gain. Small appliances, TVs and other electronics (such as information and computing technologies [ICTs]) show the largest potential savings from energy efficiency standards in the next five years. Of the regulated products in the EU Ecodesign Directive, improved efficiency in lighting, electronics and small appliances (such as air conditions and fans) delivers 61% of the projected electricity savings by 2020 while further application of standards on major appliances (refrigerators, dishwashers and washing machines) deliver only 3% (Molenbroek, Cuijpers and Blok, 2012).

[2] The 6 Degree Scenario (6DS) is largely an extension of current trends. By 2050, energy use almost doubles (compared with 2009) and total greenhouse gas (GHG) emissions rise even more. In the absence of efforts to stabilise atmospheric concentrations of GHGs, average global temperature rise is projected to be at least 6°C in the long term. The 6DS is broadly consistent with the World Energy Outlook Current Policy Scenario through 2035.

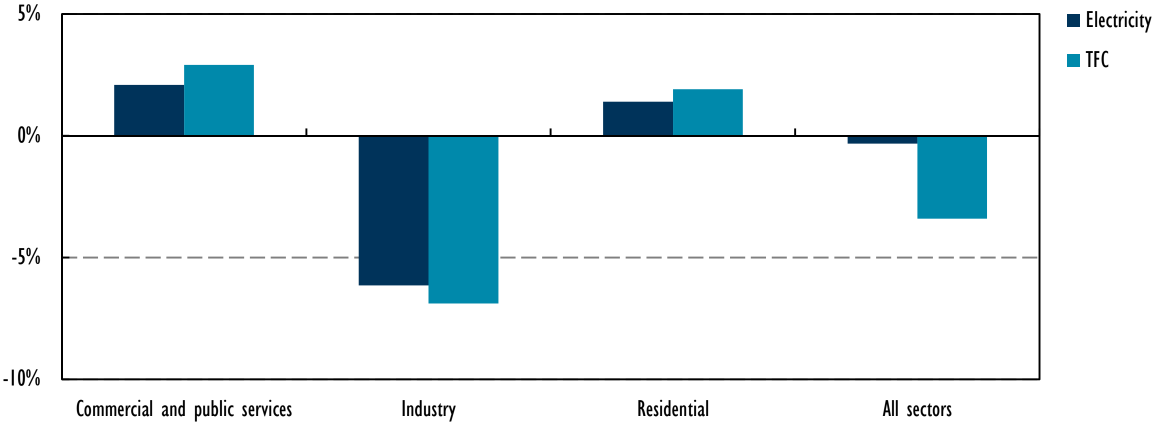
Electricity consumption and efficiency trends by sector

Electricity consumption in the **residential** sector has not declined, despite the improvement in appliance efficiency, largely because increased appliance adoption and use, particularly of small devices (which often are not yet subject to MEPS), has countered the energy efficiency gains of major appliances. Since 1990, electricity use for these devices (computers, personal electronics, TVs and other electronic devices) has increased 92% in IEA countries. The share of small device electricity consumption grew from 29% in 1990 to 37% in 2011. Growth in use of these devices is a key driver for anticipated future growth of electricity demand in the residential sector.

Improved efficiency in lighting over the past two decades has also reduced the growth in electricity consumption. Higher efficiency light bulbs and spaces designed to use more natural light are the main reasons for this dampening impact. Between 1990 and 2001, the floor area of homes in countries represented in the IEA Energy Efficiency Indicators database increased by 20%; yet electricity demand for lighting has increased by only 4%. Had lighting efficiency not improved, energy use for lighting would have been 20% higher in 2012, adding 2% to total residential electricity consumption.[3]

Overall energy consumption in the **industry** sector has declined in absolute terms since 2007, and is the main driver of the decline in electricity demand between 2007 and 2009 – and of the stagnation since 2010. Industrial electricity consumption declined by 6% or 194 TWh between 2007 and 2013, while consumption increased in commercial and public services (2% or 60 TWh), and in the residential sector (1% or 40 TWh) (Figure 4.9).

Figure 4.9 Change in TFC and electricity consumption in the OECD, 2007-13



Industrial energy intensity has improved by 6.4% since 2007 in the OECD. The recession had the effect of lowering overall production and corresponding energy consumption; in fact, industrial production in 2013 was still 2.4% below 2007 levels, explaining some of the absolute decline in electricity consumption. Over the same period, intensity improvements served to further cut energy demand, with the 6.4% improvement outpacing the 2.4% decline resulting from lower production.

[3] End-use data on lighting energy use in the services sector is not detailed enough to do this calculation, but lighting improvements in commercial spaces could have even larger energy savings.

Electricity consumption in IEA countries was an estimated 723 TWh lower in 2014 as a result of improvements in industrial energy efficiency and energy intensity since 1990.[4] Some of the key policy measures that reduced electricity consumption in industry are MEPS for electric motors. Globally, electric motors account for 69% of total industrial electricity consumption (IEA, 2011). Efforts to improve standards and promote motor replacement have been taken across most of the OECD, including updated standards adopted in 2013 that are expected to deliver energy savings of 135 TWh/yr in the European Union by 2020 (i.e. 10% of industrial electricity consumption in 2013) (ECEEE, 2014). Other major non-OECD countries, such as Brazil, the People's Republic of China ("China"), India and the Russian Federation ("Russia"), have also begun to adopt MEPS for electric motors.

Energy utilities as major investors in energy efficiency

Electricity utilities have been important players in improving electricity efficiency, largely through efficiency programmes for their own operations and through financing and investment in end-use energy efficiency. Although this may seem counter-intuitive at first glance, considering their traditional role as providers of uninterruptible and reliable power and an underlying business model that relies on sales volumes, utilities have become active players in energy efficiency markets in many jurisdictions – often as a result of direct mandates. In many cases, they channel the largest portions of energy efficiency financing.

Utilities have historically acted in response to incentives built into the policy frameworks designed by energy system regulators, which determine how electricity markets operate. Regulators are actively re-shaping the energy market by using policy to expand the opportunities and incentives for utilities to become active in providing energy efficiency services in addition to their ongoing role of supplying electricity. Utilities have responded by financing customer (i.e. end-use) energy efficiency investments, including the purchase of appliances and other consumer goods.

Utility investment in end-use energy efficiency can take many forms, but the most common is providing advice and assistance to their customers. For residential customers, the engagement typically aims to incentivise the uptake of efficient appliances and other home energy efficiency improvements. In the case of larger commercial and industrial clients, utilities may provide financial incentives to accelerate adoption of more efficient appliances and equipment and direct installations of efficiency equipment and management systems.

Available data and information show that electricity utilities in North America, the European Union, Australia and Brazil together invested over USD 13 billion in energy efficiency investments in 2013. In the United States, an evaluation of how efficiency influenced total electricity demand shows that improvements arising from utility efficiency investment and equipment efficiency standards between 1993 and 2012 made the largest contributions to the decline in electricity demand between 2007 and 2012 (Nadel and Young, 2014).

[4] Energy intensity in industry can change without focused action or investments in energy efficiency, particularly if economic conditions change. For example, a change in prices for production inputs or in market prices for outputs could affect the value of goods produced, and thus change the energy intensity. For more discussion of industrial energy intensity change see Chapter 2.

Energy efficiency investment mandates in different OECD countries

Utility energy efficiency efforts differ across countries and regions, responding to the policy and market structures in their specific jurisdictions, and regulators can adopt a number of options to stimulate utility investment in energy efficiency (Box 4.3). A quick summary of examples from Korea, the United States, the European Union and Canada offers a sense of the range of options and their effectiveness in a given context.

Box 4.3 Policy and regulatory approaches to incentivise energy efficiency investment by electricity providers

- **Revenue decoupling** aims to break the link between revenues and sales volume by changing the relationship between sales volume and profits, counterbalancing the risk that reducing sales volumes through energy efficiency will lead to reduced profit margins for regulated utilities (Table 4.3). Revenue decoupling helps to limit the disincentive of improving energy efficiency by reducing the degree to which regulated utility revenues depend on sales volume.
- **Rate design** is the practice of setting electricity rates to create better incentives for energy consumers to improve energy efficiency. Greater consumer demand for energy efficiency can increase the market opportunity for utilities (or other energy services companies) to invest in efficiency. One approach is attribute-based electricity pricing; under this model, prices recognise how ratepayers are consuming or producing various attributes that are desirable in the system. Electricity prices generally reflect the costs of generation and distribution. Thus, if consumers make energy efficiency investments that reduce congestion in the distribution system or reduce peak capacity, it creates value for the system operator. In turn, the operator compensates the consumer's investment through rate savings.
- **Energy efficiency obligation (EEO) schemes** require electricity providers to meet energy savings targets through a schedule of approved efficiency actions, typically at the end-user level. Such schemes are generally used in deregulated markets (e.g. the European Union and Australia), but have also been implemented as energy efficiency resource standards in 24 US states.
- **Performance incentives** provide a payment or rate adjustment for utilities that invest in energy efficiency and achieve greater energy savings targets. This practice of offering financial benefits to utilities can be integrated into other approaches.
- **Capacity markets** can incorporate energy efficiency as a supply resource, with utilities and other energy service companies pricing this avoided energy consumption in relation to how other generation resources contribute to energy supply and peak capacity.
- **Integrated resource planning** is a process by which the regulator can oblige generators and system operators to build in efficiency improvements as a resource type into their forward-looking system planning. In regulated utility markets, such planning often has to be approved by a public regulator. Integrated resource planning effectively demonstrates how efficiency will factor into future energy development scenarios, and how it compares to other resource acquisition plans on a cost-benefit basis.

Sources: Barbose, G.L. et al. (2013), The Future of Utility Customer-Funded Energy Efficiency Programs in the United States: Projected Spending and Savings to 2025, Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, http://emp.lbl.gov/sites/all/files/lbnl-5803e.pdf (accessed 4 July 2015); RAP (Regulatory Assistance Project) (2012), Best Practices in Designing and Implementing Energy Efficiency Obligation Schemes, International Energy Agency Demand Side Management (IEA DSM), Stockholm, www.ieadsm.org/Files/AdminUpload/(1)RAP_IEADSM%20Best%20Practices%20in%20Designing%20and%20Implementing%20Energy%20Efficiency%20Obligation%20Schemes%202012%20June(6).pdf (accessed 6 July 2015); Glick, D., M. Lehrman and O. Smith (2014), Rate Design for the Distribution Edge: Electricity Pricing for a Distributed Resource Future, Rocky Mountain Institute, Boulder, available at www.rmi.org/elab_rate_design (accessed 8 August 2015).

In Korea, utility energy efficiency investment has been stimulated by the *Rational Energy Utilization Act*. Investment for electricity energy efficiency comprised 30% of total utility spending for demand-side management.[5] The government is focused on creating markets for energy-efficient lighting, electric motors, heat pumps and automatic building control devices. To qualify, energy-efficient products must meet the high efficiency criteria described in the government's certification guidelines. The electric utility uses a subsidy per kilowatt hour saved to support energy consumer investments in eligible energy efficiency goods and services. The amount of the subsidy is determined by valuing the cost of avoided electricity.

In the United States, state-specific policies promote end-use efficiency investment by utilities. In addition, half of the states require that utilities meet specific energy saving targets in relation to annual sales, typically ranging from less than 1% of sales to more than 2% (Gilleo, 2014). Some other states obligate utilities to invest a percentage of revenue into energy efficiency. Various US states have employed other approaches such as ensuring that energy efficiency is considered a supply option in the resource planning process and providing incentives for energy efficiency savings in forward capacity markets.

In the European Union, energy efficiency investment by utilities is, in some cases, required in order to meet the policy savings target under the EU Energy Efficiency Directive, with parties (usually energy retailers, wholesalers and/or generators) obligated to deliver efficiency savings. Compliance targets are allocated to utilities, which can comply directly or can achieve compliance through a market where utilities can "trade" compliance obligations with other firms. Utilities can also finance and outsource compliance to other market sectors (such as energy services companies [ESCOs]) in accordance with a defined schedule of eligible efficiency improvements. Not all European countries opt to use utilities as the primary mechanism of energy efficiency improvement; some prefer to augment mandatory EU efficiency standards, such as the directives for eco-design, energy labelling and energy performance of buildings.[6]

In Canada, where many utilities are publicly-owned monopolies, energy efficiency programmes are often part of standards and targets for energy efficiency savings or are established as elements of government policy objectives. In some cases, the necessary programme spending is mobilised through public corporations. In provinces with more liberalised electricity markets, energy efficiency obligations and resource standards are also being used.

Energy savings from utility efficiency schemes

Energy efficiency programmes run by electricity providers, taken together, involved annualised investments totalling approximately USD 13 billion and generating annual electricity savings of 50 TWh in 2013 (Table 4.1). Given the long-term impact of the activities, such as the installation of insulation that provides benefits over multiple years, many energy efficiency investment programmes generate lifetime savings that are substantially larger than annual incremental savings (Box 4.4).

[5] Demand-side management aims to lower the cost of servicing peak demand by promoting reduced consumption (demand-side) rather than increasing generation (supply-side). Demand-side spending is investment the utility makes to boost efficiency and initiate demand response efforts.

[6] Germany, for example, uses a range of mechanisms to stimulate energy efficiency investment without relying on electricity providers, including energy efficiency standards on appliances and buildings, energy performance contracting, information sharing networks and voluntary agreements.

Table 4.1 Energy savings and spending from selected energy efficiency programmes delivered by energy providers or through obligation schemes

	Programme type	Year or period[1]	Delivered by[2]	Energy savings (GWh) [adjusted annual][3]	Programme costs[4] (USD millions/yr)	Cost per energy saved (USD/kWh)
United States	Total activity[5]	2014	Regulated electricity utilities	24 042 [same]	6 000	
Canada	Total activity	2014	Regulated and public utilities	2 016 [same]	700	
United Kingdom	Energy company obligation	2013-14	Retail energy suppliers	2 100 [same]	1 186	
France	Energy savings certificate	2006-11	Retail and wholesale energy suppliers	31 900 [6 380]	2 503	0.075
Italy	White certificate scheme	2005-12	Electricity and natural gas distributors	34 798 [4 971]	2 214	0.013
Flanders - Belgium	Rational use of energy obligation scheme	2003-11	Electricity distributors	2 709 [338]	102 (in 2011)	0.038 (in 2008)
Denmark	Energy savings agreement	2013	Electricity, gas and district heat distributors	2 300 [same]		0.052
Korea	Energy efficiency investment	2014	Korea Energy Management Corporation	538 [same]	104	0.05
Brazil	Energy efficiency programme	2013		544 [same]	142	0.26*

Notes: Values in this table are not directly comparable. For each programme, the savings, programme costs and cost per unit saved have different definitions and methodologies for calculation. The figures are collated from several different sources. The aim is to provide insight into the probable magnitude of investments and savings from energy provider programmes to improve energy efficiency.

[1] Results are reported either in annual increments or over the length of the programme, depending on the resolution of the programme's existing reporting framework.

[2] "Delivered by" refers to the parties that are obligated to achieve energy savings. Depending on the programme, the agencies or firms that are obligated to achieve savings can outsource savings to other agents (such as ESCOs) and then purchase those savings in the form of certificates. This approach is more often found in Europe.

[3] Adjusted annual savings divides reported savings over the programme period by the number of years in the period. This is an approximation of energy savings in the most current year of the programme.

[4] Programme costs can be accounted for in many different ways, depending on the programme objectives and requirements of regulators. Programme costs attempt to represent the amount of investment and administrative costs to deliver energy efficiency improvements by the agencies and firms delivering on the programme objectives. The programme costs are not calculated by the IEA but reported from the sources below. All values are converted to USD, using market exchange rates for the end of the period.

[5] "Total activity" refers to all programmes and efforts conducted by electricity utilities in the selected jurisdiction. This includes funding for energy efficiency and demand-response programmes. Demand response includes efforts to reduce consumption at peak times.

* Energy savings costs in Brazil are higher than other programmes because they focus on low-income households.

Sources: CEE (2015), *2014 State of the Efficiency Program Industry*, Consortium for Energy Efficiency, Boston, http://library.cee1.org/sites/default/files/library/12193/CEE_2014_Annual_Industry_Report.pdf (accessed 4 July 2015); ENSPOL (2015), *Energy Saving Policies and Energy Efficiency Obligation Scheme: D2.1.1: Report on existing and planned EEOs in the EU – Part 1: Evaluation of existing schemes*, Energy Saving Policies and Energy Efficiency Obligation Schemes, Groningen, http://enspol.eu/sites/default/files/results/D2.1.1 Report on existing and planned EEOs in the EU - Part I Evaluation of existing schemes.pdf (accessed 6 July 2015).

Box 4.4 Incremental and cumulative energy savings from utility energy efficiency programmes

End-use efficiency schemes run by utilities typically invest in measures such as cavity wall insulation and efficient appliance replacement. As such measures can save energy over decades, focusing solely on annual incremental savings overlooks how energy efficiency investments produce larger energy savings over time.

France, for example, estimates both the annual incremental and the cumulative and actualised[7] savings from its Energy Savings Certificates scheme.[8] Between July 2006 and December 2011, the annual incremental energy savings of the scheme were 31.9 TWh. In comparison, the cumulative and actualised savings over the measures' lifetimes are projected to be 226.5 TWh (Table 4.2) (ENSPOL, 2015).

The incremental annual electricity savings from utility energy efficiency programmes in the United States was 24 TWh between 2013 and 2014 (CEE, 2015), whereas total savings in 2013 from measures installed in 2013 and preceding years was estimated to be 160 TWh, representing over 4% of US electricity sales (Nadel, Elliott, and Langer, 2015).

Market outlook for investment by utilities: How changing demand will impact energy efficiency investments

There are both headwinds and tailwinds to the role of electricity providers in energy efficiency markets. In reducing electricity consumption, utility-led energy efficiency improvement schemes have actually created some uncertainty about the future role of utilities in the energy efficiency market. Utilities are facing changing conditions now – and into the short and medium term – that will likely influence their activity in the energy efficiency market.

Short-term outlook for electricity demand

The IEA 2015 projection for average annual growth in electricity generation across the OECD is 0.8% from 2014 to 2020. This projection takes into account reduced demand due to energy efficiency improvements, structural economic changes and the increasing role of distributed generation. Changes to the projection reflect the iterative, adaptive and uncertain process of projecting energy demand in light of changing contexts and new information (Box 4.5).

Box 4.5 Challenges in projecting future electricity consumption

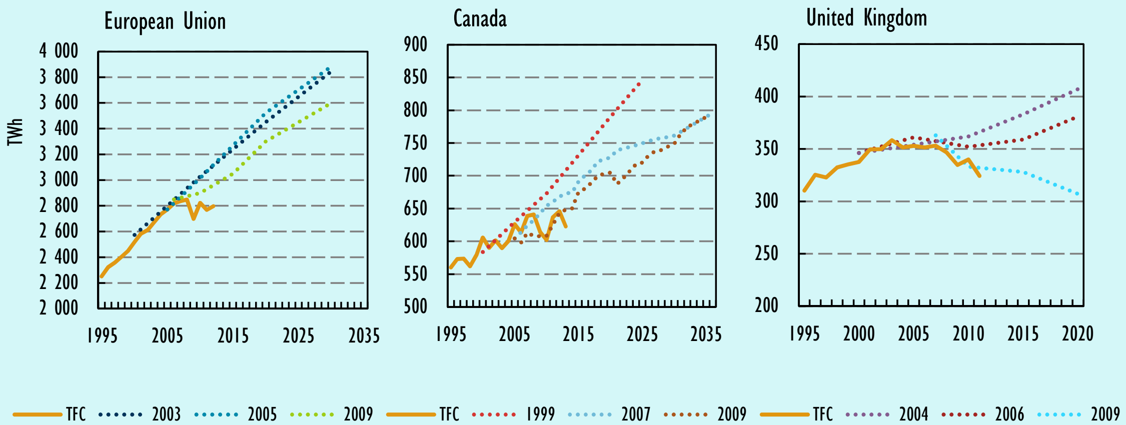
Projecting future electricity demand is subject to considerable uncertainty and, in fact, has often resulted in overestimations. The recent slowing growth in electricity consumption was not anticipated in many past growth projections, as can been seen when charting government electricity demand forecasts against actual TFC of electricity in three economic jurisdictions: the European Union, Canada and the United Kingdom (Figure 4.10).

[7] Cumulative and actualised savings account for the lifetime savings of a measure, factoring in declining savings over this lifetime. Savings are discounted to represent the declining economic value of the savings into the future and the declining efficiency due to ageing equipment and increasingly stringent standards for new equipment.

[8] The programme requires electricity providers to invest in efficiency, primarily through low-interest loans for investment in energy efficiency, subsidies for efficiency products and rebates to consumers who undertake energy efficiency improvements as a result of the programme.

Box 4.5 Challenges in projecting future electricity consumption (continued)

Figure 4.10 Actual TFC of electricity and projections by year, the European Union, Canada and the United Kingdom



Notes: The charts were compiled using actual TFC in electricity from the IEA energy balances and national projections of electricity consumption. The projections were conducted in the years indicated in the legend, and go out to 2020 for the United Kingdom and 2035 for Canada and the European Union. Actual electricity consumption is presented up until 2013, the most recent year for which data are available.

Sources: NEB (National Energy Board) (2009), *2009 Reference Case Scenario: Canadian Energy Demand and Supply to 2020*, an energy market assessment July 2009, National Energy Board of Canada; NEB (2007), *Canada's Energy Future: Reference Case and Scenarios to 2030*, an energy market assessment November 2007, National Energy Board of Canada; NEB (1999), *Canadian Energy: Supply and Demand to 2025*, National Energy Board of Canada; EC (European Commission) (2009), *EU Energy: Trends to 2030 – Update 2009*, European Commission; EC (2005), *EU Energy: Trends to 2030 – Update 2005*, European Commission; EC (2003), *EU Energy: Trends to 2030*, European Commission; DECC (Department of Energy and Climate Change) (2009), *The UK Low Carbon Transition Plan: National strategy for climate and energy*, Department of Energy and Climate Change; DECC (2006), *UK Energy and CO_2 Emissions Projections: Updated Projections to 2020*, Department of Energy and Climate Change; DECC (2004), "UEP November 2004 – Addendum", *Updated Emissions Projection*, Department of Energy and Climate Change.

These three projections consistently overestimate electricity consumption by the final year of actual data. The EU projections made in 2003 and 2005 for 2010 were both 7% higher than actual electricity consumption in 2010. Even the 2009 projection for 2010 was 3% higher than actual demand. In Canada, the 1999 projection for 2010 was 12% higher than actual consumption, while the 2007 projection was 8% higher. Electricity consumption projections in the United Kingdom anticipated a halt in growth by 2009, following clear signals since 2006 that total consumption was slowing; however, projections in 2004 and 2006 pointed to a return to growth, which has not materialised. The IEA also recently reduced its projection of electricity growth over the next five years from an average of 1.4% per year to 0.8%, reflecting the increasing importance and impact of energy efficiency on electricity demand (along with other forces).

How low electricity consumption growth affects utilities

The recent low growth of electricity consumption is a challenge to many existing utilities and to the traditional utility business model, which is predicated on growing electricity sales. Many utilities have built their business models and based operations on the presumption that electricity demand would expand, with the growth in sales and revenues accommodating the need to replace depreciated equipment or expand the network.

Generation infrastructure has high fixed capital costs, and the investments are typically paid off over decades. This makes the financial situation of utilities relatively unresponsive to changing market conditions. Because of these high fixed costs and low market response, lower-than-anticipated electricity sales, from either energy efficiency improvements or other economic conditions, have disproportionate impacts on utility profits. With fixed costs at 40% of total costs in a vertically integrated utility, a hypothetical decrease of 5% of electricity sales triggers a 28% reduction in earnings (Table 4.2).

Table 4.2 Example of the impact of changing sales on utility profits

% change in sales	Actual sales (GWh)	Earnings (USD millions)	Return on equity	Change in profits
10%	1 990	15.4	17.1	56%
5%	1 900	12.7	12.7	28%
0%	1 810	9.9	9.9	0
-5%	1 719	7.1	7.1	-28%
-10%	1 629	4.4	4.4	-56%

Note: This is a hypothetical example of changes in sales to utility profitability; it assumes revenues of USD 181 million, 11% return on equity, 45% debt to equity, 40% fixed costs and a 35% tax rate.

Source: Laitner, J.A. (Skip) (2015), "The Economic Imperative of Energy Efficiency and the Need for New Business Models", presentation to the Pacific Gas and Electric Company, San Francisco.

The amplified effect of declining sales highlights the core challenge with the "volumetric" business model on which many electricity utilities have been established and continue to operate. As long as earnings growth depends on increasing the volume of energy sold, efforts to improve energy efficiency will limit sales and are counter-productive to the goals of this form of profit-maximising utility. The IEA projection for lower electricity demand in many OECD countries implies reduced volume of sales, which will have a disproportionate effect on the fiscal health of many utilities.

Electricity utilities are facing several other challenges that interact with the projected low demand growth, including the retirement of ageing capital stock, growth in variable renewable generation and the rise of distributed generation.[9] In many jurisdictions, each of these factors challenges the existing business model for incumbent electricity providers; together, the factors may have a multiplier effect.

The low demand environment, with its attendant impact on utilities, could also reduce the incentive or interest of utilities in promoting energy efficiency programmes, which could be expected to further reduce demand. However, various drivers to promote continued utility investment in energy efficiency are expected to remain robust. The rest of this section will explore some of the main drivers for continued – and even increasing – efficiency investment by electricity providers.

Drivers for continued and increasing investment in energy efficiency by electricity providers

Although the electricity demand landscape for electricity providers is changing quickly, in part because of the success of energy efficiency improvements, a number of important drivers point to continued and expanding incentives for utilities to invest in energy efficiency, including in end-use programmes. The drivers can be set into four categories, which interact with each other: **a) policy drivers; b) infrastructure renewal; c) market and business case drivers; and d) technological drivers**

[9] Distributed generation refers to electricity generation that is "behind the meter" such as residential rooftop solar photovoltaics.

Policy drivers

Policy has been and will be one of the most important drivers for electric utility investment in energy efficiency. Most OECD and non-OECD countries have implemented influential and overarching policy objectives to improve energy efficiency. In many OECD countries, the underlying objectives include reducing energy bills for consumers (with a focus in some jurisdictions to reduce energy poverty), improving the efficiency and performance of the energy system, and increasing energy security. Improving energy efficiency is also part of a larger policy framework to cost-effectively reduce greenhouse-gas (GHG) emissions and reduce the energy sector's impact on the environment (e.g. minimise power plant pollutants). The models used in the IEA *Energy Technology Perspectives* (*ETP*) show end-use energy efficiency improvements to contribute the largest portion of GHG emissions reduction in the 2-Degree Scenario[10] (IEA, 2014a). These objectives will undoubtedly continue to be important policy-making considerations for governments, at least through the near term.

For example, in 2014, the European Council set new climate and energy targets for 2030, with a core target of reducing GHG emissions by at least 40% below the 1990 level. The initiative also includes the target to increase the share of renewable energy to at least 27% of EU energy consumption by 2030, and to improve energy efficiency by at least 27% by 2030. The Commission will review the targets by 2020, having in mind to boost the targets to 30%. The efficiency targets may make the renewable targets easier to achieve (Box 4.6).

Box 4.6 Renewable policies complementary to higher efficiency investment?

Renewable energy targets and portfolio standards could incentivise greater investment in energy efficiency. By 2013, EU member states and five other OECD countries, along with 63 OECD non-member countries, had set for themselves target shares for renewable energy (REN21, 2013).

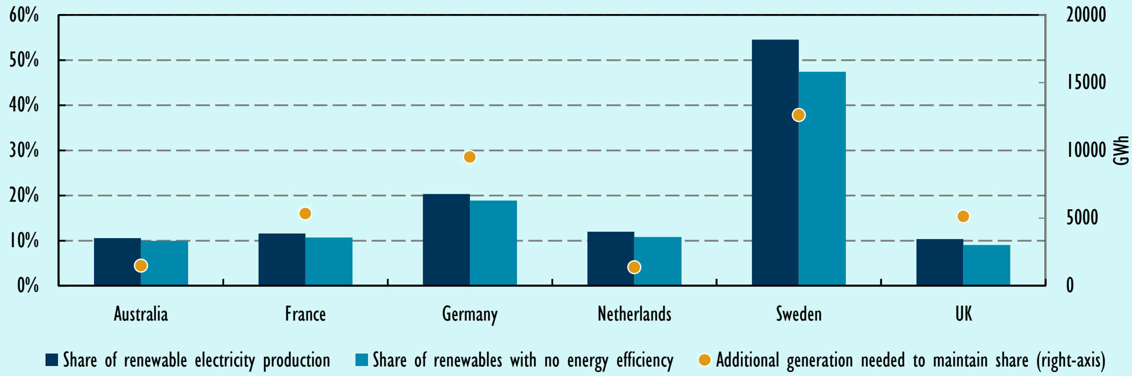
Achieving higher shares of renewable energy can be done at lower costs if lower marginal cost energy efficiency improvements are pursued in parallel. Utilities mandated to achieve both renewable and efficiency targets are in a position where greater investments in efficiency can reduce the burden of achieving renewable targets. For instance, if a renewable energy target is set to achieve 20% of total generation, then efforts to reduce electricity demand will lower the total amount of renewable generation required to achieve the target.

This situation is already evident in some countries, as can be shown by charting the actual share of renewables and the impact of efficiency in dampening the volume of renewables needed to meeting the share target (Figure 4.11). If energy efficiency had not improved since 2001, both electricity demand and generation would have been higher (as depicted in Figure 4.5), thus requiring more volume of renewables to meet the share target. With no efficiency improvements since 2001, the United Kingdom would need an additional 5 100 GWh of generation from renewables to achieve the current share. Under the same conditions, Sweden would need an extra 12 600 GWh of renewable generation.

[10] The 2-Degree Scenario (2DS) reflects technology, policy and finance actions needed for the energy sector to play its part in limiting the global temperature rise to 2° Celsius.

Box 4.6 Renewable policies complementary to higher efficiency investment? (continued)

Figure 4.11 Actual share of renewable electricity generation in select countries in 2012, with adjusted share in the absence of energy efficiency improvements since 2001



Economic drivers and the "burdens" of infrastructure renewal

The slowing growth in electricity demand creates additional challenges for electricity providers that need to renew their ageing generation infrastructure. Fleet renewal is estimated to comprise the bulk of new capacity brought into the OECD system over the next 10 years. New capacity will be increasingly higher-cost, low-carbon generation, which will drive up the overall costs of this renewal. The ability of energy efficiency to provide cost-effective supply may help to delay or offset the need for energy system renewal, thus reducing the associated financial burden for electricity providers and regulators (Box 4.7).

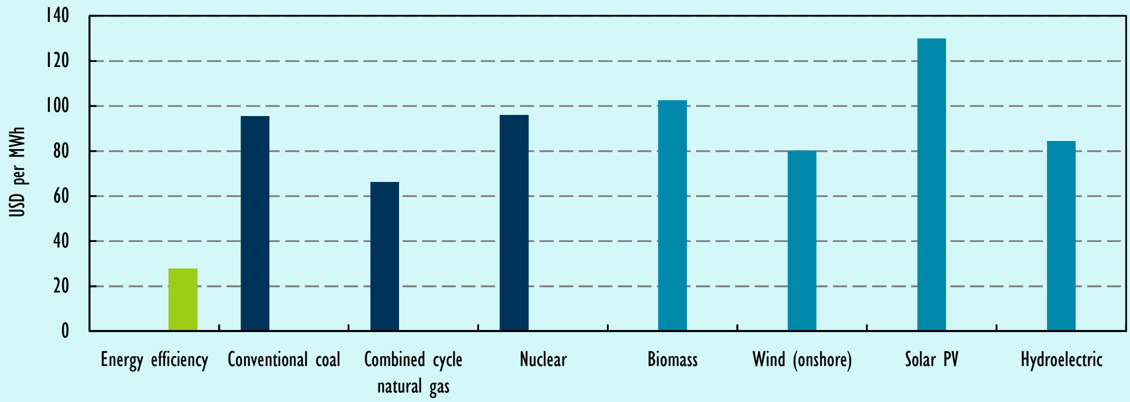
A recent evaluation of the case for energy efficiency from a technical and operations perspective shows that it can defer T&D investments, reduce line losses and avoid capacity reserve requirements (IEA, 2014b). One case study of Toronto Hydro, a municipally-owned utility in Canada, determined that USD 0.7 million spent on demand management could offset USD 56 million in network additions (Tyrell, 2013). Another evaluation of energy efficiency and other decentralised energy technologies to reduce network congestion in New South Wales (Australia) concluded that energy efficiency could defer investments worth four times the current network costs. At peak congestion times, energy efficiency investments in this case could defer infrastructure investment worth 600 times the average retail price of electricity (Dunstan, 2015).

Box 4.7 The cost of energy efficiency for electricity providers: a US case study

End-use energy efficiency investments are often the least-cost investment from an energy supply perspective, and can reduce the total investment cost needed to replace retiring generation. With costs ranging from USD 0.00/MWh to USD 50.00/MWh of demand avoided, efficiency has the least capital outlay of new supply (Lazard, 2014). Estimates on the levelised cost of energy efficiency compared to other sources of electricity supply in the United States show that energy efficiency can provide energy savings at costs substantially lower than the next cheapest supply option (Figure 4.12).

Box 4.7 The cost of energy efficiency for electricity providers: a US case study (continued)

Figure 4.12 Levelised cost comparison among energy supply sources in the United States



Notes: Energy efficiency costs are estimated by Molina (2014) at between USD 20/MWh and USD 50/MWh in 2012, with the average cost being USD 28/MWh. The levelised cost of electricity generation uses estimates from the US Department of Energy (US DoE) for new plants in 2019.

Sources: Molina, M. (2014), *The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs* American Council for an Energy-Efficient America (ACEEE), Washington, www.cectoxic.org/AEEE_Best_Value_is_Energy_Efficiency.pdf (accessed 6 July 2015); US EIA (US Energy Information Administration) (2015), *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2015*, US DoE, Washington, www.eia.gov/forecasts/aeo/pdf/electricity_generation.pdf (accessed 4 July 2015); IEA (2014a), *Energy Technology Perspectives 2014: Harnessing Electricity's Potential*, OECD/IEA, Paris, available at www.iea.org/bookshop/472-Energy_Technology_Perspectives_2014 (accessed 6 July 2015).

Market and business-case drivers

If low electricity demand growth is, in fact, an established trend in the OECD, utilities may need to look for new business opportunities through energy efficiency investments. Some large utilities are already exploring opportunities to become energy efficiency providers beyond their regulatory commitments, and some regulators show interest in supporting the growth of the energy efficiency market players. Some electricity utilities see energy-efficient products and services as a strategy to expand business opportunities by increasing retention of customers and revenues, diversifying revenue streams, and pursuing more profitable markets.

Several large European utilities have been involved in energy efficiency services markets for several years already, often through subsidiary companies. Notable examples are ESCOs linked to utilities, such as COFELY (GDF Suez), Connecting Energies (E.On) and Dalkia (EDF). Their activities range from heating/cooling solutions to energy services for buildings and industry. The energy services market in Europe is undergoing major changes that are stimulating growth, with a corresponding increase in the revenues of ESCOs; these changes, are achieving sales for products and services in the billions of euros range (close to EUR 15 billion for COFELY; close to EUR 5 billion for Dalkia). Growth rates for the energy services market in France are projected at 3% to 4% annually. Connecting Energies, which started in 2012 now employs over 650 people providing energy services in six countries. While actual potential depends on the policy context, business segments and geographic regions, the demand drivers for the market (expected increases in energy prices and regulatory changes) are applicable in most European countries.

Similar transitions are evident in the United States, with a number of utilities becoming retailers of energy-efficient products. Xcel Energy, a large integrated utility, is planning to sell energy-efficient appliances on its website. San Diego Gas and Electric (SDG&E) will improve their retail offerings by allowing customers to use the SDG&E website to shop online for energy-efficient goods from other retailers. This will create opportunities for SDG&E and online retailers to streamline product rebates for energy consumers, and to explore new business models in which consumers, the utility and retailers collaborate more closely to improve efficiency (Wang, 2015). Governments too have begun to recognise the role of efficiency as a complementary business alongside traditional utilities (Box 4.8).

Box 4.8 EfficiencyOne, an energy efficiency utility in Canada

In Canada, the province of Nova Scotia created Efficiency Nova Scotia Corporation in 2009, by which the provincial utility could act as an independent public administrator to improve energy efficiency. In 2014, the government took the initiative to another level, creating legislation to support the formation of EfficiencyOne, Canada's first electricity efficiency utility and holder of the Efficiency Nova Scotia franchise. EfficiencyOne sells volumes of energy saved through cost-effective energy efficiency improvements to the private electricity utility, Nova Scotia Power. In this way, energy savings compete with other sources of energy supply, and EfficiencyOne negotiates efficiency purchase agreements with the utility, with approval from the regulator.

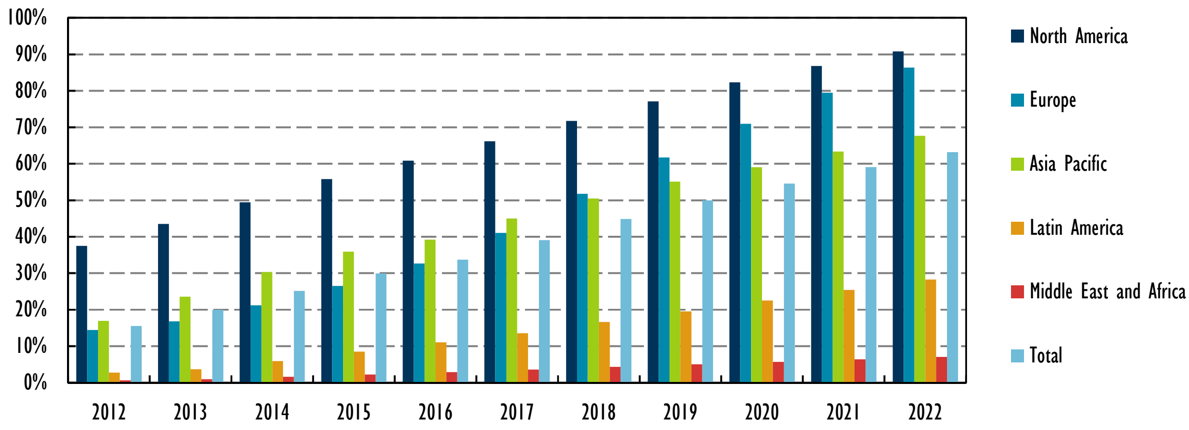
As a dedicated energy efficiency utility, EfficiencyOne has been opportunistic in pursuing efficiency savings through multiple innovative strategies. Examples of EfficiencyOne activities include: direct installation programmes of efficiency equipment in multi-unit residential buildings and houses; strategic energy management and embedded energy manager programmes for industrial consumers; lighting programmes (with CFLs in the past, but now focusing on LED technologies); partnering with consumer loyalty programmes (such as airline points providers); working with schools to build energy efficiency into the curriculum; and developing smart phone applications to support savings through behaviour change.

The utility has achieved energy savings at USD 0.03/kWh – less than one-quarter of the provincial electricity price of USD 0.12/kWh – and amassed over 615 GWh of savings since 2011. To date, EfficiencyOne's efforts have reduced in-province electricity load by an estimated 7% and saved ratepayers a total of USD 89 million in 2014.

Technological innovation

Technological innovation in electricity production, consumption, monitoring and management is enabling opportunities for investment in energy efficiency that were previously infeasible. Smart meters and third-party consumer options (such as smart internet-connected home thermostats) are interacting with other ICT innovations (such as mass data computing), creating connections that could identify cost-effective energy efficiency potential and actions. Some of these technologies encourage consumers to modify their behaviour in response to energy consumption information and price signals. Navigant Research (2013) forecasts that smart meters will penetrate over 60% of the global market by 2022 (Figure 4.13). Technologically-enabled energy efficiency investments allow for greater and more precise monitoring, verification and valuation of how such investments contribute to the energy system.

Figure 4.13 Forecast of smart meter market penetration by region, 2012-22



Source: Navigant Research (2013), "Executive Summary", Smart Meters, Smart Electric Meters, Advanced Metering Infrastructure, and Meter Communications: Global Market Analysis and Forecasts, Navigant Research, Boulder, available at www.navigantresearch.com/research/smart-meters (accessed 6 July 2015).

As the aggregators of smart-meter data, utilities can analyse and evaluate consumer energy consumption trends with an eye to developing more effective programmes. ICT advances allow for low-cost collection of data and reduce costs to standardise, monitor and account for energy consumption within smart energy networks. This opens up opportunities to evaluate efficiency efforts at a finer resolution, to target solutions to specific consumers, and to roll out responsive pricing and revenue opportunities. Additionally, these technologies make it possible to streamline energy efficiency efforts along the utility supply chain (from generation to T&D to the end-use device), creating "end-to-end" potential for utilities to evaluate grid operations, as well as the role and value of energy efficiency in that operation. These new capabilities could be one of the strongest drivers for energy efficiency investment. Several large ICT firms are exploring the opportunities in metering and energy management; whether utilities will capitalise on these opportunities remains uncertain. It is likely, however, that advancement on this front will continue, either through partnerships or increased competition.

The market opportunity exists: Who will take it?

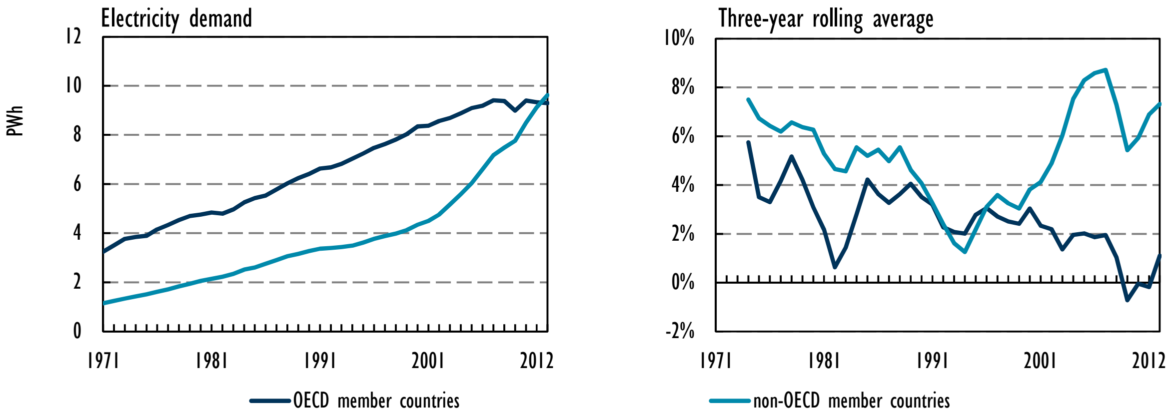
Substantial changes are underway in the electricity marketplace, some of which seem likely to stimulate incumbent utilities to shift their traditional operations, pursue new business models and alter their own behaviour while encouraging customers to do the same. The changing conditions may prompt utilities to increase or decrease their energy efficiency investments, depending on their individual technical capacities, financials and fixed assets, as well as the market and policy contexts in which they operate.

What is certain is that strong drivers for energy efficiency improvements to reduce electricity consumption will continue – and will create market opportunities and returns for firms and investors. If utilities do not step up their investments in energy efficiency, other actors will recognise the market opportunity and step in to take their place.

Electricity consumption in non-OECD countries

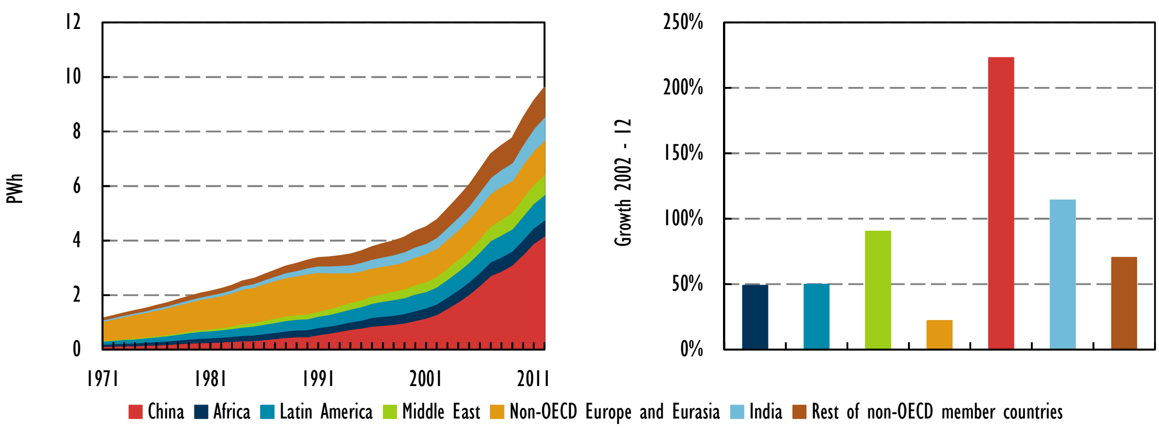
Electricity consumption at the global scale followed a standard pattern for many decades: increasing economic development and rising incomes were positively correlated with rising demand. Since the mid-1990s, electricity demand has been influenced by fundamentally different drivers in OECD and non-OECD countries – with growth rates in the two regions diverging. The three-year rolling average growth rates of electricity consumption in the OECD flattened or declined in the 2000s. By contrast, growth in the non-OECD increased to 8% per year between 2004 and 2008, declined to 5% in 2009 and returned to 7.5% average growth by 2012 (Figure 4.14). Even at the depth of the recession in 2009, the average three-year rolling growth rate of electricity demand in non-OECD was higher than at any point in the previous four decades in the OECD.

Figure 4.14 Electricity demand and average growth rates in OECD and non-OECD, 1971-2012



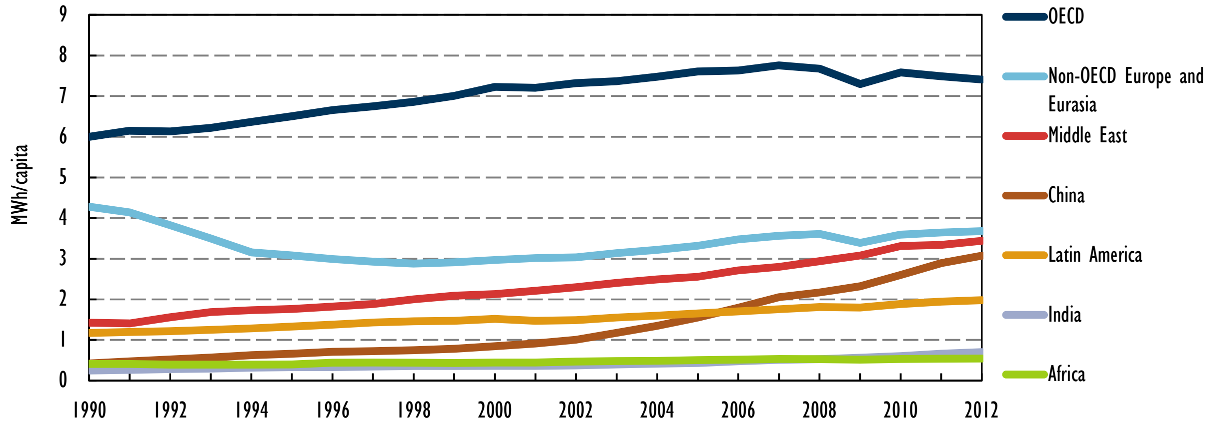
In recent years, the rate and scale of electricity demand growth in the non-OECD region have surpassed those experienced in the OECD. It took 22 years (from 1971 to 1992) for electricity demand to double in the OECD. By contrast, non-OECD electricity demand doubled (to 7 175 TWh) in just 14 years (1994-2007). Most of this non-OECD growth stems from one country, China, which increased electricity consumption 223% between 2002 and 2012. During this period, all major non-OECD countries and regions increased electricity consumption by at least 50%, with consumption more than doubling in India and increasing by 90% in Middle Eastern countries (Figure 4.15).

Figure 4.15 Electricity consumption and growth in non-OECD countries and regions



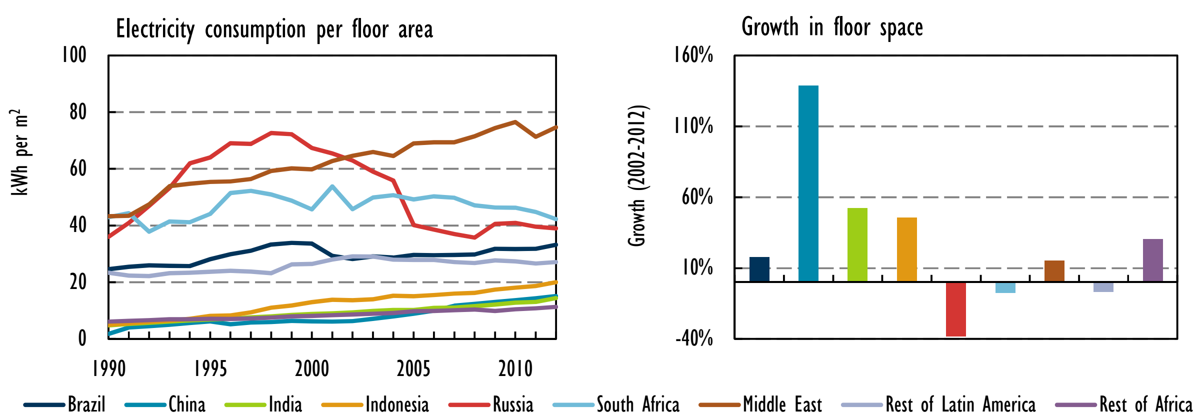
Even with strong growth in electricity demand, the volume of electricity consumed per capita in non-OECD regions remains much lower than in OECD countries. Average consumption in the OECD was more than 7 MWh per capita in 2012, more than double the per capita consumption of any non-OECD region (Figure 4.16). Yet even those figures fall short of conveying the stark contrast that exists in some places: in 2012, per capita electricity consumption on the African continent was 540 kWh and India showed slightly higher figures at 706 kWh (an amount similar to the annual consumption of a residential refrigerator/freezer in Figure 4.7). Africa is home to half of the global population with no access to electricity (630 million) (IEA, 2014d), and one-quarter of all households in India still lack access (IEA, 2014a). As these countries continue to develop, rising incomes will propel greater demand for energy services met with electricity, including from already connected populations whose incomes increase and from the businesses that serve them.

Figure 4.16 Electricity consumption per capita, OECD and non-OECD regions, 1990-2012



Electricity consumption in buildings is one of the fastest-growing areas of energy demand in the non-OECD region. Recent increases in the electricity intensity of residential buildings have been strongest in China, other non-OECD Asian countries and India (Figure 4.17). Rising incomes and increasing urbanisation in most regions are driving greater demand for residential energy services (such as to operate air conditioners and household appliances) that are satisfied with electricity (see Chapter 10, Saudi Arabia). Estimates from the IEA global buildings energy model show that growth in appliance use and space cooling was strong across most non-OECD countries. Appliance energy use is the largest new source of electricity demand and represents the largest absolute load of electricity in residential buildings in the non-OECD region.

Figure 4.17 Electricity intensity of floor space and total floor space in selected non-OECD countries

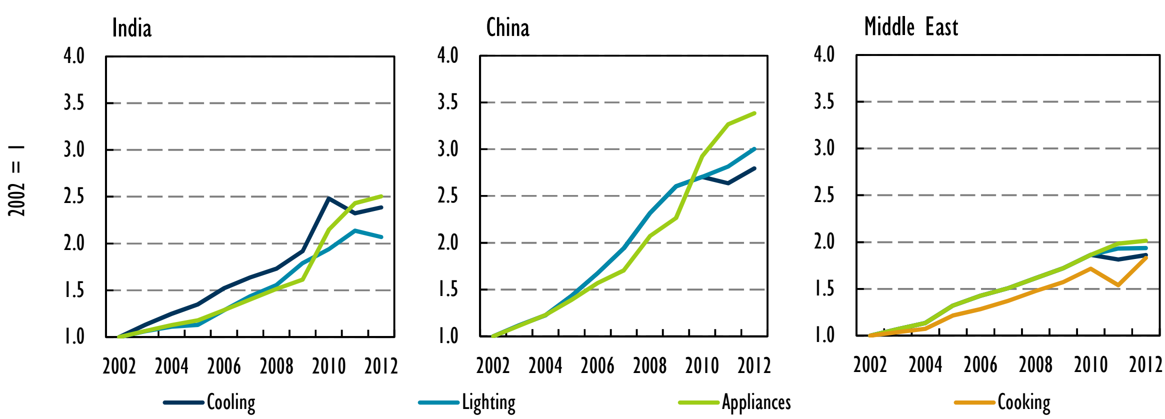


Improving the efficiency of energy supply in non-OECD regions

Economic growth will continue to drive up demand for electricity in developing countries. Even though high electrification rates have been achieved in China, Latin America and the Middle East, energy service demand is still not fully satisfied for many end-uses (unlike in the OECD, where demand is largely saturated). Appliance ownership levels, for example, in many non-OECD countries are generally much lower than in the OECD. In 2008, over 95% of households in major OECD countries owned a refrigerator and over 80% owned a microwave. By contrast, in China 55% of households owned a refrigerator and 27% owned a microwave; in India, only 15% of households owned a refrigerator or a microwave.

Air conditioner (AC) ownership rates are increasing rapidly, albeit from a low baseline. In India, AC sales increased by 20% per year from 2000 to 2008, yet their market penetration was still below 10% by 2010 (Akpinar-Ferrand and Singh, 2010). In China, urban households own, on average, one AC unit per dwelling; in rural communities, ownership drops to approximately one AC unit for every eight households. Electricity demand for air conditioning is likely to increase as the number of urban households – currently 47% of total households – is rising (Auffhammer, 2011). Since 2002, estimated energy consumption for appliances has risen 250% in India, 338% in China and 200% in the Middle East (Figure 4.18). The overall level of appliance ownership is an indicator of how energy service demand will continue to grow in the developing world as incomes increase.

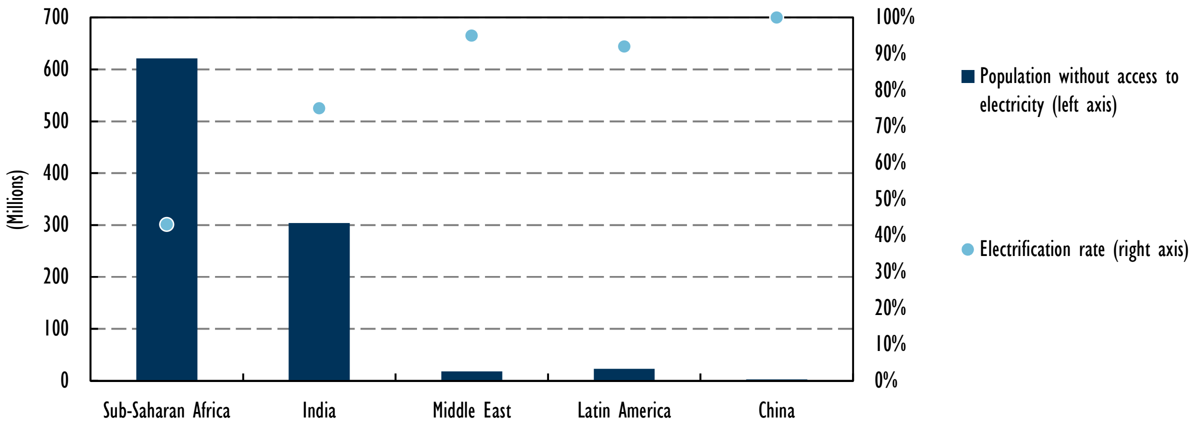
Figure 4.18 Growth in residential electricity consumption by end-use in India, China and the Middle East, 2002-12



Note: The share of electricity use in cooking in India and China is minimal compared to other end-uses, primarily because large portions of the populations still rely on traditional biomass for cooking.

Large-scale efforts to expand access will also affect the demand for electricity in non-OECD regions. In Sub-Saharan Africa, India and elsewhere, millions of people have no access to modern electricity services (Figure 4.19). For example, while India has provided electricity to over 70% of its people, another 300 million still have no access. Providing this access will inevitably increase demand for electricity, although the impact of connecting very poor households is not projected to be large on a per capita basis.

Figure 4.19 Electricity access among selected non-OECD countries and regions



Source: IEA (2014d), *World Energy Outlook 2014*, OECD/IEA, Paris, available at www.iea.org/bookshop/477-World_Energy_Outlook_2014 (accessed 6 July 2015).

Utility investment in energy efficiency in emerging and developing economies

Improving electricity system reliability is a key driver of utility investment in energy efficiency in non-OECD regions, in both richer emerging economies facing rapidly growing demand tied to expanding economic activity and in poorer countries that face high system losses. Improved efficiency efforts designed to reduce technical losses can help expand energy access by enabling existing systems to provide electricity to more people, which can also drive utility energy efficiency investments in developing countries. Strengthening the reliability of electricity supply through T&D investments is likely to remain a core objective of utilities in emerging economies and fast-growing countries, where losses through T&D are an important issue. For example, with annual losses of over 100 TWh in 2012, Latin American and Caribbean countries account for an estimated one-third of global electricity losses, at a cost of between USD 11 billion and USD 17 billion (Jiménez, Serebrisky and Mercado, 2014). Electricity losses in Brazil comprised 19% of its gross electricity generation in 2012.[11]

The investments needs for more efficient T&D infrastructure in non-OECD countries are large at USD 4.6 trillion; in fact, the IEA *World Energy Investment Outlook* (2014c) estimates that these countries will account for two-thirds of all new investment in T&D infrastructure. Most (70%) of this investment will be directed towards building new infrastructure, driven by growing demand for electricity; the remainder by the need to refurbish existing infrastructure.

Some countries are establishing energy efficiency utilities to deliver end-use energy efficiency savings. India created Energy Efficiency Services Limited in 2009 as a joint venture between National Thermal Power Corporation Limited, Power Finance Corporation Limited, Rural Electrification Corporation Limited and POWERGRID to facilitate the implementation of energy efficiency projects. The company acts as an ESCO and a resource centre, and leads the market-related actions of the National Mission for Enhanced Energy Efficiency. It is the first ESCO in South Asia and offers consultancy services in Clean Development Mechanism (CDM) projects, carbon markets, demand-side management, climate change and related areas, as well as training to build the capacity of stakeholders.

[11] Chapter 5 covers in detail recent efforts by Brazilian electricity utilities to improve energy efficiency.

In South Africa, electricity shortages from rising demand have prompted the main utility, Eskom, to undertake awareness and incentive programmes that encourage consumers to adopt energy efficiency measures and reduce consumption during peak periods. Programmes include the standard product programme (which offers pre-approved rebates for deemed energy savings achieved through specific technologies), the standard offer programme (energy efficiency payments at a fixed rate for a fixed period), the ESCO programme (demand-based payment for verified savings), and performance contracting (bulk buying of energy savings from project developers for multiple projects, which includes fixed payments for verified savings).

Outlook in non-OECD

Significant scope remains to improve both system reliability and access to electricity in non-OECD regions. China has achieved full access to electricity, but higher standards of living and the associated demand for appliances and other comforts will continue to push up energy service demand. The rate of urbanisation, growth in income per capita and the efficiency of new devices will be key determinants on the trajectory of future Chinese electricity demand. In India, increasing incomes and higher standards of living will also push up demand; this dynamic will be supplemented by efforts to provide access to the 300 million people currently lacking modern electricity services. South Africa is currently in an electricity supply crisis; demand is outstripping supply, leading to load shedding and severely challenging Eskom, the state-owned utility. More and more countries are recognising the capacity of supply-side energy efficiency investments to help to address these challenges.

Strong arguments exist for investment in end-use energy efficiency in non-OECD regions, particularly to improve system performance in meeting expanding demand (both from increasing standards of living and greater access) while dampening the electricity delivery strains on utilities. Energy efficiency in appliances has important, positive developmental implications in non-OECD countries. A doubling of refrigerator efficiency (i.e. halving consumption) allows households to save some money while also reducing electricity demand and environmental impacts. It also has the effect of doubling the number of appliances that can be operated for the same level of electricity service. Any country that currently has significant pent-up demand for electricity-specific energy services (e.g. lighting and refrigeration), or is facing the prospect of increasing demand tied to rising incomes and standard of living expectations, represents a large opportunity for increasing energy efficiency investments.

Conclusion

While electricity markets are evolving differently in OECD and non-OECD regions, energy efficiency presents important opportunities in both contexts.

Electricity consumption in the OECD has flattened over the past five years owing, in part, to continued energy efficiency improvements. In many OECD countries, these efficiency improvements were the product of utility efficiency investments that were ultimately driven by government mandates and policy. Stalling electricity consumption in no-growth markets has already destablised many incumbent energy utilities. Continued efficiency improvements leading to absolute reductions in electricity demand could threaten utility financials and undermine their support for energy efficiency.

Yet several drivers for energy efficiency remain relevant, and are likely to push and/or pull utilities to continue to invest. On the push side, many governments are intensifying their efforts to reduce

GHG emissions, with energy efficiency being an important component of policy priorities. Renewal of existing generation fleets in a context of more aggressive carbon reduction policies is likely to push up electricity prices; in this situation, regulators are expected to continue to use energy efficiency as an option to soften the impacts on ratepayers. On the pull side, technological advancements are enabling new business models and methods to monetise the various returns on energy efficiency investments.

In non-OECD regions, energy efficiency in both supply-side and end-use areas is anticipated to attract more attention as countries seek to manage increasing electricity demand tied to economic growth and rising standards of living. Even with rapid development of the electricity systems in much of the non-OECD (including China, India and the Middle East), per capita electricity consumption is still much lower than the OECD average, and the potential for growth is large. Many countries are recognising energy efficiency investments as a complement to increasing generation capacity to provide for a sounder and more efficient path to ensure their electricity sectors adequately support economic and social development.

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PART 2

ENERGY EFFICIENCY MARKET SNAPSHOTS AND PROFILES

INTRODUCTION

Part 2 of this *Energy Efficiency Market Report* provides analysis of energy efficiency developments in specific markets. Part 2 is divided into two sections: 1) Energy Efficiency Market Snapshots and 2) Energy Efficiency Market Profiles.

Energy Efficiency Market Snapshots

Energy Efficiency Market Snapshots provide a brief review of important drivers and developments in selected International Energy Agency (IEA) countries. Snapshots profile the policy mix, changing energy prices and progress on energy efficiency performance. They provide additional context by taking existing information and presenting it in a way that allows stakeholders, mainly investors and policy makers, to monitor the potential of a country's energy efficiency market. This year's Snapshots cover Australia, Germany, Spain, Sweden and the United States. Energy efficiency market potential can be further improved by ensuring full implementation of the *25 Energy Efficiency Policy Recommendations* of the IEA and recommendations on energy efficiency from IEA country reviews.

Energy Efficiency Market Profiles

The case studies presented in Part 2 capture energy efficiency market investments in the following nine diverse jurisdictions:

- Brazil
- Massachusetts
- Mexico
- Paris
- Russia
- Saudi Arabia
- Seoul
- Tokyo
- United Kingdom

Geographically, Part 2 covers both IEA (Massachusetts, Paris, Seoul, Tokyo, United Kingdom) and IEA non-member country (Brazil, Mexico, Russian Federation ["Russia"], Saudi Arabia) markets. Three main themes emerge:

Subnational actors (Massachusetts, Paris, Seoul, Tokyo): Energy efficiency investments are subject not only to national policies but also to the efforts made by cities and regions, which often surpass national ambitions. Cities and regions are major drivers of energy efficiency markets, using their urban planning powers mainly in the transport and buildings sectors. They are also particularly well placed to gain from the benefits of energy efficiency. For example, Paris has been improving the energy efficiency of its transport system in large part as a way to improve air quality for its inhabitants. Tokyo has a strategy on district energy that aims to improve the city's energy security. Seoul also has a strong focus on energy security, with its comprehensive "One Less Nuclear Power Plant" plan. In Massachusetts, a programme of policies helped catalyse energy efficiency investments in excess of USD 1 billion in 2013 (and generated over USD 2.8 billion in financial returns).

Energy exporters: Two of the world's largest energy producers are featured, Saudi Arabia and Russia. Even with huge fossil fuel reserves, both countries are increasingly recognising the role of energy efficiency in their energy systems.

Meanwhile, the United Kingdom is looking increasingly to energy efficiency to assist the transition of becoming a net energy importer.

Emerging economies in Latin America (Brazil, Mexico): *EEMR 2015* evaluates the two largest Latin American countries in terms of energy demand and how they are using energy efficiency as a component of sustainable development objectives. In the context of increasing energy consumption per capita in both Brazil and Mexico, energy efficiency has a potentially important role to play. An example of the kind of innovative efficiency programmes being put in place is the Efficiency Lighting and Appliances project in Mexico, which is expected to save over 9.5 TWh of electricity consumption in 2015 by replacing more than 1.6 million refrigerators and 200 000 air-conditioning units, as well as funding over USD 53 million for the replacement of incandescent bulbs with high-efficiency bulbs.

Each case study follows a broadly similar outline. First, it sets out the **energy profile and context** relevant to understanding energy consumption and intensity trends in each economy. Next, it provides an overview of the **market supply and potential for energy savings**, followed by a discussion of the key **energy efficiency policies and programmes** that drive energy efficiency investments. The chapters then present an in-depth look at **current energy efficiency activity** in selected sectors and activities. This section aims to highlight salient data and information on investments and outcomes where available. Each case study then highlights **prospects for future energy efficiency market activity**, including planned government funding and activities. The chapters wrap up with a discussion of key **challenges** for energy efficiency markets in the particular country, and **conclude** with an assessment of the economy's future energy efficiency activity and, in some cases, recommendations for how to improve the market for energy efficiency.

Intended to complement earlier chapters of the report, which provide broad assessments, the compendium of case studies in Part 2 conveys the richness and diversity of energy efficiency markets worldwide, and highlights the specific and dynamic contexts within which they operate.

5. ENERGY EFFICIENCY MARKET SNAPSHOTS

This edition of the *Energy Efficiency Market Report* includes for the first time a series of Energy Efficiency Market Snapshots, which combine performance on energy efficiency indicators with two other critical elements of the market potential for energy efficiency: energy efficiency policies and energy prices. The Snapshots provide additional context and present existing information in a way that allows all stakeholders (investors, policy makers, civil society, etc.) to better assess the potential of a country's energy efficiency market. The Snapshots can also help identify possible trade-offs among the three elements, for example whether ambitious policies in a particular country are being undermined by low energy prices.

Five Snapshots are presented here – Australia, Germany, Spain, Sweden and the United States. All of these countries are included in the *Energy Efficiency Indicators* (EEI) database, the IEA *Energy Efficiency Policies and Measures* (EE PAMS)[1] database and the IEA *Energy Prices and Taxes* database (IEA, 2015a).

The three pillars of the Energy Efficiency Market Snapshots

Three key drivers of energy efficiency investment at country level have been identified as: a supportive policy environment, rising energy prices, and recent changes in energy efficiency indicators as a guide to momentum. The Snapshots thus comprise three pillars:

- The **policy** pillar indicates the extent to which best practice policies are in place in a country; it is based on EE PAMS.
- The **price** pillar reflects the extent to which end-user prices can be expected to affect the potential for energy efficiency investment; data come from the Energy Prices and Taxes database.
- The **performance** pillar provides quantified evidence of changes in energy intensity and efficiency in recent years; it is measured using the decomposition of IEA energy efficiency indicators.[2]

No pillar on its own can credibly create a thriving energy efficiency market. Energy efficiency policy may be limited by the scale of intervention required. Policies to raise energy prices may be limited by the blunt nature of the approach, resistance to rising fuel bills and competitiveness concerns. Past performance on energy efficiency indicators is not always (though it often is) a good predictor of future performance.

Also, results on any one pillar are not necessarily positively correlated with the other two – a country may well be strong on one pillar but weak on another. Taken together, however, a country's results on the policy, price and performance pillars give a snapshot of its energy efficiency market potential.

[1] See www.iea.org/policiesandmeasures/energyefficiency/.

[2] Note that the Snapshots are restricted to existing IEA data and analysis. The IEA engages with countries (primarily member countries but also others) on an ongoing basis to improve the completeness of its databases. In this way, it is expected that work on the Snapshots and the IEA databases will mutually reinforce each other over time.

It should also be remembered that policies are implemented and take effect over several years. The prices and performance pillars cover a ten-year span, which corresponds well to the lifetime of many policies (though not all).

Policy

The policy pillar uses a matrix based on EE PAMS, which combines policy types, and the end-use sector categories of the ***25 Energy Efficiency Policy Recommendations*** (IEA, 2011). It is considered that a well-designed policy framework should cover as many of the resulting matrix cells as possible, though some will be more important than others. The sector categories are Cross-sectoral, Energy utilities, Industry, Existing buildings, New buildings, Appliances, Lighting, and Transport. The policy types listed in EE PAMS are:

- **Regulatory instruments:** auditing, codes and standards, monitoring, obligation schemes, other mandatory requirements
- **Policy support:** institutional creation, strategic planning
- **Economic instruments:** direct investment, fiscal/financial incentives, market-based instruments
- **Information and education:** advice/aid in implementation, information provision, performance label, professional training and qualification
- **Voluntary approaches:** negotiated agreements (public-private sector), public voluntary schemes, unilateral commitments (private sector)
- **Research, development, and deployment (RD&D):** research programme, demonstration project.

The different policy types are not weighted but it is recognised that, for example, regulatory instruments will in most cases be more immediately effective than information and education or RD&D (though these can play an important role in driving the market). The sectors are not weighted either, but again it is clear that if, for example, industry accounts for a very high share of energy consumption in a particular country, strong policies in that sector are very important and likely to have the largest impact.

To a certain degree, the buildings sector is weighted more than others because it is broken down further into existing buildings, new buildings, appliances and lighting. This reflects the overall importance of the sector and the fact that it is the sector with the largest number of policies enacted to date. Although new and existing buildings are weighted equally, the ratio of new to existing buildings in the stock should be fully considered in decision-making in order to ensure sufficient impact.

Cells of the policy matrix are colour-coded. Dark green indicates relevant policy coverage. Lighter green indicates partial or indirect coverage; for example, if only part of the sector is covered or if the policies are only moderately effective. Cells are left blank if no relevant policies have yet been included in EE PAMS.

If available, the Snapshot states a country's energy demand target. Finally, some policy priorities are suggested based on the key recommendations in the area of energy efficiency from the latest in-depth review of the country concerned (the IEA conducts in-depth energy policy reviews of its member countries on a rotating basis, with the evaluation criteria based on Shared Goals adopted by the energy ministers of IEA countries).

The Snapshots are primarily intended to be stand-alone and country-specific. However, it should be noted that in summarising the results of the Snapshots, the total number of policies included in EE PAMS is used for comparison, for example in Figure 5.1.

Prices

Energy prices for end-users are a key driver of energy efficiency markets, and thus a pillar of the Energy Efficiency Market Snapshots. The criteria used for this pillar are the increases in prices (including taxes) between 2002 and 2014. The rate of increase, if significant, has an important impact on end-user behaviour and thus on markets,[3] while prices including taxes are used because these are the prices faced by end-users and which ultimately affect energy efficiency markets. The criteria are therefore increases in weighted prices of one unit of energy, based on IEA indices of real energy prices for industry and households.

A rise in the weighted price of a unit of energy reflects a number of factors that can include an increase in the share of higher cost energy carriers, such as electricity. Providing electricity to households is more expensive per unit of energy than other energy carriers, but has greater value in that it is capable of satisfying a wider array of energy service demands.

Performance

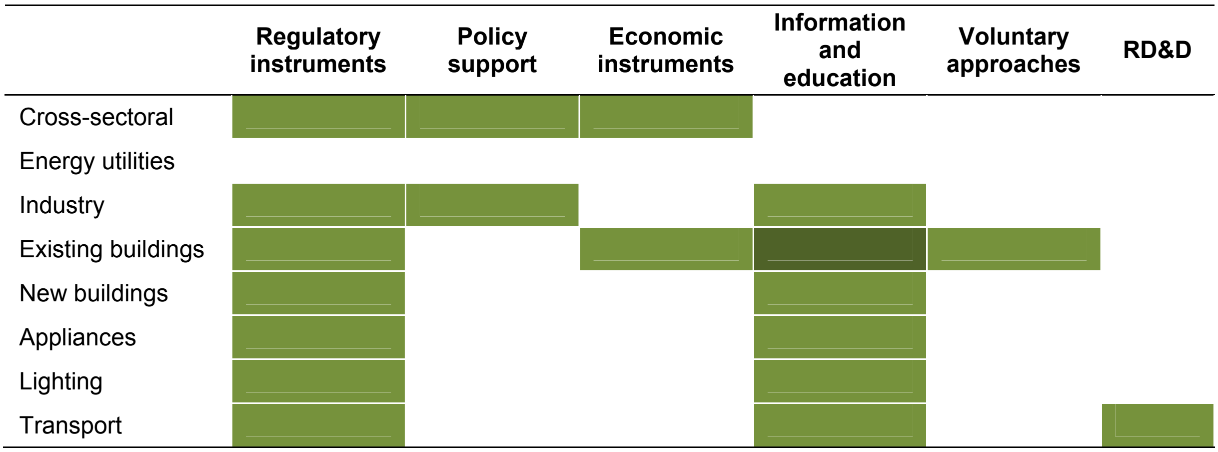
The performance pillar uses change in total final consumption (TFC) in 2012 relative to 2002, decomposed by factors. A single economy-wide decomposition indicator is shown, as well as decomposition by sector.

This pillar can be used to assess the maturity of the energy efficiency market, assuming that improvement in energy efficiency across a number of end-use sectors is a proxy for the maturity of energy efficiency market players and support systems. A strong level of past performance in a country could be interpreted to mean that less potential remains. However, under most scenarios energy efficiency investment is set to ramp up significantly rather than decline. Thus, past performance can be a meaningful indicator of a mature market that is ready for future efficiency investments. As few investors are willing to be the first to invest in a given country or sector, this record of achievements to date can be important to attracting new investment.

[3] Absolute values and volatility are also very important but as price data are not yet robust enough for all countries, the rates of increase are preferred for this exercise. Also note that energy taxation as a policy is covered under the policy pillar.

AUSTRALIA ENERGY EFFICIENCY MARKET SNAPSHOT

POLICIES: Coverage by type and sector based on the IEA EE PAMS database



DARK GREEN = Several relevant policies are in place. **GREEN** = At least one relevant policy is in place. WHITE = No relevant policies have been identified in EE PAMS.

Highlights

- The overarching framework for energy efficiency is the National Partnership Agreement on Energy Efficiency and the National Strategy on Energy Efficiency (NSEE). In July 2015 the Council of Australian Governments Energy Council committed to develop a National Energy Productivity Plan to co-ordinate nationally across both energy efficiency and energy market reform by the end of 2015. This plan will replace the NSEE.
- A successful programme for industry, Energy Efficiency Opportunities (EEO) (see *EEMR-2013*), has ceased. It was a mandatory disclosure (audits) programme with no obligation to implement the identified opportunities.
- All new buildings in Australia are covered by building codes, while the Commercial Building Disclosure programme makes information about the energy efficiency performance of large office buildings (both new and existing) available to potential buyers or tenants.

Energy demand target

- Australia's Energy White Paper 2015 commits to an energy productivity target that will be determined as part of the development of the National Energy Productivity Plan. A national improvement target of up to 40% by 2030 is achievable.

Suggested priorities, based on most recent IEA recommendations (2012)

- Develop an enhanced consumer and residential energy efficiency programme, including a review of existing energy efficiency initiatives. The outcome of this review should be clarity of objectives and to ensure that efforts, particularly funding, are directed into the most appropriate initiatives.
- Develop a revised EEO programme and extend it to the electricity and gas transmission and distribution sectors to provide improved information on the scale of network losses and opportunities to reduce them. Examine mechanisms to provide incentives for networks to implement opportunities identified through the EEO programme.
- Continue efforts to improve energy efficiency in the transport sector, including the implementation of mandatory CO_2 emissions standards for light-duty vehicles.

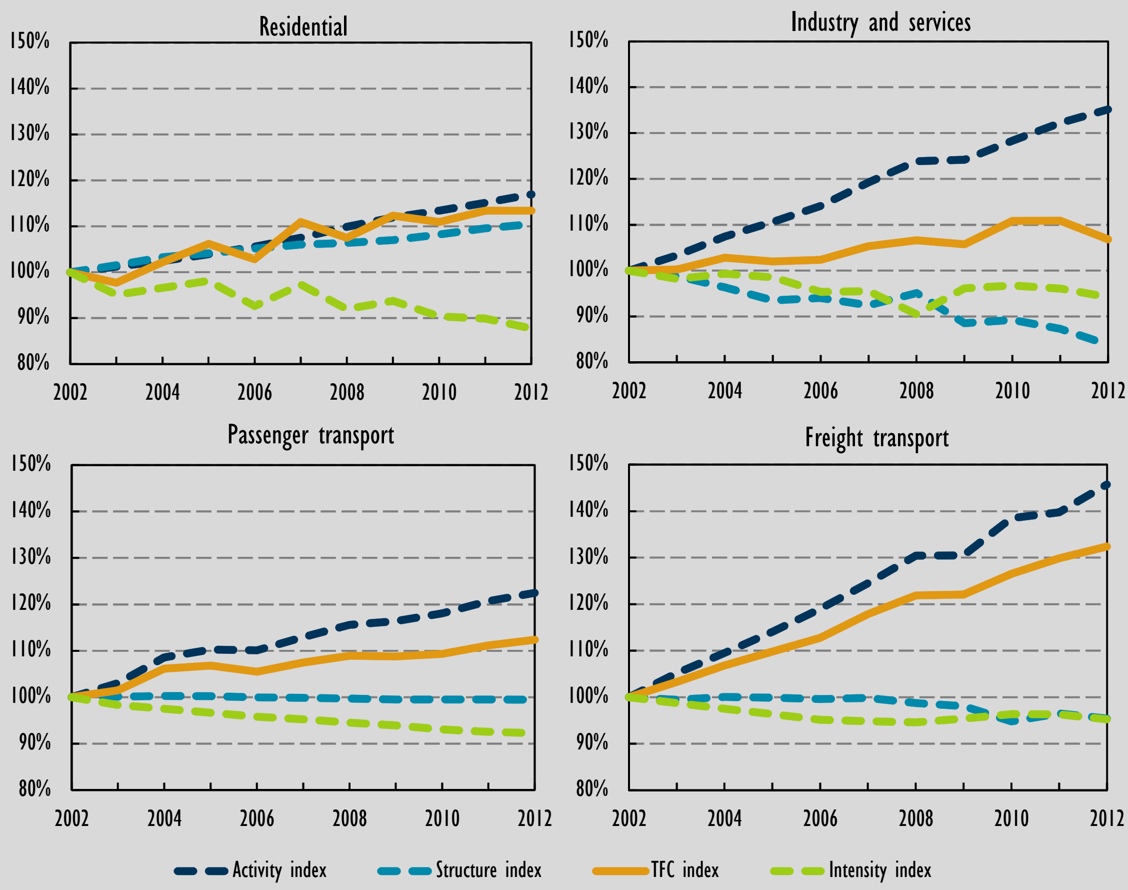
PRICE: Weighted price of one unit of energy, percentage increases, 2002-14

Household	Industry	Industry and households
31%	37%	**33%**

PERFORMANCE: Change in TFC in 2012 relative to 2002, decomposed

	Total	Residential	Industry and services	Passenger transport	Freight transport
TFC	12.5%	13.43%	6.81%	12.39%	32.41%
Activity effect	30.9%	16.94%	35.14%	22.48%	45.74%
Structure effect	-8.1%	10.49%	-16.15%	-0.53%	-4.59%
Efficiency effect	**-6.9%**	-12.2%	-5.74%	-7.74%	-4.77%

Sector decompositions of energy use



Notes: Results shown are multiplicative (rather than additive). See also the Australian Department of Industry and Science's own decomposition analysis (Stanwix et al., 2015).

GERMANY ENERGY EFFICIENCY MARKET SNAPSHOT

POLICIES: Coverage by type and sector based on the IEA EE PAMS database

	Regulatory instruments	Policy support	Economic instruments	Information and education	Voluntary approaches	RD&D
Cross-sectoral	Green	Dark green	Dark green	Green	White	Dark green
Energy utilities	Green	Green	Green	Green	White	Green
Industry	Dark green	Green	Dark green	Dark green	Green	Dark green
Existing buildings	Dark green	Green	Dark green	Dark green	White	Dark green
New buildings	Dark green	Green	Dark green	Green	White	Green
Appliances	Dark green	Green	Green	Dark green	White	Green
Lighting	Green	Green	Green	Green	White	Green
Transport	Dark green	Green	Dark green	Dark green	White	Dark green

DARK GREEN = Several relevant policies are in place. **GREEN** = At least one relevant policy is in place. WHITE = No relevant policies have been identified in EE PAMS.

Highlights

- Energy intensity has been declining but additional measures may be needed to achieve the 2050 target of reducing primary energy consumption by 50% compared to 2008.
- The National Action Plan on Energy Efficiency (NAPE) announced in December 2014 is the key framework policy to achieve improved energy efficiency, along with the Energy Efficiency Directive and other EU legislation.
- Funding for the building refurbishment programme administered by the state-owned bank KfW has been secured in the NAPE. The funding available has been increased to EUR 2 billion annually. This public co-funding is available for measures exceeding the legal efficiency standards in place and linked to performance. Other measures regarding the buildings sector endorsed in the NAPE include legal changes and optimisation of energy consulting. R&D for existing and new buildings will be continued; a new research network "energy in buildings and districts" has been established. Based on these measures Germany is developing a comprehensive strategy to achieve a "nearly climate-neutral" building stock by 2050.

Energy demand target

- The European Union is committed to an indicative target of a 20% reduction in primary energy consumption by 2020 and 27% by 2030 (relative to a projected reference level), to be achieved jointly.
- Germany has a target of a 20% reduction in primary energy consumption by 2020 compared to 2008, and 50% by 2050 (for the buildings sector the target is -80% compared to 2008), as well as a target to improve energy productivity by 2.1% per year on average from 2008 to 2020

Suggested priorities, based on most recent IEA recommendations (2013)

- Continue to move away from energy tax reliefs in the industry sector and instead focus on requirements for energy management and reporting of energy savings opportunities identified (at present, relief is granted only if companies implement a system but price reductions are not yet linked to any official reporting requirements). Reward the best-in-class companies and provide support for capacity building in small and medium-sized enterprises through grants from the Energy and Climate Fund.

- Increase efforts to improve energy efficiency in the transport sector by encouraging modal shift for passenger and freight transport. Consider aligning vehicle labels with the motor taxation system, and consider road pricing for passenger cars.

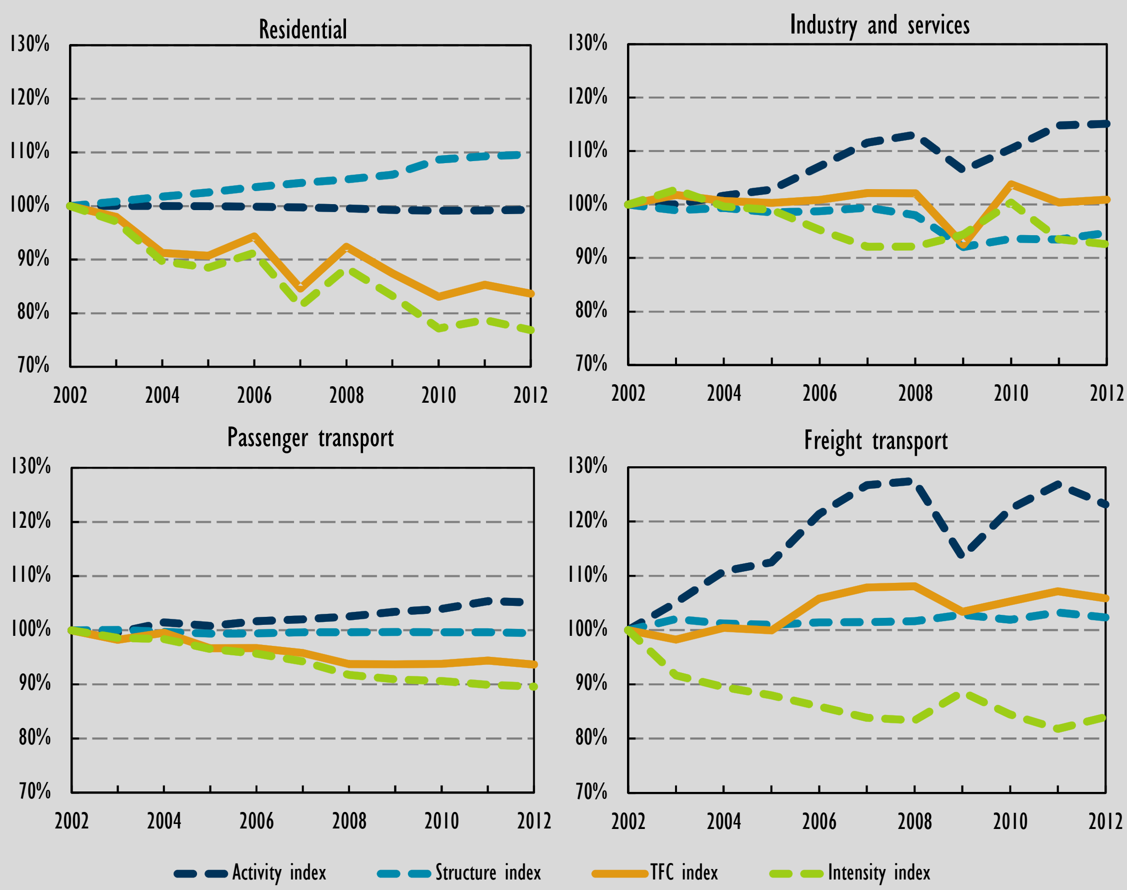
PRICE: Weighted price of one unit of energy, percentage increases, 2002-14

Household	Industry	Industry and households
43%	63%	50%

PERFORMANCE: Change in TFC in 2012 relative to 2002, decomposed

	Total	Residential	Industry and services	Passenger transport	Freight transport
TFC	-5.4%	-16.33%	0.91%	-6.32%	5.85%
Activity effect	9.0%	-0.68%	15.11%	5.11%	23.17%
Structure effect	-0.1%	9.63%	-5.31%	-0.52%	2.32%
Efficiency effect	**-13.5%**	-23.15%	-7.41%	-10.41%	-16.00%

Sector decompositions of energy use



Note: Results shown are multiplicative (rather than additive).

SPAIN ENERGY EFFICIENCY MARKET SNAPSHOT

POLICIES: Coverage by type and sector based on the IEA EE PAMS database

	Regulatory instruments	Policy support	Economic instruments	Information and education	Voluntary approaches	RD&D
Cross-sectoral	Green	Green	Dark green	White	White	White
Energy utilities	Green	White	White	White	White	White
Industry	White	Green	Green	Green	White	White
Existing buildings	Dark green	Green	Dark green	Green	White	White
New buildings	Dark green	Green	Dark green	Green	White	White
Appliances	Green	White	Green	Green	White	White
Lighting	White	White	White	White	White	White
Transport	Green	Green	Dark green	Green	White	White

DARK GREEN = Several relevant policies are in place. **GREEN** = At least one relevant policy is in place. WHITE = No relevant policies have been identified in EE PAMS.

Highlights

- Spain achieved its 2016 energy efficiency target by 2010 and is close to achieving the 2020 target. While the recession has played a role in decreasing overall demand, the government has put in place a series of framework strategies on energy efficiency, with additional policies planned.
- In the transport sector, a key policy is the Efficient Vehicle Incentives Programme (PIVE, since October 2012). At EU level, the cross-sectoral Energy Efficiency Directive (EED) has been introduced.

Energy demand target

- The European Union is committed to an indicative target of 20% reduction in primary energy consumption by 2020 and 27% by 2030 (relative to a projected reference level), to be achieved jointly.
- Spain's recent National Energy Efficiency Action Plan 2014-2020 sets an objective of 26.4% reduction in primary energy consumption by 2020.

Suggested priorities, based on most recent IEA recommendations (2015)

- Introduce a coherent and well-balanced policy mix in the area of energy efficiency to help ensure energy demand and greenhouse gas emissions remain decoupled from economic growth when the economy begins to recover.
- Remove barriers to enable municipalities and companies to fully take advantage of the services offered by ESCOs.
- Increase energy efficiency in all modes of transport through a coherent and well-balanced set of tax measures, economic incentives, energy efficiency performance standards and information campaigns. Continue, and intensify, the promotion of public transport, electrification and gasification of road vehicles, but also encourage walking and cycling. Increase consumer awareness about the environmental and societal costs of all modes of mobility.
- Continue to support energy renovations of buildings and consider gradually increasing the funding for this purpose. Support financing mechanisms that increase private sector activity in buildings efficiency improvements.

- Strengthen the market surveillance regime of energy-related products to ensure it can detect non-compliant products, protect consumers and ensure a level playing field among manufacturers and dealers.

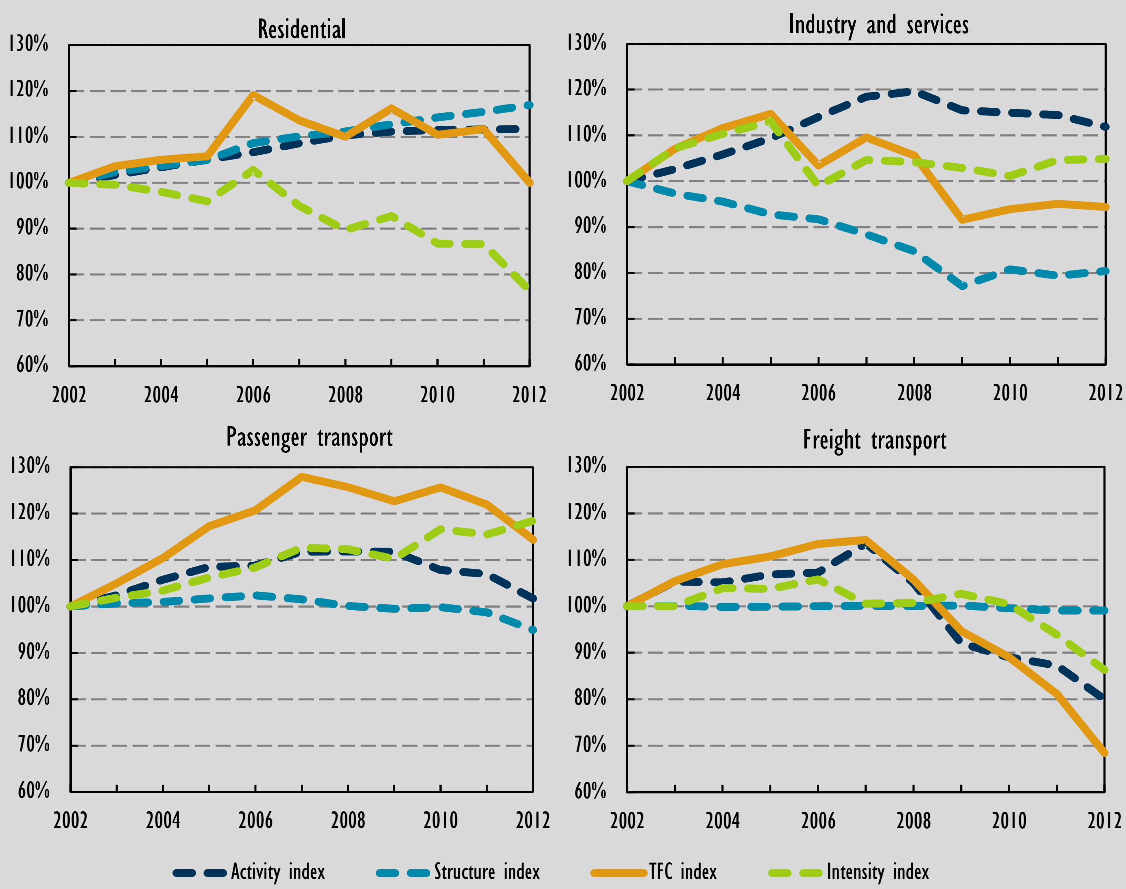
PRICE: Weighted price of one unit of energy, percentage increases, 2002-14

Household	Industry	Industry and households
39%	47%	44%

PERFORMANCE: Change in TFC in 2012 relative to 2002, decomposed

	Total	Residential	Industry and services	Passenger transport	Freight transport
TFC	-7.0%	-0.05%	-5.63%	14.43%	-31.55%
Activity effect	3.0%	12%	12%	2%	-20%
Structure effect	-9.3%	17%	-20%	-5%	-1%
Efficiency effect	**-1.8%**	-24%	5%	18%	-14%

Sector decompositions of energy use



Note: Results shown are multiplicative (rather than additive).

SWEDEN ENERGY EFFICIENCY MARKET SNAPSHOT

POLICIES: Coverage by type and sector based on the IEA EE PAMS database

	Regulatory instruments	Policy support	Economic instruments	Information and education	Voluntary approaches	RD&D
Cross-sectoral	Dark green	Dark green	Dark green	Green	Green	Green
Energy utilities			Green			
Industry	Green		Green	Green	Green	
Existing buildings	Green	Green	Green	Green	Green	Green
New buildings	Green	Green	Green	Green	Green	Green
Appliances	Green		Green		Green	Green
Lighting						
Transport	Green	Green	Green	Green	Green	

DARK GREEN = Several relevant policies are in place. **GREEN** = At least one relevant policy is in place. WHITE = No relevant policies have been identified in EE PAMS.

Highlights

- Sweden has implemented a number of industrial energy efficiency programmes and framework climate and energy policies; it also has carbon and energy taxes, and is subject to EU legislation.

Energy demand target

- The European Union is committed to an indicative target of 20% reduction in primary energy consumption by 2020 and 27% by 2030 (relative to a projected reference level), to be achieved jointly.
- In 2009, Sweden adopted a target of a 20% reduction in energy intensity between 2008 and 2020.

Suggested priorities, based on most recent set of IEA recommendations (2013)

- Review energy efficiency policies with a view to prioritising and scaling up high-potential, cost-effective energy saving measures for the 2030 and 2050 objectives.
- Increase energy efficiency across the whole energy system, by mobilising demand-side services, promoting energy savings in industry and energy efficiency in the heat sector.
- Consider measures that encourage private finance and enable the market for Energy Performance Contracting to further improve energy efficiency in the industry sector.
- Evaluate progress in renovation and consider future tightening of minimum energy performance requirements in building codes, with the goal of reaching zero-energy buildings. Publish clear guidelines for the enforcement of building energy codes that include a review of compliance at both the design stage and after building construction.
- Collaborate with private financial institutions to develop frameworks that facilitate energy efficiency financing, particularly for deep building retrofits.
- Take leadership to promote ambitious, binding fuel-economy standards for heavy-duty vehicles within the European Union.
- Implement a programme to certify energy managers and auditors to ensure that high quality, standardised and industry-specific information is provided by qualified and trained individuals and companies.

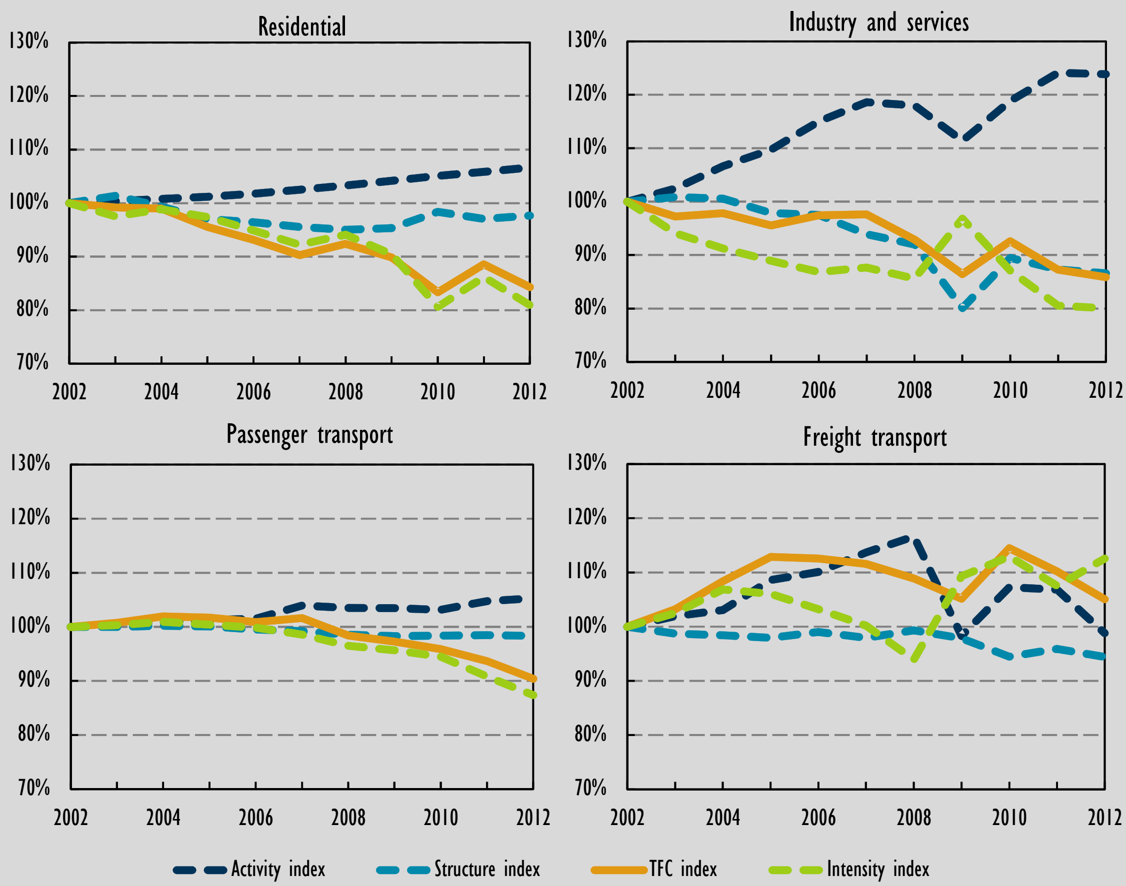
PRICE: Weighted price of one unit of energy, percentage increases, 2002-14

Household	Industry	Industry and households
36%	57%	43%

PERFORMANCE: Change in TFC in 2012 relative to 2002, decomposed

	Total	Residential	Industry and services	Passenger transport	Freight transport
TFC	-12.5%	-15.68%	-14.14%	-9.56%	5.06%
Activity effect	14.6%	6.65%	23.85%	5.28%	-1.16%
Structure effect	-9.0%	-2.31%	-13.4%	-1.66%	-5.58%
Efficiency effect	**-16.7%**	-19.07%	-19.94%	-12.65%	12.58%

Sector decompositions of energy use



Note: Results shown are multiplicative (rather than additive).

UNITED STATES ENERGY EFFICIENCY MARKET SNAPSHOT

POLICIES: Coverage by type and sector based on the IEA EE PAMS database

	Regulatory instruments	Policy support	Economic instruments	Information and education	Voluntary approaches	RD&D
Cross-sectoral	Dark green	Dark green	Dark green	Dark green	Green	Green
Energy utilities	Green	White	Dark green	Green	White	Green
Industry	Green	White	Green	Dark green	Green	Green
Existing buildings	Green	Green	Dark green	Dark green	Green	Green
New buildings	Dark green	Green	Dark green	Dark green	Dark green	Green
Appliances	Green	Green	White	Green	Green	Green
Lighting	Green	Green	Green	White	Green	Green
Transport	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green

DARK GREEN = Several relevant policies are in place. **GREEN** = At least one relevant policy is in place. WHITE = No relevant policies have been identified in EE PAMS.

Highlights

- The United States has broad policy coverage by type and sector, in particular at state level, with possible room for development in some sectors. Economic instruments and information measures seem to be preferred, and the transport sector has the largest number of dedicated policies.
- Recent policies and measures include standards for electric motors and other equipment and appliances, and proposals for the extension of truck fuel efficiency standards.

Energy demand target

- The United States has a target of cumulative energy savings exceeding 200 billion kWh in addition to current energy savings by 2025 compared to 2008.
- Other targets include: phasing out the use of incandescent light bulbs by 2014, and improving lighting efficiency by more than 70% by 2020; all new federal buildings to be carbon-neutral by 2030; reducing federal agency building energy intensity in 2016-25 by 2.5% annually; from 2020, all new construction of federal buildings greater than 5 000 gross square feet designed to achieve energy net-zero and, where feasible, water or waste net-zero by fiscal year 2030; reducing CO_2 emissions by 3 Gt cumulatively by 2030 through energy efficiency standards (Nachmany et al., 2015).

Suggested priorities, based on most recent IEA recommendations (2014)

- Prioritise funding to support state and local energy efficiency policies, especially model building energy codes and energy efficiency resource standards. Strengthen existing programmes (e.g. the Safety and Environmental Enforcement Action Network) and launch new initiatives such as the proposed "Race to the Top" grant for state energy efficiency policy.
- Review the results of tax incentives for residential and commercial energy efficiency improvements at the state and federal levels, and develop a more efficient and effective tax incentive structure for the renovation of buildings.

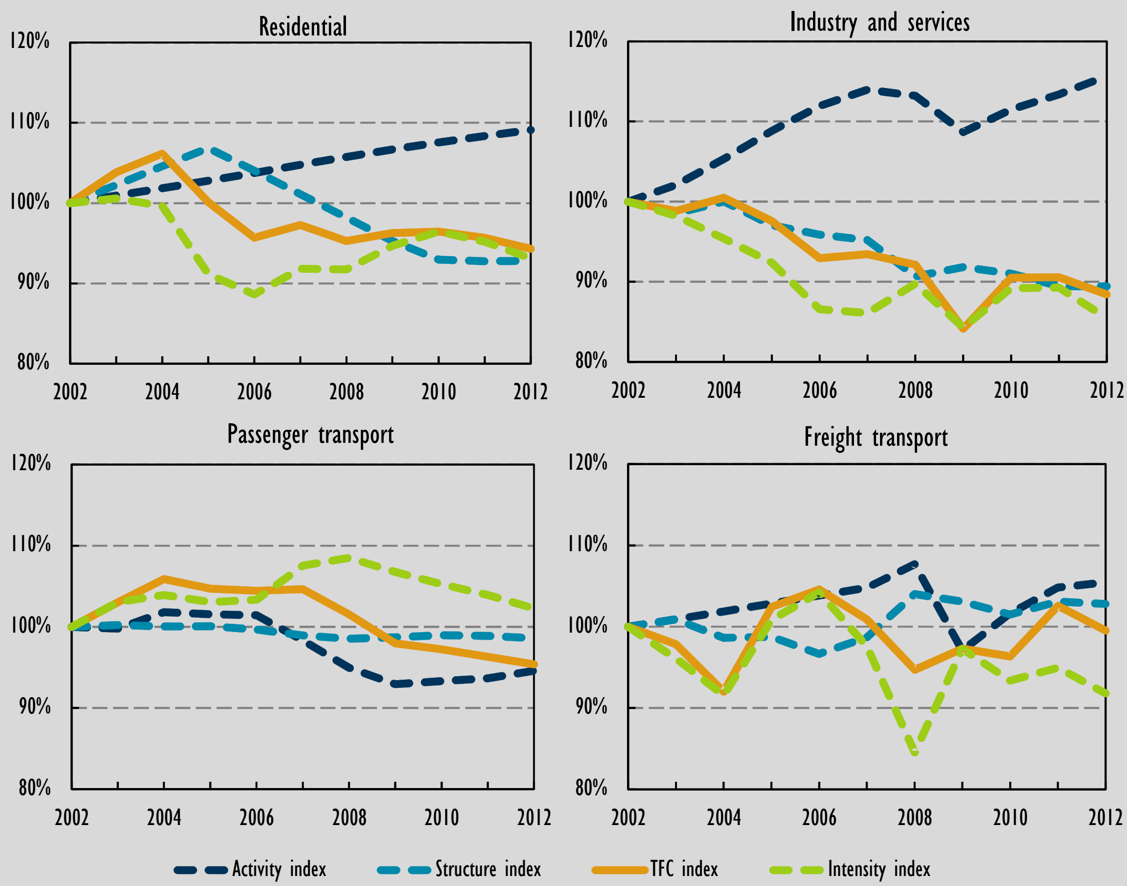
PRICE: Weighted price of one unit of energy, percentage increases, 2002-14

Household	Industry	Industry and households
54%	47%	52%

PERFORMANCE: Change in TFC in 2012 relative to 2002, decomposed

	Total	Residential	Industry and services	Passenger transport	Freight transport
TFC	-6.8%	-5.67%	-10.82%	-4.62%	-0.45%
Activity effect	5.6%	9.13%	15.65%	-5.4%	5.48%
Structure effect	-5.5%	-7.17%	-10.10%	-1.41%	2.79%
Efficiency effect	**-7.3%**	-6.89%	-14.23%	2.27%	-8.19%

Sector decompositions of energy use



Note: Results shown are multiplicative (rather than additive).

Snapshots main findings

Acknowledging that five countries is a limited sample, the Snapshots do provide some interesting insights when examined collectively. Whatever the results shown in the Snapshot for a particular country, it remains the case that *all* countries need to scale up investment in energy efficiency, from both public and private sector sources (at EU level, much of this is being done by the member states).

Policy

The Snapshots show the diversity of policy options that have been put in place, but the matrix clearly demonstrates that relevant policies are not yet implemented across the board. Policies directed at the buildings sector are the most widely implemented, followed by cross-sectoral policies and policies directed at transport. New buildings are almost as well covered as existing buildings, despite their much smaller share of the building stock. Energy utilities and lighting are the least well-covered sectors in EE PAMS, though in Europe lighting and appliances are covered by EU-wide Directives that are binding in all member states and there is not much scope for further policy development at national level in those sectors.

Information and education, and economic instruments are the most widely implemented policy types, followed by regulation. This may be important when considering the relative effectiveness of different policy types (information and education is usually considered to be much less effective than regulation for example). As for RD&D, energy efficiency may be covered under broader research programmes in many countries, which means it is less visible and also harder to ring-fence and monitor. There is also often a misperception that energy efficiency technologies are already fully mature.

Matching policy types to sectors shows that different policy types are being chosen depending on the sector. Economic instruments and policy support are the most likely to be applied across sectors. Information and education is the most common type in the industry and buildings sectors. Appliances are subject to a combination of regulatory and information measures. Lighting policies tend to lean more towards regulation, while the transport sector is subject equally to economic instruments and information measures.

Countries may wish to examine thoroughly their policy portfolios and implement or strengthen policies in weak areas. In some areas, countries can learn from each other; other areas still lack best practice examples.

Price

The countries assessed have seen quite strong energy price increases over the period 2002-14, ranging from 33% for Australia up to 52% in the United States for the combined industry and households index. The three European countries lie within that range. The price pillar may be a more important driver in the industry sector than in the residential sector: industry prices rose significantly faster than household prices in all countries except the United States. It should also be noted that prices will vary greatly within countries, especially in larger and federal countries such as the United States.

Performance

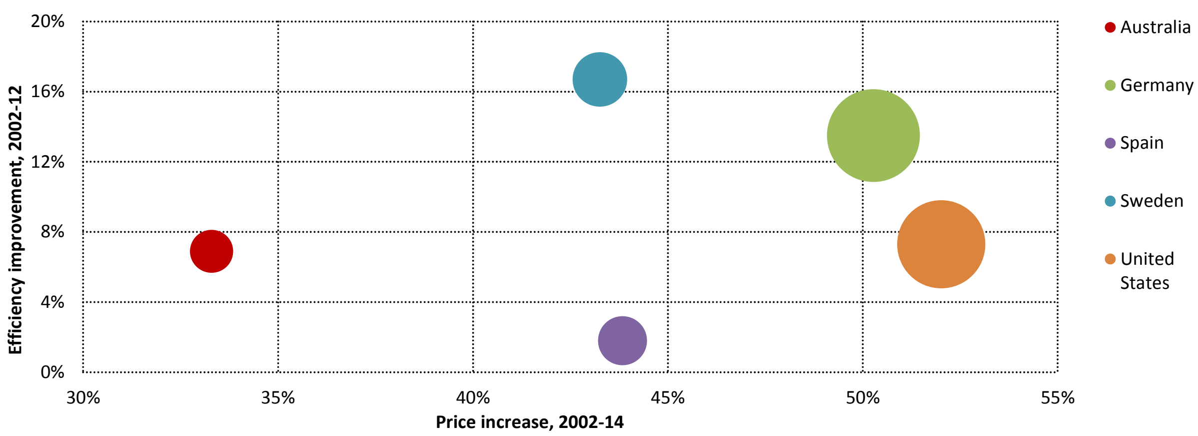
The overall efficiency effect at country level between 2002 and 2012 ranges from -16.7% in Sweden (the biggest improvement) to -1.8% in Spain. However, the decompositions at sector level are more informative. In the residential sector, for example, Spain had the largest efficiency effect at -24%. Meanwhile, the efficiency effect in Sweden's freight transport sector was 12.6%.

Policy, price and performance pillars collectively

Even across this small sample of Snapshots, there is evidence that more energy efficiency policies have been introduced in countries that are experiencing larger price increases (Figure 5.1). Of the five countries examined in this report, efficiency market potential seems particularly high in Germany, though all countries have challenges and opportunities. In Australia, the federal government has been reforming efficiency programmes and institutions over the past year or two, so the situation is changing rapidly. However, prices and other factors, including at state level, have driven reductions in absolute nationwide electricity demand in the past few years. Most energy policy in the United States has been made at state rather than federal level as well, and the main drivers may be market rather than policy factors.

A number of important caveats should be considered when attempting to evaluate the Snapshots. Relatively large countries, such as Germany and the United States, may have more capacity to implement a greater number of policies. Countries with federal systems of government such as the United States, Australia, Spain and Germany may not have complete coverage of subnational energy efficiency policies in the EE PAMS database. Those two factors may affect policy coverage as shown in the Snapshots and could increase the total number of policies and measures submitted to EE PAMS, which is the metric used in Figure 5.1. Australia may have policies at the subnational level in the utilities sector that have not yet been submitted to EE PAMS. European Union member states may be under-represented in EE PAMS, if they do not include in their reporting the common EU legislative and regulatory framework (e.g. Energy Efficiency Directive in the cross-sectoral category, EPBD for buildings, Ecodesign and energy labelling for appliances, etc.). That said, the comprehensive EU framework is being implemented with variable speed and depth in different countries.

Figure 5.1 Policy (size of bubble), price (x-axis) and performance (y-axis) pillars by country



Note: Bubble size refers to the total number of policies currently in force according to the IEA EE PAMS database.

The countries with the most favourable Snapshots are not necessarily world leaders in the active pursuit of energy efficiency measures, particularly considering the sample is of only five countries. Also, the Snapshot exercise is constrained by the fact that it assesses all countries on the same basis, even though they are diverse in regards to economies, policy-making processes, size, institutions, public opinion, etc.

The Snapshots aim to provide additional information for decision makers (both investors and policy makers) as to which countries have mature frameworks for an energy efficiency market, and thus are most primed for private sector participation. Specific investment or policy decisions would, of course, also have to take into account other country factors such as: market conditions, macroeconomic stability, financial environment, other assessments and rankings (Box 4), etc.

Box 5.4 Energy efficiency country rankings

The Energy Efficiency Market Snapshots did not aim to produce a ranking, although other organisations have attempted to do so, two of which are described below. Such rankings can serve as a complement to the Snapshots.

The World Bank assesses government support for energy efficiency through the **Readiness for Investment in Sustainable Energy (RISE)** project, a suite of indicators that encompasses policies and regulations relevant for attracting investments. RISE is a product of the World Bank knowledge hub of the SE4All initiative, and so covers each of the three SE4All pillars: energy efficiency, energy access and renewable energy. RISE focuses on elements that policy makers can take action on including, for energy efficiency, government plans and commitments to improve energy efficiency, how energy usage and price information is provided to consumers, energy efficiency obligations and incentives for utilities and major public and private consumers, energy performance standards and labels, building energy codes, and electricity prices and subsidies. Unlike the Snapshots in this report, RISE does not directly measure final outcomes such as energy intensity, nor does it assess broader macroeconomic or political conditions that may influence investment.

RISE indicators were developed through extensive consultation with sector experts, including the IEA, to reflect a set of benchmarks comprising good practices. Each indicator is weighted equally and scored on a scale from 0-100. Countries are not given overall numerical scores or ranks, but performance on each pillar can be directly calculated and compared. The initial RISE pilot covered 17 countries in 2014, and results can be seen at http://rise.worldbank.org. A full global edition covering over 100 countries is planned for release in early 2016.

The American Council for an Energy-Efficient Economy (ACEEE) produces an annual states energy efficiency scorecard and a biannual International Energy Efficiency Scorecard (IEES) (Young et al., 2014). The most recent edition (2014) covers 16 countries, ranked as follows (those bolded are also covered here in the Snapshots): **Germany** (first), Italy, the European Union, France, the People's Republic of China, Japan, United Kingdom, **Spain**, Canada, **Australia**, India, Korea, the **United States**, Russian Federation ("Russia"), Brazil, Mexico. The IEES uses 31 metrics divided roughly half and half between policies and performance.

Each metric has sub-metrics that determine the ultimate scoring. For example, the point allocation for appliance and equipment standards and labelling awards 5 points for countries with 35 appliance and equipment standards, 4 points for countries with 30 standards, with the score decreasing down to 1 point for countries with only 15 standards.

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Stanwix, G., Pham, P. and A. Ball (2015), *End-use energy intensity in Australia*, Department of Industry and Science, Canberra, June.

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6. BRAZIL

Summary

Brazil has a long and well-established portfolio of successful energy efficiency programmes. These have primarily been funded by the government and by leveraging private investment, predominantly through electricity distributors. Electricity distributors and Eletrobras, a majority state-owned electricity company, invested at least BRL 1.89 billion (Brazilian Real) (USD 530 million)[1] in energy efficiency programmes from 2012 to 2014. However, overall investments in energy efficiency are down from a peak in 2011, due to scaled back government funding as a result of fiscal stresses in Brazil, particularly for the national energy efficiency flagship PROCEL programme. The recent fall in hydropower generation and the related high electricity prices are expected to fuel increased interest in energy efficiency. The Brazilian Economic and Social Development Bank (BNDES) is providing country-wide support to leverage private sector investment.

Energy profile and context

Brazil enjoys vast renewable and fossil fuel energy sources and has achieved virtually universal access to electricity for its population, which is spread across a vast territory. The country has one of the least carbon-intensive energy sectors in the world with almost 45% of the country's primary energy demand met by renewable energy. It is the second-largest producer of hydropower in the world (391 TWh, which represented 10% of global hydropower generation in 2013). In 2013, about 68.6% of domestic electricity generation was from hydropower. One of the key challenges, despite its potential for additional hydropower, is the limited accessibility to potential areas in the Amazon region which are far away from the large centres of electricity demand. Added to this are environmental and social sensitivities, as well as the variability in rainfall. This variability resulted in electricity supply challenges in 2001-02 and 2014-15.

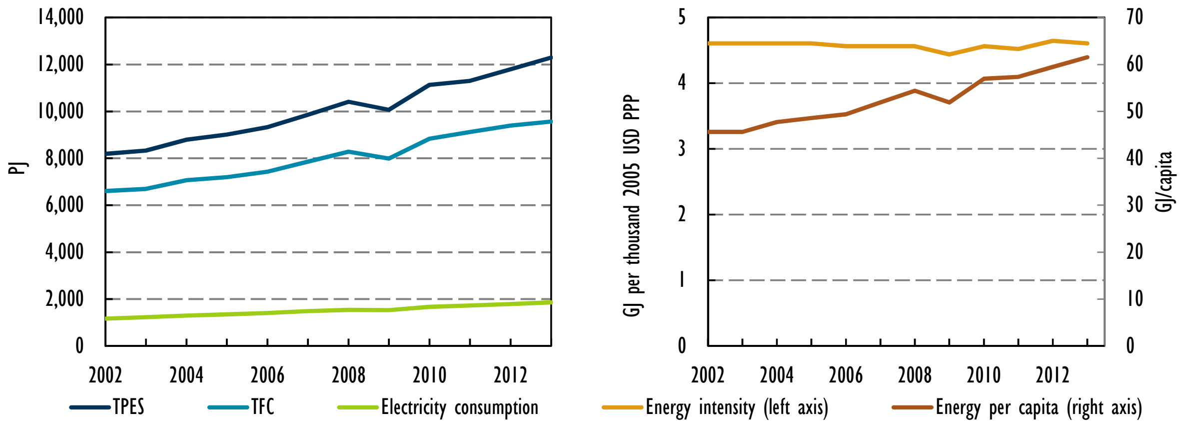
Energy consumption growth is closely coupled with gross domestic product (GDP) in Brazil. A growing middle class has led to increases in vehicle ownership, which has tripled since 1990. It has also led to an increase in the number of electrical appliances in households and to growth in residential and commercial electricity use by about 5.0% annually, slightly higher than the average annual growth rate of 4.6% for the same sectors across the Latin American and Caribbean region[2] from 2002 to 2013.

As shown in Figure 6.1, total primary energy supply (TPES) reached 12 296 petajoules (PJ), while total final consumption (TFC) reached 9 564 PJ in 2013. Electricity consumption also rose to 517 TWh in 2013 (Figure 6.1). Despite the recent economic downturn, TPES, TFC, electricity consumption, and energy consumption increased in 2012 and 2013 but at a lower rate than in 2011. Energy intensity has remained relatively unchanged since 2002 and decreased by 0.9% from 2012 to 2013, potentially reflecting the economic slowdown and structural changes.

[1] Exchange rate used from 24-08-2015: 1 BRL = 0.280825 USD.

[2] Non-OECD Americas.

Figure 6.1 TPES, TFC, electricity consumption, energy intensity, and energy use per capita, 2002-13

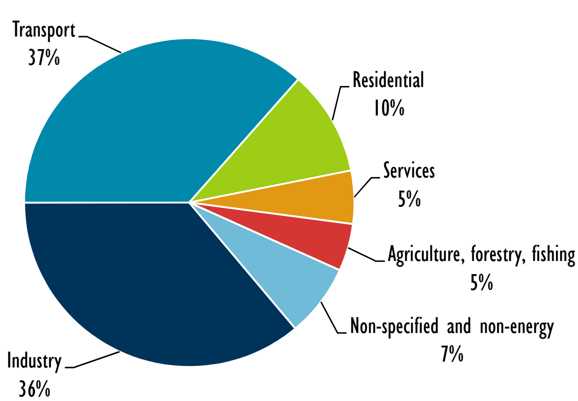


Source: IEA (2015), *Energy Balances of non-OECD Countries 2015*, OECD/IEA, http://dx.doi.org/10.1787/energy_non-oecd-2015-en.

The transport and industrial sectors account for the largest shares of TFC (Figure 6.2). In 2013, for the first time since 1971,[3] the TFC for the transport sector surpassed the industrial sector by a small margin. Biofuels make up 15% of transport demand and compressed natural gas has become common in taxi fleets in the cities of Rio de Janeiro and São Paulo. Brazil requires gasoline to be blended with ethanol (18-27.5%), which supports the biofuel industry (Senado Federal, 2014).

Industrial sector energy consumption has experienced a downward trend since 2012. The iron and steel industry represent about 20% of total energy consumption for the sector and are predominant in most of the country except in the southern and mid-western regions, where the production of food products is the principal industrial electricity consumer (EPE, 2014a). The industrial sector in Brazil has one of the highest average electricity tariffs in the world (USD 178/megawatt hour [MWh]), lower only than Japan and Italy.

Figure 6.2 TFC per sector, 2013

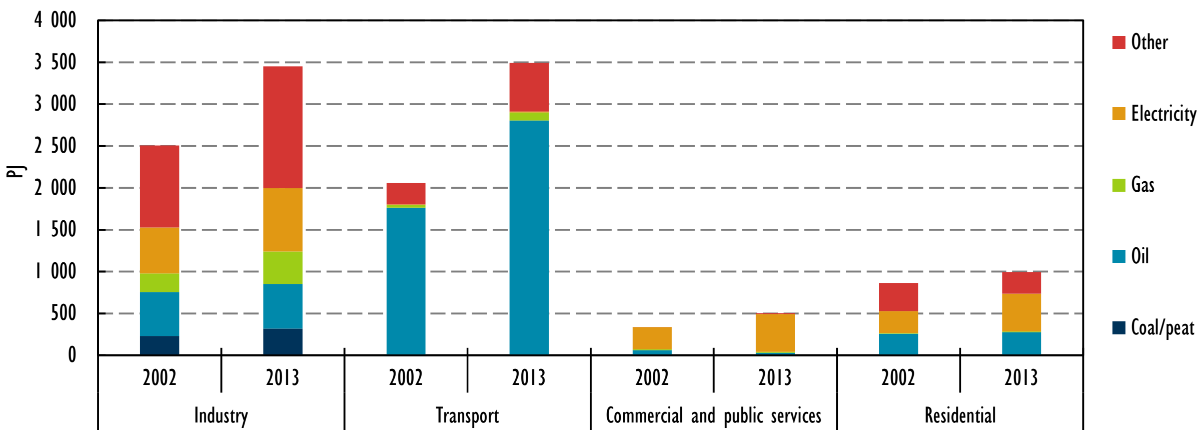


Source: IEA (2015), *Energy Balances of non-OECD Countries 2015*, OECD/IEA, http://dx.doi.org/10.1787/energy_non-oecd-2015-en.

[3] Year that IEA started collecting energy data for Brazil.

Transport sector TFC increased at an average rate of approximately 4.8% annually, showing the highest increase in TFC per sector from 2002 to 2013 (Figure 6.3). In the industrial sector, "other fuel sources" such as biofuels and waste experienced the highest increase in TFC. In the transport sector, TFC of oil and biofuels increased significantly. Despite a small rise of TFC in the residential, commercial, and public services sectors, the buildings sector accounts for approximately 48.0% of total electricity consumption with growth rates of 6.1% for the residential sector and 5.7% for the commercial sector.

Figure 6.3 TFC by sector and by energy source, 2002 and 2013



Source: IEA (2015), *Energy Balances of non-OECD Countries 2015*, OECD/IEA, http://dx.doi.org/10.1787/energy_non-oecd-2015-en.

Market driver: Energy efficiency policies and programmes

The government has a long and extensive history of promoting energy efficiency policies and programmes. Energy efficiency policy in Brazil is planned by the Ministry of Mines and Energy (MME) and implemented primarily by several agencies including Eletrobras and the Brazilian Electricity Regulator (Agência Nacional de Energia Elétrica – ANEEL).

Government funding has been an important part of energy efficiency efforts, mainly through the National Fund for Scientific and Technological Development and, until recently, the Global Reversion Reserve (RGR) (described in more detail later in the chapter) as well as electricity distributors and the national utility, Eletrobras. This support has enabled the implementation of key energy efficiency programmes that have had a considerable impact on the energy efficiency market. These programmes include the National Electricity Conservation Programme (*Programa Nacional de Conservação de Energia Elétrica* – PROCEL) and the Energy Efficiency Programme (*Programa de Eficiência Energética das Concessionárias de Distribuição de Energia Elétrica* – PEE) which invested over BRL 1.89 billion (USD 530 million) in energy efficiency from 2012 to 2014 and are described below.

National Energy Efficiency Plan

The National Energy Efficiency Plan (*Plano Nacional de Eficiencia Energética* – PNEf) provides an overarching national energy efficiency policy framework. It was introduced in 2011 to provide direction and establish the necessary actions to reach an electricity consumption reduction target of 10% (107 TWh) by 2030 as indicated in the National Energy Plan for 2030 (*Plano Nacional de Energia* – PNE 2030) (EPE, 2014b).

National Electricity Conservation Programme (PROCEL)

PROCEL is a federal government programme, managed by Eletrobras, to raise awareness and promote innovation in energy efficiency in the electricity sector. PROCEL includes a wide range of sub-programmes such as the energy labelling programme for appliances and equipment *(Selo PROCEL*), the industrial energy efficiency programme (*PROCEL Indústria*), a street lighting programme (*PROCEL Reluz*), an energy efficiency in buildings programme (*PROCEL Edifica*) and many others:

1. The **Selo PROCEL**[4] is a voluntary endorsement label covering 39 categories of appliances with about 177 participating manufacturers. More than 59 million PROCEL labelled appliances were sold in 2014.

2. The **PROCEL Reluz Programme** for energy-efficient street and traffic lighting has replaced 2.7 million street lighting points across the country since 2000. In 2013 alone, 62 000 points were retrofitted in six municipalities in a BRL 23 million (USD 6.5 million) investment that resulted in estimated electricity savings of 157 gigawatt (GWh) and approximately 36 MW generation capacity reduction (PROCEL, 2015a). From 2014 to 2018, the projected investment will amount to BRL 187 million (USD 52.5 million) for 1 million streetlights across 12 municipalities. Part of the investment will be made through a PROESCO financing line from the Brazilian Economic and Social Development Bank (*Banco Nacional de Desenvolvimento Económico e Social – BNDES*) to promote investments of energy service companies (ESCO) (PROCEL, 2015a).

3. The **PROCEL Edifica** has had a voluntary labelling programme since 2014 for energy-efficient buildings and has funded BRL 30.5 million (USD 8.6 million) of energy efficiency projects in residential, commercial, services and public buildings. More than 2 100 labels have been issued since 2009. Approximately BRL 25 million (USD 7.0 million) of the PROCEL Edifica funds were used for the development of building labelling regulations including research on energy efficiency and thermal comfort in buildings and development of publications. An additional BRL 5 million (USD 1.4 million) was used for development and capacity building of laboratories to evaluate energy efficiency and thermal comfort in buildings, and BRL 0.5 million (USD 140 thousand) was used to promote energy efficiency projects and the sharing of international experience. The label will become mandatory in 2020 for public buildings, in 2025 for commercial buildings and in 2030 for residential buildings (PROCEL, 2015a).

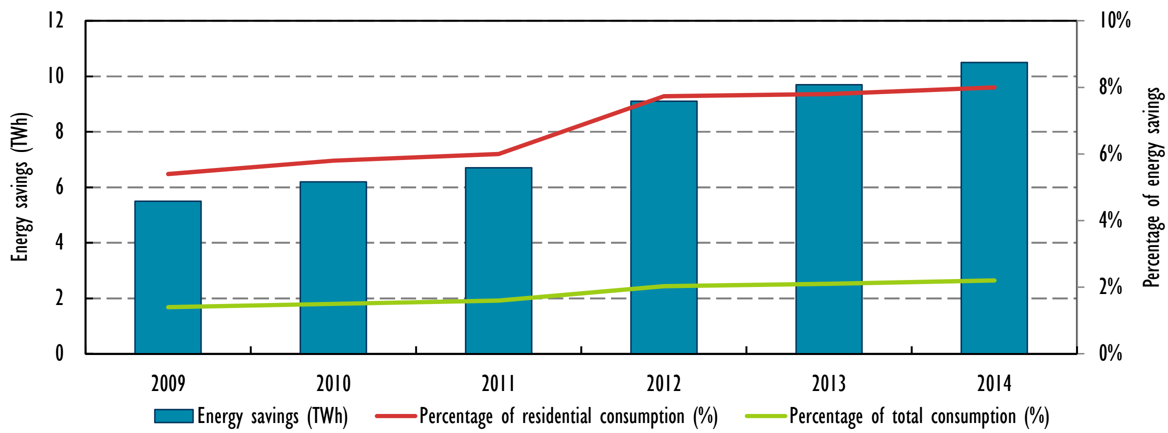
In 2014, PROCEL invested a total of BRL 18 million (USD 5.1 million) in the programmes mentioned above and achieved an estimated 10.5 TWh savings (Figure 6.4). From 1986 to 2014, cumulative electricity savings amounted to 80 TWh, with total cumulative investment of BRL 925 million (US 259.8 million) from Eletrobras's own resources and BRL 1.47 million (USD 413.1 million) from the RGR.

However, annual investment in the PROCEL programme decreased substantially from BRL 114 million (USD 32 million) in 2011 to BRL 36 million (USD 10.1 million) in 2013 and decreased further

[4] Brazil also has a comparative energy labelling scheme (*Programa Brasileiro de Etiquetagem - PBE*) which is managed by the National Institute of Metrology, Quality and Technology (*Instituto Nacional de Metrologia, Qualidade e Tecnologia – INMETRO*). The Selo PROCEL is given to quality appliances with the highest energy efficiency rating under the PBE (i.e. A).

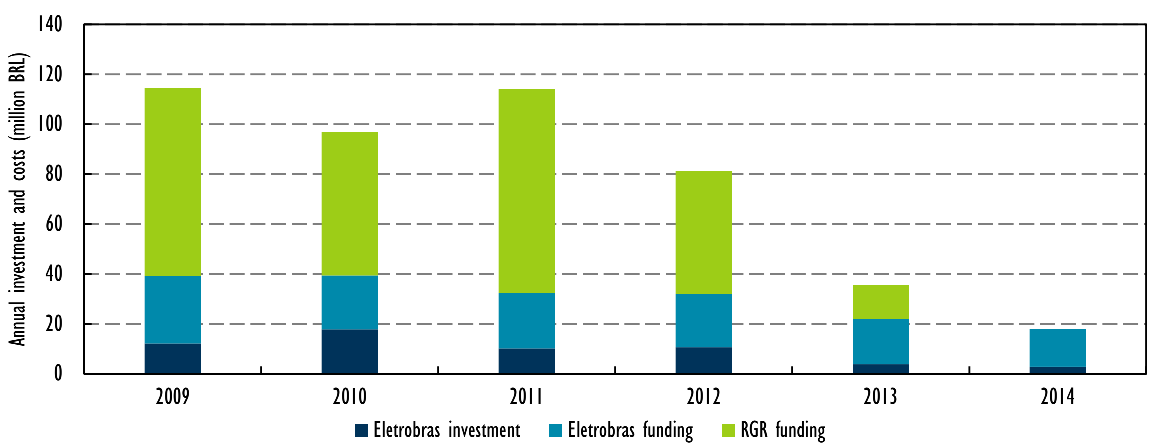
to BRL 18 million (USD 5.1 million) in 2014 (Figure 6.5). The main reason for this fall is the retargeting of the RGR, which partially funds PROCEL (up to 70% in 2011), to subsidise electricity prices by 20% in 2012 and 2013. In 2014, PROCEL received no funding following the discontinuation of the RGR (PROCEL, 2015a). Nevertheless, PROCEL continues to deliver substantial energy savings as a result of previous and ongoing programmes.

Figure 6.4 Estimated energy savings from PROCEL programme in relation to total electricity consumption from 2009 to 2014



Source: PROCEL (2015a), *Resultado do Procel 2015 – Ano Base 2014* , *Programa Nacional de Conservação de Energia Elétrica*, www.procelinfo.com.br.

Figure 6.5 Annual funding of the PROCEL programme from 2009 to 2014



Source: PROCEL (2015a), *Resultado do Procel 2015 – Ano Base 2014* , *Programa Nacional de Conservação de Energia Elétrica*, www.procelinfo.com.br.

Energy efficiency obligation scheme for electricity distributors: the PEE

While PROCEL is a government-led initiative that relies heavily on its majority state-owned enterprise, Eletrobras, Brazil has also created a partially market-led[5] energy efficiency programme

[5] Although triggered by a government obligation which also states that 60% of the investment must be directed to low-income residential consumers.

through the Brazilian Energy Regulator (ANEEL). The Energy Efficiency Programme, (*Programa de Eficiência Energética das Concessionárias de Distribuição de Energia Elétrica – PEE*), invested a total of BRL 4.6 billion (USD 1.3 billion) between 1998 and 2013 resulting in annual energy savings equivalent to 8 500 GWh annually and peak demand reduction of 2.5 GW.

PEE, created in 1998, established obligations on the electricity distributors to invest in energy efficiency. It was designed to demonstrate the importance and economic viability of energy conservation measures and energy efficiency improvements in equipment and processes. In the first years of the programme, investments focused mainly on reducing energy losses in the distribution grid, improving the energy efficiency of street lighting, and providing energy audits in the industrial, commercial, and services sectors. More recently, most of the investments covered energy management optimisation, in some cases in partnership with ESCOs.

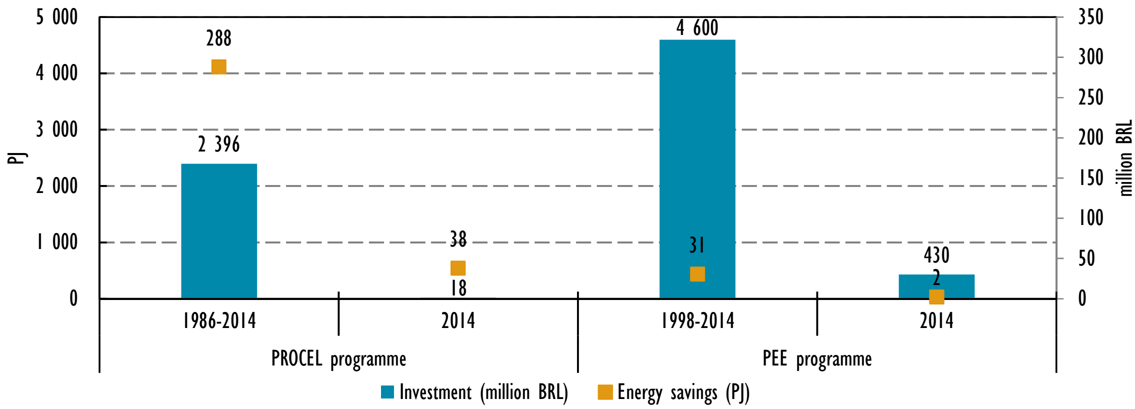
Pursuant to Law 9.991 in 2000, electricity distributors were obliged to invest at least 0.50% of their annual net revenue in energy efficiency activities. The obligation will be reduced to 0.25% starting in 2016, which may slow the development of the energy efficiency market in Brazil. In an effort to address fuel poverty, in 2010, at least 60% of the energy efficiency investment under the PEE was required to be for low-income residential consumers (an increase from the 50% requirement established as of 2005).

In 2013, the electricity distributors initiated 125 energy efficiency projects worth BRL 430 million (USD 120.8 million) with estimated annual energy savings of 544 GWh and a peak demand reduction of 163 MW. With the fall in electricity revenue in 2013, energy efficiency investments under the PEE decreased by more than half to BRL 342 million (USD 96.0 million) in 2014 from BRL 712 million (USD 199.9 million) in 2011. An additional decrease is expected over the next couple years, particularly in 2016 when the obligation changes from 0.50% to 0.25% (ANEEL, 2013).

Current energy efficiency market activity

PROCEL and PEE are the main drivers for energy efficiency in the country. Figure 6.6 shows the investment made by PROCEL and PEE in 2014 as well as throughout their lifetimes of 27 and 15 years, respectively. Their combined investment was approximately BRL 7 billion (USD 1.97 billion), up to 2014.

Figure 6.6 Investment and energy savings achieved by the PROCEL and PEE programmes



Source: Adapted by IEA from ANEEL (2013), *Eficiência Energética – A busca da articulação entre ações de incentivo, ANEEL*, available at: www.aneel.gov.br/arquivos/PDF/revista_pee_2013.pdf.

BNDES, the national development bank, is very active in the energy efficiency market. BNDES is providing the following financing options specifically to support energy efficiency:

1. The **PROESCO programme** was established in 2006 to support the implementation of projects that improve the energy efficiency of lighting, motors, optimisation of processes, compressed air, pumping, air conditioning and ventilation, refrigeration and heating, and many others. The programme offers a BRL 100 million (USD 28.1 million) credit line and financing up to 80% of the total project value to final energy users who purchase new energy-efficient equipment. From 2006 to March 2015, the PROESCO programme financed 43 projects worth approximately BRL 500 million (USD 140.4 million), equivalent to BRL 55 million per year (USD 15.4 million), with the majority of projects in the commercial/services sector. For example, in 2012 the programme funded the replacement, purchase, and modernisation of equipment for an electric utility in the amount of BRL 35.5 million (USD 10.0 million) (74.6% of the total investment). The project generated savings of approximately 70 GWh per year (BNDES, 2012).

2. The innovative micro, small, and medium-size companies (**MPME Inovadora**) programme was introduced in June 2014 in partnership with PROCEL Edifica and the National Institute of Metrology, Standardisation and Quality (*Instituto Nacional de Metrologia, Qualidade e Tecnologia* – INMETRO). The objective is to support projects that increase the productivity and efficiency of the commercial and services sector, especially tourism. This programme includes a permanent line of credit for new buildings with an energy label level A (highest efficiency), and for refurbished buildings that obtain an energy label level of A or B. The interest rate under this programme is reduced from the standard rate of 3.0% to 1.5% per year. Energy audits need to be conducted by an ABESCO registered and certified ESCO to be eligible for the loan. The BNDES will finance up to 90% of the total value of the investment with minimum loans of BRL 20 million (USD 5.6 million) (PROCEL, 2015b).

BNDES has a number of other energy financing programmes that also fund the replacement of existing equipment with high efficiency equipment. Consequently, the bank's investment in energy efficiency is likely to be much higher than mentioned above. However, at the moment, there is no breakdown of how much was invested for energy efficiency projects.

Box 6.1 The Energy Efficiency Guarantee Mechanism

The Inter-American Development Bank (IDB), in partnership with the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF), established a USD 25 million Energy Efficiency Guarantee Mechanism (EEGM) to stimulate investment from local banks in energy efficiency in existing commercial, industrial and public buildings, as well as strengthen the ESCO market in Brazil which is still small for the size of the country. The IDB and GEF provide the guarantees and financing, and the UNDP provides the capacity-building expertise under the Brazil: Market Transformation for Energy Efficiency in Buildings project. The EEGM is administered by an independent expert organisation selected by IDB.

The EEGM will be available from 2013 to 2018 with an additional seven-year monitoring process afterwards (until 2025). The EEGM provides two types of partial credit guarantees directed at ESCOs, equipment providers and others:

- a technical risk guarantee in case the energy efficiency project underperforms
- a comprehensive risk guarantee covering both technical and financial underperformance.

Box 6.1 The Energy Efficiency Guarantee Mechanism (continued)

The guarantee will cover up to 80% of the value of the energy efficiency investment (including installation, labour and equipment) up to a limit of USD 1.6 million. The minimum investment required is USD 100 000.

The ESCO market in Brazil is expected to benefit from this mechanism and obtain lower interest rates, and higher and longer loan periods because of the lower risk of investment and quicker approval process with local Brazilian banks.

As of June 2014, the EEGM had completed four projects worth USD 1.6 million with an additional three projects in the pipeline worth USD 4.5 million. The projects focused mainly on energy efficiency, with Banco Indusval and Partners being one of the most active participants. The uptake of guarantees increased particularly in December 2014, potentially as a response to the rise in electricity prices (IDB, 2015).

Main energy efficiency funding sources

The Brazilian government has established two main funding sources for energy efficiency:

1. The **National Fund for Scientific and Technological Development** (*Fundo Nacional de Desenvolvimento Científico e Tecnológico* – FNDCT) is managed by the Funding Authority for Studies and Projects (*Financiadora de Estudos e Projectos* – FINEP) and supports innovative technologies that increase energy efficiency, build national capacity and enable the increase in competiveness of the national industrial sector. In 2013, the FNDCT under its CT-ENERG component secured BRL 47 million (USD 13.2 million) to finance several innovative energy projects including energy efficiency (Ambiente Energia, 2013; Finep, 2013).

2. The **Global Reversion Reserve** (*Reserva Global de Reversão* – RGR) was the main funding source for the PROCEL programme with BRL 277.4 million (USD 63.9 million) disbursed from 2009 to 2014 (60% of total funding). It comprised a certain percentage of the revenue of electricity public service companies, collected by the national electricity utility Eletrobras, and used for expansion and improvement of the quality of their services. However, this fund was eliminated by Law 12.783/2013, which established that the revenues from electricity public service companies could no longer be charged. The remaining funds were transferred to the Energy Development Bill (*Conta de Desenvolvimento Energético* – CDE) to be applied to other financing areas excluding energy efficiency.

Prospects for energy efficiency market activity

Energy efficiency funding from the government sector and electricity distributors is expected to decrease considerably for 2015 and 2016. High electricity prices could drive greater interest in energy efficiency investments but the lack of financing options from local banks, limited awareness and insufficient expert capacity in the country may slow the rate of actual investments. The public sector is anticipated to be active in areas such as street lighting, while residential sector expenditure on energy efficiency is likely to be prompted by rising minimum energy performance standards (MEPS) for incandescent light bulbs, leading to higher investment in energy-efficient alternatives such as light-emitting diodes (LEDs).

Even though government funding for energy efficiency is declining in the short term, the achievement of a variety of government targets will require additional investment in energy efficiency. The MME and the Energy Research Agency (*Empresa de Pesquisa Energetica* – EPE) have developed energy demand projections under the National Energy Plan for 2030 (*Plano Nacional de Energia* – PNE 2030) and also the Ten-Year Energy Expansion Plan for 2023 (*Plano Decenal de Expansão de Energia* – PDE 2023). The PDE 2023 forecasts approximately 795.5 PJ in energy savings by 2023, equivalent to approximately 20% of national oil consumption in 2013, with 49% coming from the industrial sector, 37% from the transport sector and 8% from the residential sector (Table 6.1). The projections for electricity savings alone would be about 54 TWh by 2023, equivalent to a 13 GW hydropower plant (EPE, 2014c). Energy savings in the industrial sector are based on the assumption that there will be improvements in industrial processes, while in the transport sector the energy savings result from improvement in fuel efficiency and technologies in vehicles. Achieving these savings will require substantial future investments in energy efficiency.

Table 6.1 Projections for final energy consumption and energy efficiency under the PDE 2023 (PJ)

Consumption*	2014	2018	2023	Growth 2014-23
Potential final energy consumption, without energy efficiency	10 708.9	12 987.2	15 515.4	44.9%
Energy savings	53.6	349.9	805.0	38.1%
Percentage of energy saved (%)	0.5	2.7	5.2	-
Energy savings per sector				**Share of total savings in 2023**
Industrial sector**	30.5	177.8	390.5	48.5%
Transport sector	14.5	112.3	299.4	37.2%
Services sector	3.1	16.0	34.7	4.3%
Residential sector***	3.8	36.7	65.8	8.2%
Agriculture and livestock sector	1.7	7.1	14.7	1.8%

Notes: * This corresponds to the total consumption of electricity in all sectors plus the consumption of fuels from the industrial, energy, agriculture and livestock, commercial, public and transport sectors. It does not include the consumption of fuels in the residential sector. ** Includes the power sector. *** Includes energy consumption in urban and rural households.

Source: EPE (2014c), Plano Decenal de Expansão de Energia 2023, www.epe.gov.br/Estudos/Documents/PDE2023.pdf.

Challenges

Although Brazil is aiming to mainstream energy efficiency, a number of important challenges persist. First, a number of stakeholders and institutions are involved in implementing energy efficiency policy and programmes in Brazil such as the MME, Eletrobras, ANEEL, EPE, electricity distributors and local energy departments. Consequently, the MME has a challenging task to co-ordinate, manage and integrate all activities across the country. Second, the reduction in public funding for energy efficiency programmes has created uncertainty for energy efficiency investors. For example, government funding directed to the PROCEL programme was used to subsidise electricity prices, and therefore was not available to fund energy efficiency investments. At the same time, the PEE programme budget is diminishing, with corresponding reductions in the amounts available for investment in energy efficiency. Finally, notwithstanding a noteworthy effort being made by a number of institutions to build the capacity of energy efficiency market actors, there is still a lack of qualified technical expertise and this will take some time to develop and mature.

Conclusions

Brazil has a long history of public support for energy efficiency investment, including longstanding programmes that have effectively used electricity companies to catalyse the market with important successes. However, the recent reductions in government funding may slow the further development of the energy efficiency market unless the private sector is able to significantly expand its activities in this area.

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7. MASSACHUSETTS, UNITED STATES

Summary

Massachusetts is a leading US state on energy efficiency investment and improvement; it ranked first in the recent American Council for an Energy-Efficient Economy (ACEEE) 2014 State Energy Efficiency Scorecard, the fourth year in a row that it achieved this distinction (ACEEE, 2014a). Strong policies coupled with investment in energy efficiency have supported state-level energy use decreasing by 10% from 2002 to 2012, while both the gross domestic product (GDP) and population have increased. Total energy efficiency investment in the state was almost USD 1 billion in 2013 and generated over USD 2.8 billion in benefits.

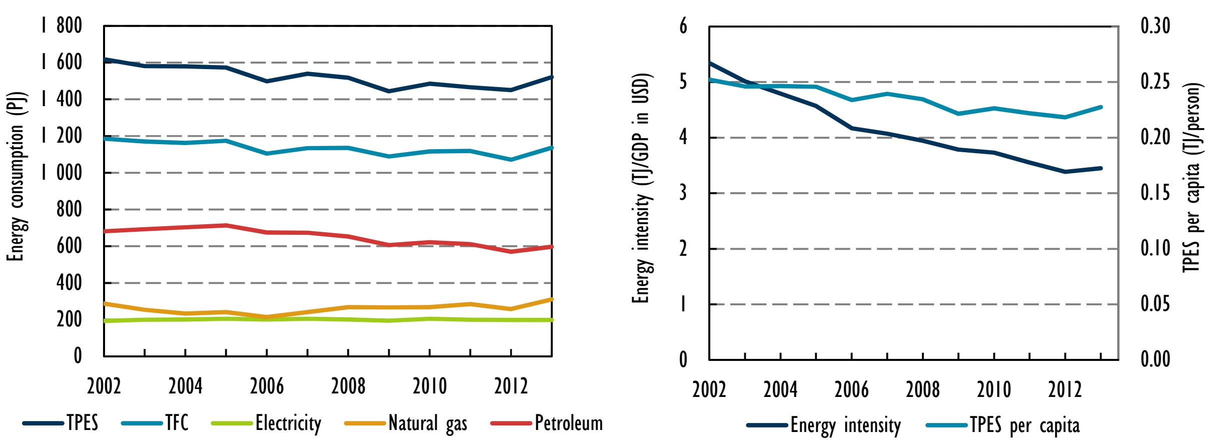
Energy profile and context

Massachusetts is a wealthy state, with the fourth-highest average per capita income in the United States, and is densely populated, with the country's third-highest population density. It is located in the northeast of the United States (US Census, 2010b; US DOE, 2015a). Much of the population is concentrated in urban areas near Boston and Worcester in eastern Massachusetts, and a second concentration of population is located near the Connecticut River and the city of Springfield (US Census, 2010a).

Even though the population of Massachusetts is relatively wealthy and can afford to consume energy, its total energy consumption per capita is 43rd out of the 50 states (US DOE, 2013a). This low energy consumption is likely caused in part by a combination of relatively high energy prices (third-highest electricity prices and sixth-highest natural gas prices in the United States) (US DOE, 2015b and US DOE, 2015c), a service-dominated economy, and strong energy efficiency policies.

Energy consumption in Massachusetts decreased by 10% from 2002 to 2012, but increased from 2012 to 2013, driven in part by cold weather conditions (Figure 7.1). From 2002 to 2013, energy intensity decreased in all years except for 2013, indicating that the energy consumption increase was separate from economic activity. Cold weather conditions (e.g. higher heating degree days) across Massachusetts in 2013 helped drive increases in both residential and commercial energy consumption, while industrial energy consumption decreased.

Figure 7.1 TPES, TFC, energy consumption, energy intensity and energy use per capita, 2002-13

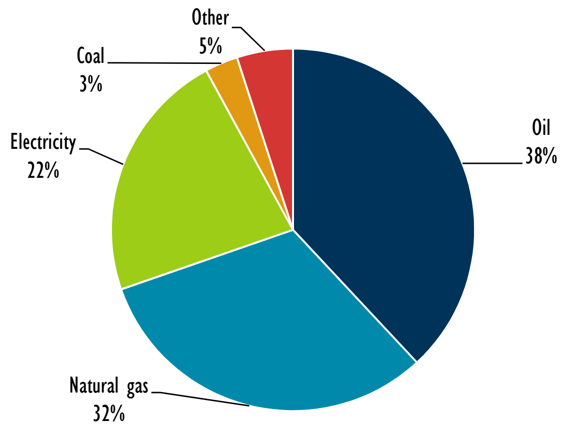


Source: US DOE (2013b), Massachusetts: State Profile and Energy Estimates, www.eia.gov/state/?sid=MA.

From 2002 to 2013, energy consumption decreased for both total primary energy supply (TPES) and total final consumption (TFC), and in energy intensity, per GDP and per capita. The reductions in TPES, TFC, and energy intensity per capita are all in the range of 4% to 10%. The Massachusetts economy grew at a modest pace, at an average annual growth rate of 3.4%, or 34th out of the 50 states (US BEA, 2015). Declining energy consumption coupled with a growing economy led to a 35% improvement in energy intensity from 2002 to 2013 (Figure 7.1).

Natural gas is the most consumed energy type in Massachusetts followed by electricity and gasoline, with these three fuels accounting for more than three-quarters of energy consumption in Massachusetts. When aggregated, the largest fuel category consumed in Massachusetts is oil products (38%), followed by natural gas (32%) and electricity (22%) (Figure 7.2). The oil products are dominated by gasoline (56%) primarily used by the transport sector and distillate fuel oil (32%) used in both the transport and buildings sectors.

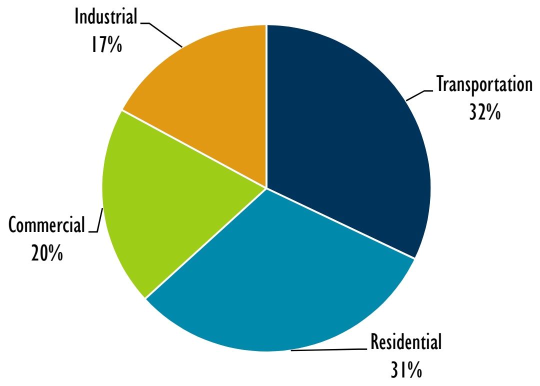
Figure 7.2 Energy consumption by energy type for Massachusetts (2013)



Source: US DOE (2013b), Massachusetts: State Profile and Energy Estimates, www.eia.gov/state/?sid=MA.

The transport sector is the largest energy-consuming sector in Massachusetts at 32%, followed by residential buildings (31%), commercial buildings (20%), and industry (17%) (Figure 7.3). This split of energy use shows that the buildings sectors (residential and commercial) have a higher share of state energy use at 51% compared to the national average of 40%; conversely, industry and transport sectors have lower energy shares in Massachusetts compared to the national average.

Figure 7.3 Energy consumption by end-user sector for Massachusetts (2013)



Source: US DOE (2013b), Massachusetts: State Profile and Energy Estimates, www.eia.gov/state/?sid=MA.

Massachusetts' residential energy consumption comprises 2.1% of total US residential energy use and is equal to the state's population share at 2.1% of the total US population. Transport energy consumption comprises 1.7% of total US transport energy use, which is lower than the 2.1% population share. Massachusetts' commercial (1.6%) and industrial (0.8%) energy use share are significantly lower when compared to Massachusetts GDP at 2.6% of US GDP (Table 7.1). These figures indicate that residential energy use per person is similar to the average across the United States, while commercial and industrial energy use is low compared to the economic output of the commercial and industrial sectors in Massachusetts.

Table 7.1 Energy consumption and expenditures by sector Massachusetts (2013)

	Energy consumption (PJ)	Energy consumption share (% of US total per sector)	Energy expenditures (USD million)	Energy expenditures share (% of US total per sector)
Residential	477.5	2.1%	7 613	3.0%
Commercial	306.9	1.6%	3 994	2.2%
Industrial	256.2	0.8%	3 240	1.4%
Transportation	481.3	1.7%	12 991	1.8%

Source: US DOE (2013b), Massachusetts: State Profile and Energy Estimates, www.eia.gov/state/?sid=MA.

Market driver: Energy efficiency policies and programmes

Massachusetts has a range of state, local, and utility policies and programmes that have resulted in a strong uptake of energy efficiency actions across the economy. These policies and programmes have been influenced by the Green Communities Act of 2008, which includes requirements for achieving all cost-effective energy efficiency opportunities (MA EEAC, 2013). In the recent ACEEE 2014 State Energy Efficiency Scorecard, Massachusetts ranked first for the fourth year in a row, based on having a strong portfolio of energy efficiency policies. In addition, at the local level, in the 2015 ACEEE City Energy Efficiency Scorecard, Boston, the largest city and capital of Massachusetts, was also ranked first (ACEEE, 2015).

A number of state and utility policies and programmes that have an impact on energy and energy efficiency are broadly defined under 14 state-level initiatives (Massachusetts EEA, 2015c). Within the 14 policy and programme categories in Massachusetts, there are a number of specific programmes and policies, including building codes, utility energy efficiency programmes, financing, rebates, and technology programmes. Each of these policies and programmes adds to the energy savings that are being seen across the Massachusetts economy. Some of these programmes are further described below.

- **Mass Save** (Mass Save, 2015a)**:** Funded largely through ratepayer funds, and administered by both the natural gas and electricity utilities in Massachusetts, Mass Save co-ordinates with the state government by means of the Massachusetts Department of Energy Resources (DOER) to provide energy efficiency services and incentives to help residential and commercial customers identify energy efficiency opportunities. The current 2013-15 state-wide plan invests USD 2.2 billion in energy efficiency projects with a forecast return of over USD 8 billion over the average 12 year lifetime of the project.

- **Building Energy Codes** (Massachusetts EEA, 2015d): The state has adopted the 2012 International Energy Conservation Code (IECC) for residential buildings and the Energy Standard for Buildings Except Low-Rise Residential Buildings ASHRAE 90.1-2010 for commercial buildings. Both of these codes are consistent with practice in the leading states in the United States. By July 2017, the next code adoption will be the 2015 IECC for both residential and commercial buildings, which will maintain Massachusetts' position as an early adopter of the most recent building energy codes. As of June 2015, 157 jurisdictions in Massachusetts had adopted the "stretch" building energy code that is at least 20% more energy efficient compared to the "base" building code (Massachusetts DOER, 2015). The US Department of Energy (DOE) estimates that the energy cost savings for Massachusetts from updating its residential and commercial buildings to the current base building energy code will result in USD 144 million of energy cost savings annually by 2030 (US DOE, 2014). The continued adoption of the stretch building energy code results in savings in addition to this estimate. By continuing to update the building energy codes in future years, and with the continued adoption of stretch building energy codes, the energy cost savings will be significantly higher.
- **Leading by Example (LBE) programme** (Massachusetts EEA, 2015b): Massachusetts developed the LBE programme to ensure that state-owned and operated facilities would provide leadership to the market by implementing energy efficiency, practicing energy conservation, reducing greenhouse gas (GHG) emissions, using renewable energy, living in sustainable buildings, and practicing water conservation. Within this programme, they have been tracking progress in improvements with a state portfolio of over 3 000 vehicles and 8 million square metres (m^2) of buildings, including hospitals, colleges and university campuses, prisons, visitor centres, state parks, roads, tunnels, airports, dams, waste water treatment facilities, etc. (Massachusetts EEA, 2015a). The results of the programme include a 22% reduction in GHG emissions through 2014, a 14% improvement in energy intensity (energy per floor area), a 72% reduction in oil consumption, and estimated avoided energy costs of between USD 42 million and 59 million compared to business as usual in 2014.
- **Clean Cities Coalition** (Massachusetts EEA, 2015e)**:** Clean Cities is part of the US DOE national programme that is focused on reducing petroleum consumption in the transport sector. In 2014, USD 18.4 million in grants were made available, with Massachusetts investing USD 2.8 million in 2014 resulting in over 16 000 tonnes of GHG emission reductions and a reduction of almost 6 million gallons of gasoline-equivalent, through alternative fuels.[1] In addition, over 800 electric and plug in electric consumer rebates were distributed, to Massachusetts residents, increasing the number of clean vehicles on the road.

Energy pricing

Energy pricing affects the cost effectiveness of energy efficiency, and Massachusetts has relatively high energy prices compared to other states in the United States. Electricity prices in Massachusetts are significantly higher than the US average electricity prices for each of the three sectors (Table 7.2). Natural gas prices are also higher than the US average for the residential sector although they are not significantly higher at the city gate (Table 7.3).[2]

[1] See www.mass.gov/eea/docs/doer/clean-cities/clean-cities-2014-annual-report-massachusetts-clean-cities.pdf.

[2] City gate is the point at which natural gas is transferred to the local utility.

Table 7.2 Electricity prices by sector for Massachusetts (January 2015)

	Massachusetts (USD/kWh)	Massachusetts (% of US)	United States (USD/kWh)
Residential	0.208	172%	0.121
Commercial	0.165	160%	0.103
Industrial	0.132	200%	0.066

Source: US DOE (2015b), *Massachusetts: State Energy Profile Data*, www.eia.gov/state/data.cfm?sid=MA#EnergyIndicators.

Table 7.3 Natural gas prices by sector for Massachusetts (January 2015)

	Massachusetts (USD/GJ)	United States (USD/GJ)
City gate	5.16	4.23
Residential	13.69	9.00

Source: US DOE (2015b), *Massachusetts: State Energy Profile Data*, www.eia.gov/state/data.cfm?sid=MA#EnergyIndicators.

Energy efficiency market activity

The energy efficiency market in Massachusetts includes a combination of money spent on energy efficiency programmes and money invested in energy efficiency businesses. Mass Save is the largest source of energy efficiency spending in Massachusetts at USD 490 million in the 2013 programme, which involves spending by electricity and natural gas utilities on energy efficiency products or services. Total spending by energy efficiency programmes in Massachusetts is estimated by ACEEE to be USD 681 million in 2013 (Table 7.4).

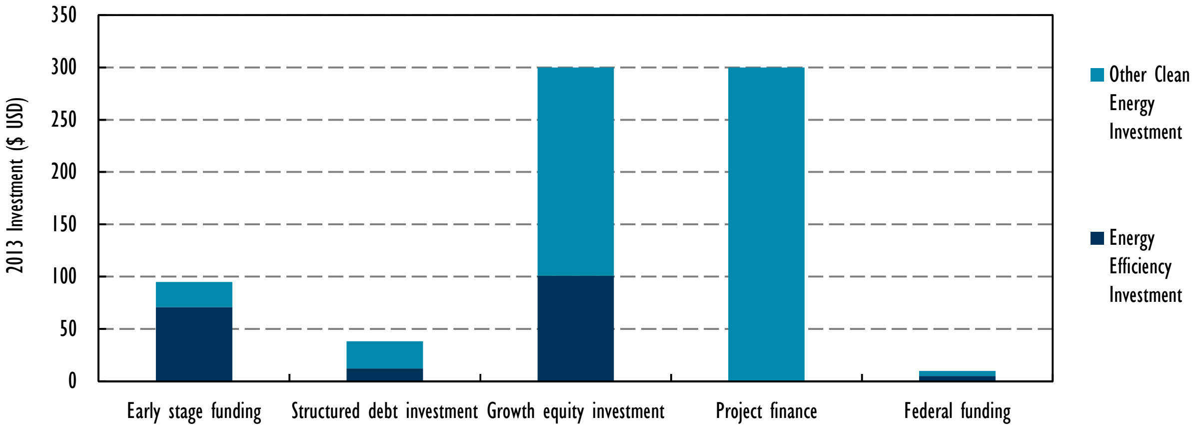
Table 7.4 Massachusetts energy efficiency programme spending and annual energy savings (2013)

	Programme spending (USD million)	Electricity savings (GWh)	Natural gas savings (PJ)
Electric programmes	507.7	1 116	
Natural gas programmes	173.5		2.6

Source: ACEEE (2014b), *Spending Savings Tables*, Washington D.C. http://database.aceee.org/sites/default/files/docs/spending-savings-tables.pdf and Mass Save (2015b) Mass Save Data, http://masssavedata.com/Public/SectorOverView.aspx.

In addition, the Massachusetts Clean Energy Industry Report, supported by the Massachusetts Clean Energy Center (MassCEC) identifies equity and other financial investments that are made in energy efficiency businesses. The MassCEC annual report on the clean energy industry analysed the energy efficiency investment in businesses by examining each of the private investment types, such as early stage funding, structured debt, and growth equity investment. Using "strict investment sector definitions", MassCEC estimates that energy efficiency investment is approximately USD 260 million or 37% of all clean energy investments (Figure 7.4). The majority of these energy efficiency investments in Massachusetts are estimated to be from private investment, followed by growth equity investment and early stage funding.

Figure 7.4 Massachusetts investment-sector clean energy investment



Source: BW Research Partnership (2014), *2014 Massachusetts Clean Energy Industry Report*, http://images.masscec.com/reports/Web Optimized 2014 Report Final.pdf.

Combining the energy efficiency programme spending (including the USD 681 million spending on energy efficiency programmes estimated by ACEEE) and the energy efficiency investment (including USD 260 million in private investment estimated by MassCEC) spending to total energy efficiency investments of approximately USD 941 million in the energy efficiency market in Massachusetts in 2013. This set of investments provides direct benefits to consumers with energy efficiency improvements, benefits through increased energy efficiency jobs, and future energy efficiency market benefits through energy efficiency research, development, and capacity building.

The state estimates that the Mass Save programme generated USD 2.8 billion in economic benefits in 2013 through almost 3.3 million programme participants, primarily in the residential sector (Table 7.5). It is projected that the number of energy efficiency jobs in Massachusetts will increase from 65 200 jobs in 2014 by 11.7% to 72 800 jobs in 2015 (BW Research Partnership, 2014).

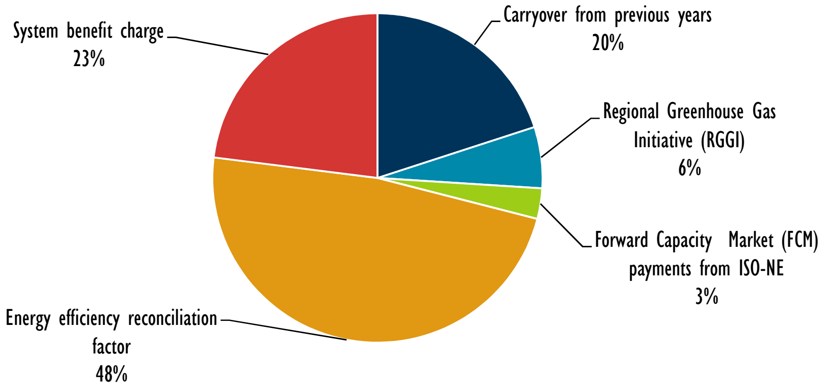
Table 7.5 Mass Save programme spending and results (2013)

Sector	Programme Participants	Programme Spending (USD million)	Annual Electricity Savings (GWh)	Annual Natural Gas Savings (PJ)
Residential	3 212 000	264	419	1.50
Low-Income	46 166	85	36	0.22
Commercial and Industrial	36 013	226	668	0.29

Source: Mass Save (2015b) *Mass Save Data*, http://masssavedata.com/Public/SectorOverView.aspx.

Funding for Massachusetts electric energy efficiency programmes comes from a combination of sources, with the majority of resources provided by charges to electricity consumers through the energy efficiency reconciliation factor (48%) and the system benefit charge (23%) (Figure 7.5).

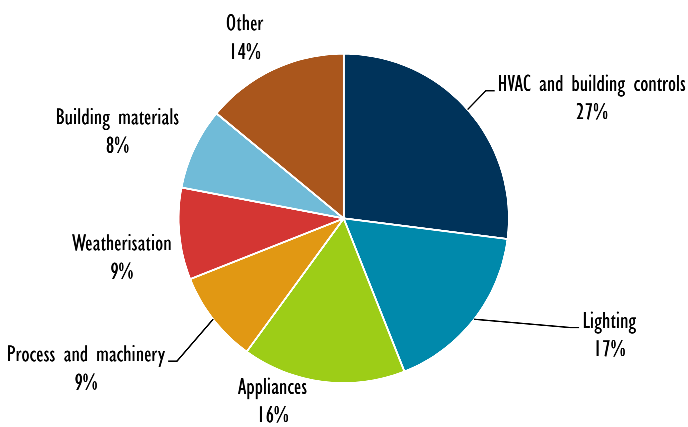
Figure 7.5 Massachusetts electric energy efficiency programme funding sources



Source: MA EEAC (2013), *2013 Annual Report: Energy Efficiency Sets the Stage for Sustainable*, Energy Efficiency Advisory Council, www.mass.gov/eea/docs/doer/energy-efficiency/eeac-annual-report-2013.pdf.

The MassCEC report estimates the energy efficiency investment impacts on direct employment in green jobs. From these estimates the main job creation is associated with technologies, including heating, ventilation and air conditioning (HVAC) (27%), lighting (17%), and appliances (16%) (Figure 7.6).

Figure 7.6 Massachusetts energy efficiency employment by technology and service



Source: BW Research Partnership (2014), *2014 Massachusetts Clean Energy Industry Report*, http://images.masscec.com/reports/Web Optimized 2014 Report Final.pdf.

Prospects for energy efficiency market activity

Massachusetts policies are promoting continued growth of the energy efficiency market by implementing a "decoupling" policy that enables the utilities to increase or maintain profits while decreasing revenues. This policy is now in place for all of its gas and electric utilities (ACEEE, 2014b) and enables utilities to receive profits through incentives based on meeting the energy efficiency programme goals. Moreover, continued technology, process, and financial innovation will be taking place in Massachusetts given the presence of sophisticated organisations, educational institutions, and financial firms, which should enable further improvements in costs and returns in the energy efficiency product sector, thereby supporting further energy efficiency market activity.

Challenges

Massachusetts has continued to innovate and improve its energy efficiency policies and investments. However, challenges still exist for continued future energy efficiency investment. These challenges include: (1) low energy prices compared to global energy prices; (2) an old building stock with minimal new construction; and (3) the lock-in effect of current investments (for both inefficient and moderately efficient technology investment) which will limit the turnover of technologies in the coming decades.

While these challenges are important to plan for in future programmes and policies, each of these challenges is likely to have a minimal negative impact on continuing reductions in energy intensity if current energy efficiency approaches in Massachusetts are maintained.

Conclusions

Massachusetts is a leading state in energy efficiency activities. Favourable factors driving this success include strong state policies, significant incentives and services through the energy utilities, financial commitments from the investment sector, and strong support from residents, businesses and institutions by adopting energy-efficient technologies and services. Total investments in energy efficiency in recent years are estimated to be nearly USD 1 billion per year which has supported the 10% reduction in total primary energy consumption from 2002 to 2012. Government policies have borne their fruit; ongoing policy and technology support are set to generate further gains.

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8. MEXICO

Summary

Mexico is one of the leading countries in energy efficiency policy in Latin America. The government has undertaken a suite of measures that effectively combine policies, funding vehicles and institutions. These include the National Programme for Sustainable Energy Use for 2014-18 which sets the strategy and actions for energy efficiency at the national level for all sectors and the Law for Renewable Energy Use and Energy Transition Financing which provides funding for energy efficiency projects.

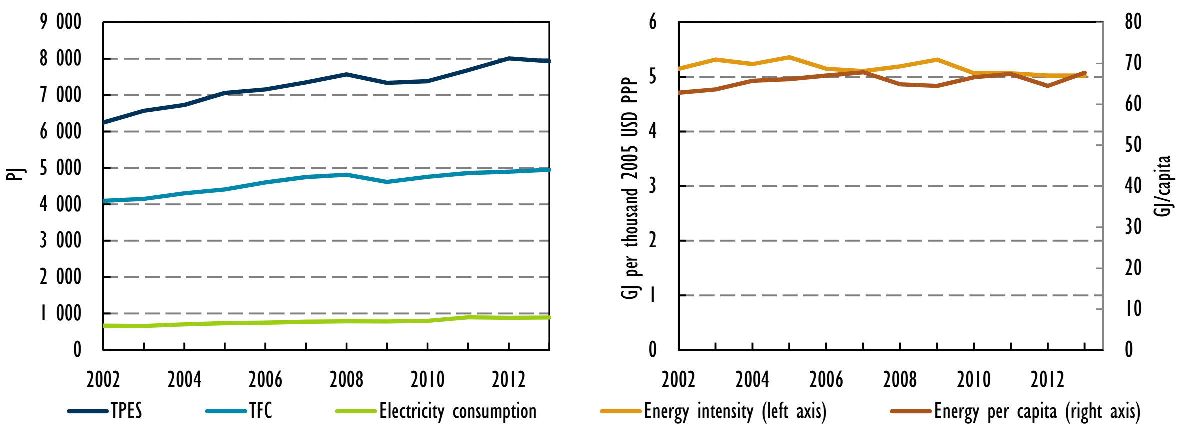
For 2013 and 2014, total government energy efficiency funding was at least MXN 900 million (Mexican Pesos) (USD 52.3 million[1]). International development financing for energy efficiency, including loans and grants, reached over USD 100 million for the same period.

Energy profile and context

In 2012, Mexico was the tenth-largest exporter of crude oil but also the fourth-largest net importer of oil products in the world. Oil production peaked in 2004 and is now decreasing due in part to the lack of investment in additional production. The share of natural gas for electricity production has surpassed oil. In 2001, oil and natural gas each had a share of 34%, compared with 16% and 56% respectively in 2013.

Total final energy consumption (TFC) increased at an average of 1.8% between 2002 and 2013, while the gross domestic product (GDP in 2005 USD using purchasing power parities [PPP]) rose, on average, by 2.6% per year (Figure 8.1). In 2013, Mexico's GDP was approximately USD 1 596 billion, just above South Korea with USD 1 556 billion. Energy intensity remained relatively unchanged from 2002 to 2013 at an average of 5.17 gigajoules (GJ), indicating that energy efficiency efforts need to progress further in Mexico. Total primary energy supply (TPES) continues to rise slowly, primarily on the back of oil and natural gas, with minor fluctuations in 2009 and 2010 (Figures 8.1 and 8.2). TPES per capita has been fluctuating over the last 10 years from 67.41 GJ per capita in 2011 to 67.66 GJ per capita in 2013 (Figure 8.1).

Figure 8.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13

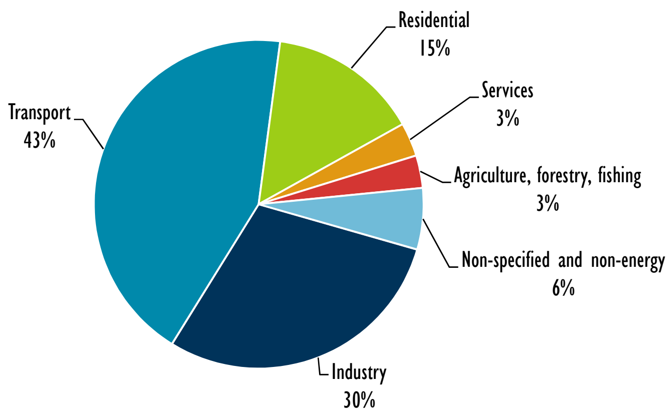


Source: IEA (2015), *Energy Statistics of OECD Countries 2015*, OECD/IEA, http://dx.doi.org/10.1787/energy_stats_oecd-2015-en.

[1] Exchange rate used from 26-08-2015: 1 MXN = 0.0581553 USD.

The transport sector in Mexico accounts for 43% of TFC, followed by industry (26%) and the residential sector (16%) (Figure 8.2). In 2013, approximately 65% of the TFC of the transport sector was for gasoline, followed by 27% for diesel. Energy demand in the transport sector is expected to increase further with population and income growth. Vehicle ownership in Mexico currently stands at 210 units per 1 000 inhabitants compared to the United States where the figure is approximately 786 units per 1 000 people (Bloomberg, 2015; SENER, 2014a). According to the *Crude Oil and Oil Products Sector Outlook* (*Prospectivas de Petróleo Crudo y Petrolíferos*), the number of gasoline vehicles will grow by 75% and diesel vehicles will double between 2013 and 2028 to reach 49.6 million gasoline vehicles and 2.1 million diesel vehicles (SENER, 2014a).

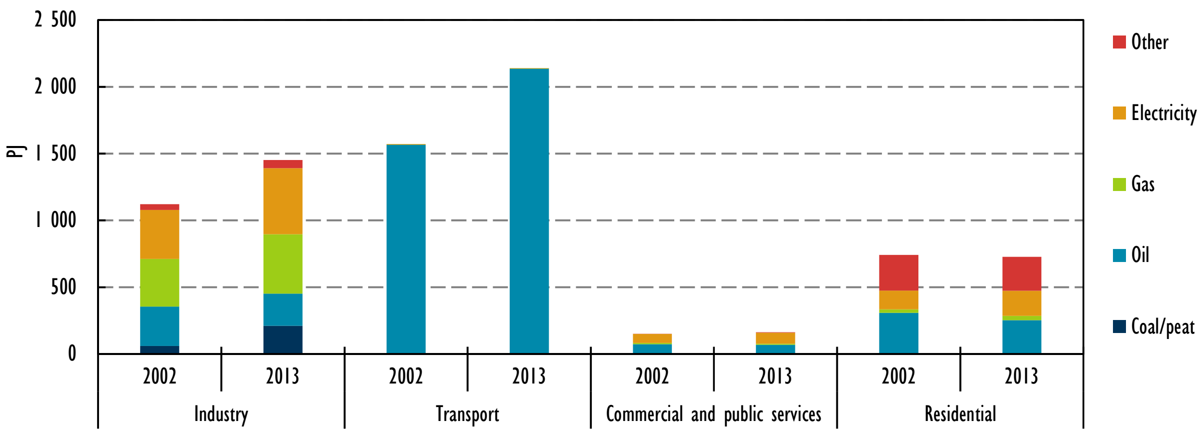
Figure 8.2 TFC by sector, 2013



Source: IEA (2015), *Energy Statistics of OECD Countries 2015*, OECD/IEA, http://dx.doi.org/10.1787/energy_stats_oecd-2015-en.

Oil consumption in the transport sector represented the highest increase in TFC from 2002 to 2013 (Figure 8.3). Electricity and natural gas consumption grew in the industrial and residential sectors from 2002 to 2013, whereas oil consumption declined. In 2013, electricity consumption in Mexico rose by only 0.6% to reach 235 terawatt hours (TWh); however, internal electricity sales decreased marginally by 0.2% to 207 TWh, of which 58.3% were from the industrial sector and 25.6% from the residential sector. The installed electricity capacity reached 65 460 megawatts (MW) which was 1.1% more than in 2012 and peak demand increased by 0.4% to 38 140 MW (SENER, 2014b).

Figure 8.3 TFC by sector and by energy source, 2002 and 2013



Source: IEA (2015), *Energy Statistics of OECD Countries 2015*, OECD/IEA, http://dx.doi.org/10.1787/energy_stats_oecd-2015-en.

Market driver: Energy efficiency policies and programmes

Mexico has undertaken a variety of policy and institutional measures to promote energy efficiency and to reduce energy use. In 1998, the government created a dedicated national commission for energy savings, today known as the National Commission for the Efficient Use of Energy (*Comisión Nacional para el Uso Eficiente de la Energía,* CONUEE) which reports to SENER to help in the implementation of these measures. CONUEE is responsible for promoting energy efficiency and provides technical expertise regarding sustainable energy use, while SENER is responsible for Mexico's energy strategy and policy, including energy efficiency and energy security.

The Mexican government has introduced a number of key policies and funding instruments for energy efficiency such as:

- **The Law for the Sustainable Use of Energy** (*Ley para el Aprovechamiento Sustentable de la Energía,* LASE). LASE was established to promote the optimal use of energy in all processes and activities, from exploration to consumption.
- Under LASE, the government established the **National Programme for Sustainable Energy Use** (*Programa Nacional para el Aprovechamiento Sustentable de la Energía*, PRONASE) which sets the strategy and actions for energy efficiency at a national level for all sectors. The first PRONASE covered the period 2009-12 and indicated that the greatest potential energy savings could be found in lighting, appliances and industrial motors. The primary target of the current 2014-18 PRONASE is to maintain energy intensity at least at the same level as in 2012 (SEGOB, 2014a).
- **The Law for Renewable Energy Use and Energy Transition Financing** (*Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética,* LAERFTE) sets the national strategy and financing for Mexico's energy transition.
- The LAERFTE established the **Fund for Energy Transition and Sustainable Energy Use** (*Fondo para la Transición Energética y el Aprovechamiento Sustentable de la Energia,* FOTEASE). Since 2009, this fund has financed 26 projects with more than MXN 7 500 million (USD 436.2 million) of which approximately 77% were for energy efficiency projects (MXN 5 775 million – USD 335.8 million) and 13% were for combined renewable energy and energy efficiency projects.
- **The Sustainable Energy Fund** (*Fondo de Sustentabilidad Energética,* FSE) was created in 2008 under the Law of Science and Technology and the reform of the Federal Law of Rights in Matters of Hydrocarbons in 2007 which ensured the allocation of 0.63% of the annual value of oil crude and gas to research and development activities on energy. In 2013, only 2% of the FSE budget was used for energy efficiency projects worth MXN 52.8 million (USD 3.1 million) (SENER, 2015a).
- **The Programme of Energy Savings in the Electricity Sector** (*Programa de Ahorro de Energía del Sector Eléctrico,* PAESE) is managed by the national state-owned utility, the Federal Electricity Commission (*Comisión Federal de Electricidad,* CFE). It aims to promote energy savings and efficient energy use in CFE's production and distribution of electricity through energy efficiency projects, technical consulting and training activities. PAESE covers a number of areas such as clean energy technologies, photovoltaic systems, energy-efficient lighting, air conditioning, water pumping and others. The available budget for PAESE in 2013 and 2014 was approximately MXN 45.0 million per year (USD 2.6 million) (SHCP, 2013; SEGOB, 2014a).

Mexico also has a **Trust Fund for Electricity Savings** (*Fideicomiso para el Ahorro de Energía Eléctrica,* FIDE). This private, not-for-profit institution, made up of a mix of private and government sector members, promotes and funds projects for efficient end-use, particularly technology development and innovation. The Trust Fund is responsible for programmes such as a voluntary appliance endorsement label known as Sello FIDE (FIDE, 2015a).

Current energy efficiency market activity

The energy efficiency market potential in Mexico is significant and investment in energy efficiency has been growing progressively, stimulated by government policies. Currently, the main investment focus is on energy efficiency in buildings, lighting and appliances (e.g. street lighting and residential lighting replacement programmes) and most projects have a component for low-income households. The section below summarises some of the recent energy efficiency investment activities in the lighting, appliances and buildings sectors.

Lighting and appliance replacement programmes in the residential sector

From 2010 to 2015, the Mexican government, through SENER, implemented an Efficient Lighting and Appliances Project to promote the adoption of energy-efficient technologies such as compact fluorescent lamps (CFLs). This project focused primarily on the residential sector to lower household electricity bills and enhance energy security by avoiding new generation capacity, lowering fossil fuel consumption and reducing electricity subsidies. The project, which was supported by a World Bank loan of USD 250.6 million, had a total project cost of USD 713.4 million (including consumer expenditures for more efficient appliances).

Approximately 45.8 million incandescent bulbs were replaced with CFLs in 11.3 million households, resulting in estimated savings of 6 993 gigawatt hours (GWh). The project also replaced a total of 1.9 million refrigerators and air conditioners resulting in estimated savings of 2 586 GWh (Table 8.1) (World Bank, 2015).

Table 8.1 Number of appliances replaced and energy savings under the Efficient Lighting and Appliances Project

Appliance type	Number of appliances replaced	Estimated annual savings (GWh) in 2014	Estimated accumulated savings (GWh) (2009-14)
Refrigerators	1 682 802	492	1 903
Air conditioners	201 327	185	684
TOTAL	**1 884,129**	**677**	**2 587**

Source*:* SENER (2015b), Personal Communication with SENER.

Other activities in this area include:

- 2013: Pilot programme for the replacement of incandescent bulbs with CFLs in cities with up to 100 000 inhabitants in the State of Michoacán at a cost of MXN 300 000 (USD 17 000) and in the states of Guerrero, Sonora y Chihuahua at a cost of MXN 657 000 (USD 38 000).
- 2014: National programme for the replacement of incandescent bulbs with CFLs in cities up to 100 000 inhabitants (funding amounted to MXN 816 million – USD 47.5 million).

Equipment replacement programme in the commercial sector

In 2012, the Mexican government also implemented a Programme for Energy Efficiency and Savings in Enterprises (*Programa de Ahorro y Eficiencia Energética Empresarial*, PAEEEM) with the support of SENER, the Ministry of Economy, the CFE, the Mexican National Development Bank (*Nacional Financiera,* NAFIN) and FIDE. PAEEM finances the replacement of inefficient equipment in small and medium-sized enterprises (SMEs) such as hotels, restaurants, hospitals, offices and convenience stores. The appliances and equipment eligible for replacement includes air conditioners, commercial refrigerators, lighting and electric motors (FIDE, 2015b).

Up to May 2015, the programme supported approximately 10 000 SMEs in replacing just over 20 000 appliances with electricity savings of 48 GWh annually. The total amount invested by the programme was MXN 393.4 million (USD 22.9 million) with almost 90% being used to replace commercial refrigerators (Table 8.2).

Table 8.2 Equipment replaced and amount invested under the PAEEEM

Equipment type	Number of pieces of equipment replaced	Amount invested (MNX 000s)[1]	Amount invested (USD 000s)
Commercial refrigeration	12 852	353 440	20 552
Air conditioners	1 845	28 890	1 680
Lighting	5 364	2 290	133
Electrical substations	20 238	8 750	509
Electric motors	1	23	1.3
Capacitor banks	2	18	1.1
TOTAL	**40 302**	**393 411**	**22 878**

Note: 1- rounded to the nearest thousandth

Source: SENER (2015b), Personal Communication with SENER.

National effort to improve street lighting efficiency

The National Energy Efficiency Municipal Public Lighting Project (*Projecto Nacional de Eficiencia Energética en Alumbrado Público,* NEEAP) was introduced in 2011 with the support of SENER, CONUEE, CFE and the National Bank for Public Works and Services (BANOBRAS). The objective is to promote and finance energy-efficient street lighting across the country.

Table 8.3 Municipalities supported by the NEEAP – Results achieved in 2013

Municipality	Number of systems installed	Monthly electricity consumption for public lighting (kWh/month)	Estimated average energy savings as % of electricity consumption
Apodaca	28 000	893 220	29
Durango	26 321	851 224	43
Delicias	6 117	278 548	67
Xochitepec	4 815	158 004	44
Ocotlán	4 175	60 526	21
Ixtlahuacán del Río	2 475	41 890	36
San Miguel el Alto	1 668	28 519	32

Source*:* CONUEE (2013), *Activity Report – 2013*, www.CONUEE.gob.mx/pdfs/informelabores2013_2.pdf.

In 2013 and 2014, the funding provided amounted to MXN 519.5 million (USD 30.2 million). During this period a total of 150 182 streetlights were replaced resulting in estimated energy savings of 4.4 GWh per month and cost savings of 37.2% (CONUEE, 2014).

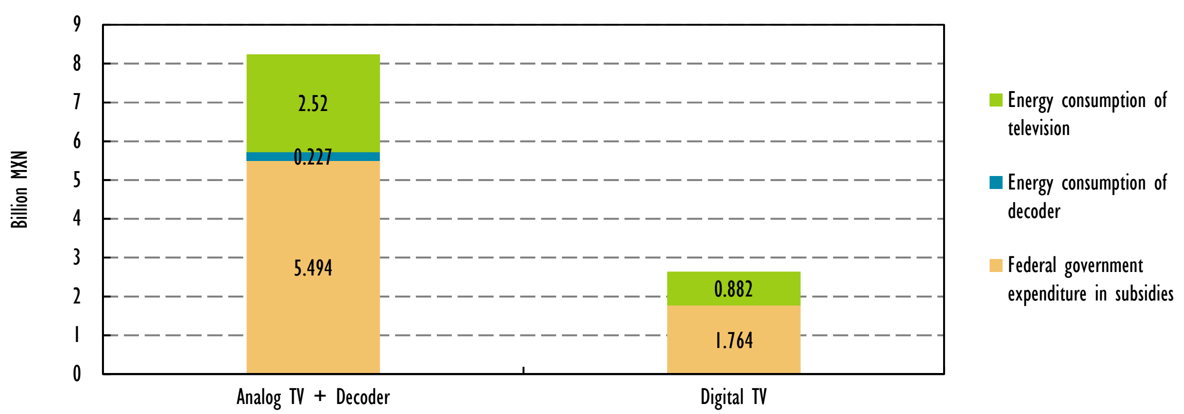
Energy-efficient buildings for low-income households

Initiated in 2013, the Ecohome programme, also known as "EcoCasa", is managed by the government's Federal Mortgage Society (Sociedad Hipotecaria Federal, SHF) and supported by the KfW Development Bank (KfW, 2014). The aim is to promote energy-efficient social housing which consumes at least 20% less energy than typical existing buildings and to subsequently help establish a new standard for energy-efficient buildings in Mexico. The eligible technologies covered by the programme include insulation of ceilings and walls, reflective paint, efficient gas heaters and others. The target is to reach 27 000 energy-efficient housing units, of which 600 should meet passive-house standards (UN, 2014). By April 2015, the programme had established contracts with ten project developers, representing a total of USD 171 million in 12 320 Ecohomes (Ashden, 2015).

Box 8.1 Televisions: Innovative policies for introducing energy-efficient products

Mexico is undergoing a market transformation from an analogue to a digital signal for television broadcast in approximately 12.6 million households. The existing less efficient analogue cathode ray tube (CRT) televisions would need a new digital set top box (STB) to continue to work with the new digital signal. To address this situation, the Mexican government decided that instead of subsidising digital STBs and adding a new source of energy demand (18 kWh annually per STB), it will be giving away 14 million new LED televisions to low-income households. The LED televisions are on average 60% more efficient than standard CRT television models. The Mexican government projects, based on a ten-year lifetime, that the MXN 1.76 billion (USD 102.4 million) spent on new LED televisions is expected to be recovered through avoided electricity consumption of the new more efficient televisions worth MXN 1.60 billion (USD 93.1 million) and federal government saving in subsidies (including electricity tariffs) of MXN 3.73 billion (USD 216.9 million) (Figure 8.4) (SEGOB, 2014b).

Figure 8.4 Comparison of annual expenses by households and Mexican government with analogue television and decoder versus digital television



Source: SEGOB (2014b), *Diario Oficial de la Federación 13.05.2014 - Programa de Trabajo para la Transición a la Televisión Digital Terrestre (TDT) – Secretária de Comunicaciones y Transportes*, http://dof.gob.mx/nota_detalle.php?codigo=5344585&fecha=13/05/2014.

Overall, the EcoCasa programme will invest approximately USD 230 million over a seven year period. The KfW Development Bank is providing a loan of approximately USD 145 million to SHF, of which USD 102 million is from the Inter-American Development Bank (IDB). The SHF then offers low-interest loans to project developers who invest in energy-efficient houses for low and middle-income people. (IDB, 2015; KfW, 2013).

Private sector financing initiatives for energy efficiency

NAFIN is working with local banks to help mainstream energy efficiency financing in the private sector. In May 2014, NAFIN agreed with the bank HSBC Mexico to offer financing to companies, from the public or private sector, for energy related investments including energy efficiency. The programme is called "Impulso Energético" (Energy Drive) and has a budget of MXN 26 billion (USD 1.5 billion). Financing for individual projects can range from MXN 500 000 to MXN 500 million (USD 29 000 to USD 29 million) and NAFIN provides credit guarantees of 50% to 80%. The programme can finance labour, acquisition of machinery and equipment as well as investment projects for modernisation, creation and development of infrastructure, environmental improvement and technology development for renewable and non-renewable technologies (HSBC, 2015; NAFIN, 2015). No results are available as yet but it is likely that the funds will be used mostly to finance large renewable energy projects rather than energy efficiency projects.

Prospects for energy efficiency market activity

SENER carries out long-term projections of electricity savings in its annual Electricity Sector Outlook report (*Prospectiva del Sector Eléctrico*). For the period of 2014 to 2028, SENER estimates that, based on the energy efficiency policies implemented under the PRONASE and LAEFRTE described above, electricity savings will amount to 28.5 TWh for the residential sector (69.8% of total electricity savings) and 8.1 TWh for the industrial sector (19.8% of total electricity savings) by 2028. The significant anticipated savings for the residential sector are related to the change in standards for lighting appliances and building retrofit (SENER, 2014b). This is an area where there is bound to be significant investment in the next decade.

In line with this outlook, SENER and the World Bank set up the Mexico Municipal Energy Efficiency Project worth USD 130 million to support the demonstration of large-scale energy efficiency investments in the municipal service sector and in public buildings, and to improve national and local capacity in designing and implementing municipal energy efficiency programmes. Mexico is also working with the IDB on potential energy efficiency and clean energy projects via NAFIN (USD 200 million) and a co-generation and renewable energy project (USD 100 million) (IDB, 2013).

Challenges

Global oil prices are having an impact on Mexico's federal budget and the main challenge will be to ensure that energy efficiency policies continue to be prioritised and well-funded as the budget contracts. Other barriers to energy efficiency investment include energy subsidies for petrol and electricity, high dependence on government support, lack of awareness of energy efficiency and a limited ESCO market capacity for technical support and financing.

Conclusions

Mexico has a fast-growing energy efficiency market with considerable potential in the short and long-term based on expected economic growth and reflecting increasing government support. To successfully and fully mainstream energy efficiency at the national and local level will require greater support from the local financing sector; recent investment projects provide examples of how this can be achieved. Through SENER, CONUEE and the suite of energy efficiency related policies, Mexico is expected to continue to encourage further development of its energy efficiency market.

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9. PARIS, FRANCE

Summary

Paris has a very dense city centre with a low energy intensity. The municipal government has prioritised further improvements in this area, enacting measures that will improve the energy efficiency of the city; low-energy housing and transport are areas of focus. District heating and cooling networks are also a major part of the city's efforts to promote energy efficiency. Such networks were developed over decades for their economic merits and ability to provide security of supply, but they also have important energy efficiency benefits.

Policy making, especially in planning and transport policy, will benefit from being more integrated at the level of the newly created Greater Paris Metropolis. There is also still significant savings potential in the city centre, notably through renovation of residential buildings. Significant investment, both public and private, will be needed. Two possible ways to encourage this are energy service companies (ESCOs) and partnerships with the private sector (successful examples include Paris' district energy networks and rental schemes for bicycles and electric cars).

Energy profile and context

Context

This chapter outlines the current state and the policy drivers of energy efficiency markets in Paris, the capital city of France and France's largest city by population. Paris is the core of the Greater Paris Metropolis (*Métropole du Grand Paris*, MGP) that will begin to come into effect in January 2016 (Figure 9.1). Paris itself is divided into 20 municipal *arrondissements* (districts) and has an elected mayor. Paris is located within the *Île-de-France* region (Paris-IDF).

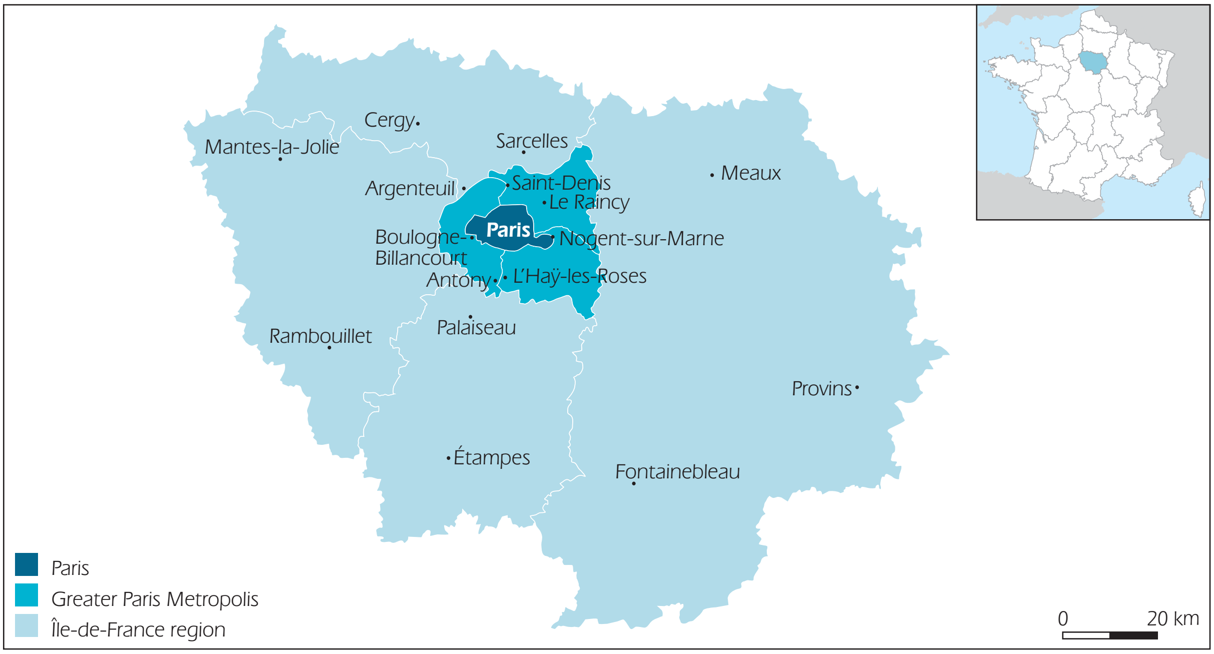
Paris-IDF has a population of around 12 million, with an average population growth rate during the period 2000-10 of 0.68% per year (OECD, 2012). The MGP has a population of 6.7 million, while Paris itself has a population of 2.53 million.

Its area of 105 square kilometres (km^2) makes Paris one of the densest cities in the world (24 120 inhabitants/km^2).[1] Density thins progressively outside Paris, though MGP population density is still high, at 8 793 inhabitants/km^2. Paris-IDF, with 50% of its area devoted to forestry and agriculture, has a population density of less than one thousand inhabitants per km^2.

The gross domestic product (GDP) of Paris-IDF is over USD 600 billion, representing about 30% of national wealth. Paris-IDF GDP per capita in 2010 was well above the national average at USD 49 498. There is an imbalance in financial resources and per capita GDP between Paris and the outskirts of Paris-IDF (Kamal-Chaoui and Plouin, 2012). Paris GDP is about USD 160 billion, or 27% of the GDP of Paris-IDF. MGP as a whole accounts for 70-80% of Paris-IDF GDP.

[1] In addition to its resident population, Paris is also the most visited city in the world (29.3 million tourists in 2013) (Office du Tourisme et des Congrès de Paris, 2014).

Figure 9.1 Map of Paris, Greater Paris Metropolis and *Île-de-France* region



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Adapted from www.paris-green.com/en/ile-de-france/.

Energy profile

Paris-IDF

Paris-IDF is the region of France that consumes the most energy. Energy consumption grew by around 1% a year between 1990 and 2005, faster than the national average. However, the energy intensity of GDP in Paris-IDF is the lowest of any French region at 2 000 GJ/USD billion.[2] Total final consumption (TFC) per capita is below the French average: 89.6 GJ/person in Paris-IDF in 2013 compared to the national average of 100.1 GJ/person. Electricity consumption in Paris-IDF, at 5.02 MWh/person, is similar to that of other European city regions (Kamal-Chaoui and Plouin, 2012) and lower than France (7.38 MWh/person in 2013).

TFC in Paris-IDF is driven by energy demand in buildings and transport. Buildings account for 48% of total energy consumption (29% residential and 19% tertiary), while the transport sector accounts for 44% of the Paris-IDF total and grew by 25% between 1990 and 2005.

The share of industry in the energy consumption of Paris-IDF is 8%. Paris-IDF remains France's leading industrial region, accounting for 14% of industrial employment, although it has been shedding industrial jobs for the past two decades (in part to other regions of France but also abroad).

Meanwhile, the region has seen strong job creation in the service sector. This includes the Paris administration itself and a large number of regional, national and even international public administrations (including the IEA). Paris-IDF is also France's leading agricultural region, though agriculture only accounts for 0.4% of energy consumption and 1.6% of regional value added (Kamal-Chaoui and Plouin, 2012).

[2] Exchange rate used from 17-09-2015: 1 EUR = 1.13 USD.

Paris

A general energy consumption assessment and greenhouse gas (GHG) inventory have been carried out every five years since 2004, both for the city administration and for the city of Paris as a whole. These will be updated in 2016 based on emissions during 2014. In addition, the implementation of the Paris Climate and Energy Action Plan (*Le Plan Climat-énergie de Paris*) is assessed every year. Information on achievements and spending are compiled into annual *Bleu Climat* reports.

The residential sector accounts for about one-third of energy consumption in Paris. In 2004, the energy consumption of Paris residential buildings amounted to 15.3 TWh (Table 9.1). By 2012, an 11% reduction (to 13.6 TWh) had been achieved, despite an increasing population.

Table 9.1 Energy consumption in buildings in Paris by sector (GWh)

	2004 reference year	2009	2012	2020 objective
Residential buildings	15 300	14 200	13 600	11 500
Service sector buildings	16 900	16 400	15 642	12 700

Sources: Mairie de Paris.

Paris has almost 78 million m^2 of residential floor space and 1.3 million housing units (Mairie de Paris, 2012a); 99% of those are apartments and there are more than 43 000 co-owned buildings (*copropriétés*) (Mairie de Paris, 2012b). In the rest of Paris-IDF there are progressively fewer apartment blocks.

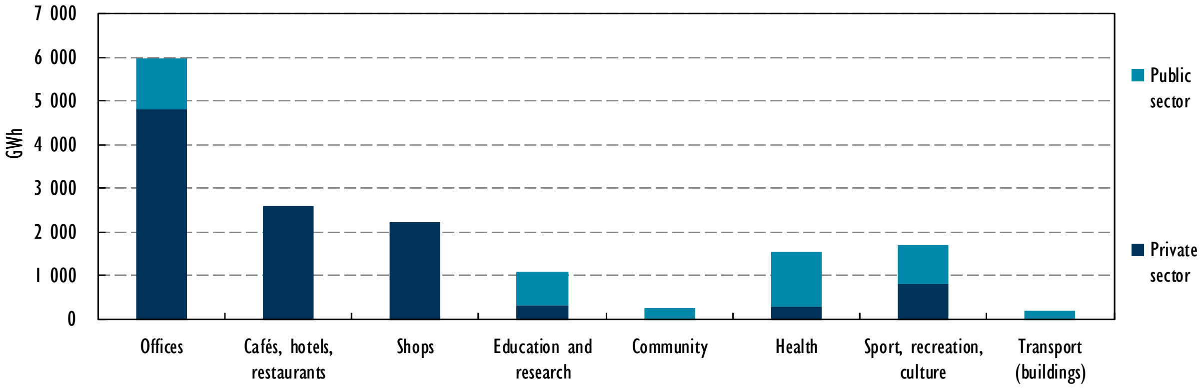
The residential building stock of Paris has a very old age profile; 85% of the stock was built before 1975 (i.e. before the first energy efficiency building codes) and about half dates from the period 1850-1910. These older buildings have a level of energy performance comparable to buildings constructed in recent decades, while the greatest potential for renovation lies in buildings constructed between the 1930s and the 1980s. Paris is already almost completely built up, with less than 1% free area, so the number of buildings is growing very slowly at about 6 000-10 000 new housing units per year.

In 2004, the energy bill of Parisian residential buildings amounted to almost USD 680 (EUR 600) per resident. The annual energy bill climbed to an estimated USD 745 (EUR 660) per resident by 2011, due to rising energy prices. The fact that some residents used their heating less or switched from oil to gas or steam is estimated to have absorbed only 20% of the price increase (Mairie de Paris, 2012a).

The service sector occupies over 58 million m^2 (a 1.2% increase in five years). While building stock is increasing at a rate of 0.22% per year, the energy consumption of the service sector decreased by 5.7% between 2004 and 2012. This decrease was mainly in heating (-15%), while other uses increased (air conditioning +15%, lighting +2%, etc.) (Mairie de Paris, 2014).

The public sector (national, regional, municipal) and state-owned companies (RATP, La Poste, etc.) account for over 29% of the energy consumption of the service sector. The remainder is generated by private actors, mainly companies (31%), restaurants, cafés and hotels (16%), and shops (14%) (Mairie de Paris, 2014).

Figure 9.2 Energy consumption of service sector buildings in Paris by subsector, 2012



Source: Mairie de Paris, 2014.

Electricity accounted for 50% of the service sector's consumption in 2012. As for heating energy, district heating is predominant in offices and health activities while gas prevails for heating cafés, hotels and restaurants. Oil (still used to heat some older buildings) is gradually being replaced by other forms of energy (district heating, gas and electricity). There is significant economic potential in the education sector, where nearly 60% of the energy bill is related to heating (Mairie de Paris, 2014). For some activities or small businesses, the energy bill has a significant impact. Paris is home to 500 000 companies or organisations and 1.8 million jobs. Their total energy bill rose from USD 744 million (EUR 658 million) in 2004 to USD 1.47 billion (EUR 1.3 billion) in 2009 before falling back again to USD 1.19 billion (EUR 1.05 billion) in 2012.

The share of transport is around 25% (compared to 28% for France). Paris is a densely populated, built-up area, which reduces the demand for vehicle trips. Public transport is well provisioned in most areas. Survey data indicates that in 2012, cars accounted for 7% of trips within Paris (Mairie de Paris, 2015). In 2013, 3.15 million trips were made using public transport. High fuel prices and vehicle efficiency standards in France promote the adoption of efficient vehicles. Car use becomes much more intensive with distance from the city centre. Four million journeys are made between Paris and the rest of Paris-IDF daily and regional public transport has at times struggled to keep up with demand.

The Paris-Charles de Gaulle (CDG) airport had 62 million passengers and Paris-Orly airport 28.3 million passengers in 2013 – both record numbers (Office du Tourisme et des Congrès de Paris, 2014). CDG is first in Europe for freight and second for number of passengers (Agence Parisienne du Climat, 2014). In 2013, 2.04 Mt of freight were transported by the river Seine. Freight transport by rail in Paris-IDF amounted to 7.6 Mt. As can be expected in a dense service-oriented city, the share of the industry sector in Paris itself is less than 1%.

As regional energy production caters for only 11% of the energy needs of Paris-IDF, the region depends on imported fossil fuels and on electricity produced in other regions of France. Paris itself produces just over 5% of its energy requirements, thanks to its heating network. District heating and cooling saves energy, promotes the use of local resources, helps guarantee flexibility and security and improves efficiency. The Paris authorities own the electricity, gas, heating and cooling networks and organise energy distribution.

Market driver: Energy efficiency policies and programmes

Energy efficiency investments in Paris are driven by policies in a variety of domains, including climate change, and at multiple levels of governance. The international, European and national contexts are important mainly in setting the energy efficiency policy framework, while regional, municipal and local levels are more important in implementation, especially in the buildings sector and for energy networks. A variety of policies and programmes at municipal level are driving investment in the energy efficiency market.

Paris Climate and Energy Action Plan

Paris was a leader among cities worldwide in introducing a climate action plan in 2007, with more ambitious targets than those at EU level at the time. Such plans are now mandatory throughout France. The 2007 climate action plan was updated and relaunched in 2012 as the Paris Climate and Energy Action Plan. The plan sets the objective of a 75% reduction in GHG emissions by 2050 compared to 2004, and three interim objectives by 2020: 25% emissions reduction, 25% reduction of energy consumption, and 25% share of renewable energy sources. The energy consumption objective translates into a reduction from 32 200 GWh in 2004 to 24 200 GWh in 2020 (by 2009 it was 30 600 GWh). The plan encompasses many actions, a selection of which are listed in the table below.

Table 9.2 Selected activities to reduce Paris city-wide GHG emissions and projected emissions reduction over lifetime ($ktCO_2$)

Emissions reduction	Activity description
1 245	Bringing agriculture closer to Paris, improving quality etc.
1 000	Extending and adding new tram and metro lines, extending opening hours
600	Specific urban planning to favour pedestrians and bikes over cars
570	Retrofitting 55 000 social housing units by 2020
500	Developing logistics platforms for rail or river transport
500	Upgrading engines of old buses
300	Incentivising private owners to retrofit their buildings
250	Eco-neighbourhoods (green infrastructure, low energy consumption, etc.)
250	Smart system to inform passengers of bus times
250	Obliging urban development to exceed national building codes by 20%
200	Improving bus infrastructure, services and operations
100	Developing district heating
50	Green public procurement
15	ESCO financing
15	Encouraging cycling (cycle paths, traffic management, etc.)
5	Renovating public lighting

Source: Mairie de Paris.

The actions are grouped into seven main areas (for the purposes of this chapter, we focus on the first four as they are biggest drivers from an energy efficiency perspective):

1. an energy strategy for the Paris administration
2. low-energy and affordable housing

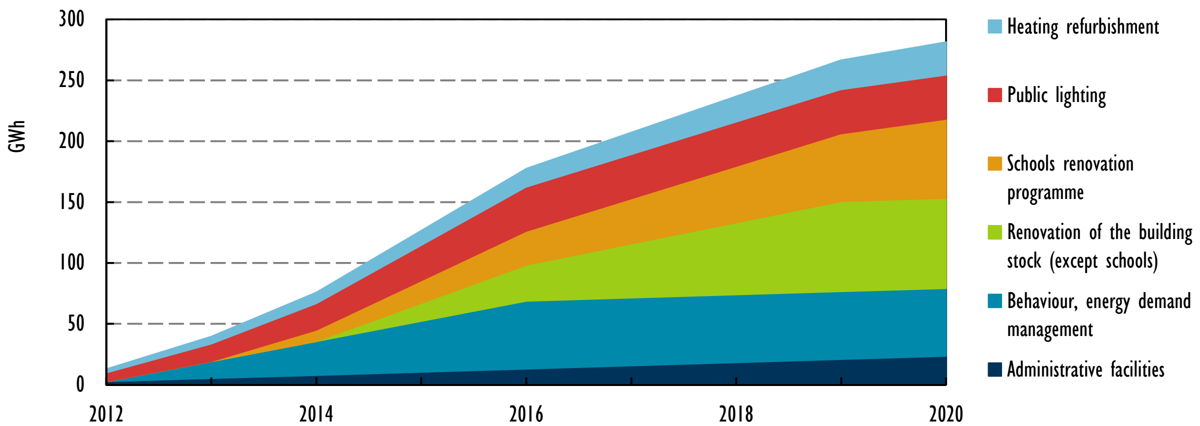
3. urban planning for energy efficiency
4. towards transport that improves the climate and air quality
5. towards sustainable consumption that generates less waste
6. the service industry in Paris, a new challenge
7. climate adaptation.

An energy strategy for the Paris administration

The energy consumption of the Paris administration in 2013 was 634.9 GWh, a drop of 6% from 2012. In 2009, energy consumption had been 895 GWh. Its energy bill in 2013 was USD 70 million (EUR 62 million).

Paris has adopted a voluntary commitment of a 30% reduction in the energy consumption of its buildings, municipal vehicle fleet and public lighting in 2020 compared with 2004 (Figure 9.3). Energy consumption must drop below 601 GWh. Selected activities are listed in Table 9.3.

Figure 9.3 Energy savings of planned activities in public buildings, 2012-20



Source: Mairie de Paris (2012c), Le Carnet de l'Administration du Plan Climat-Energie de Paris, Mairie de Paris, Paris.

In the area of public lighting, an energy savings performance contract (ESPC) was implemented by Paris in 2011. It commits the operator to achieve a 30% (36 GWh) saving by 2020 compared to 2004, with fines for non-compliance (Mairie de Paris, 2012c). Since 1 July 2013, a policy initiated at the national level asks offices, shops and other buildings in Paris to switch off unnecessary lights between 1 a.m. and 7 a.m. This measure is estimated to reduce 250 000 tCO_2 and save USD 225 million (EUR 200 million).

In 2011 Paris set up a climate agency (Agence Parisienne du Climat). One of its aims is to mobilise all the relevant actors involved in the renovation of buildings, working with apartment owners to help them arrange energy audits, renovation work and financing. An innovative web platform (CoachCopro®) was set up as a one-stop shop.[3]

[3] See http://paris.coachcopro.com.

Table 9.3 Selected Paris administration activities and projected lifetime GHG emissions reduction and energy savings

Energy saving (GWh)	Emissions reduction (tCO_2)	Activity description
65	13 484	Retrofitting 600 primary schools
..	12 994	Reducing transmission and distribution losses
74	10 111	Retrofitting 25% of municipal buildings (other than schools)
56	9 789	Educating staff to use less electricity, reducing building energy consumption by 8%
27	5 603	Improving the energy efficiency of thermal boilers
17	4 496	Educating staff: travel by bicycle, eco-driving etc.
36	3 879	Reducing energy consumption for municipal lighting by 30% by 2020
..	3 789	Using the district heat network

Note: .. = data not available.

Source: Mairie de Paris (2014), Energy challenges of the Parisian service industry, 2014-20, Mairie de Paris, Paris.

In December 2015, Paris hosts the United Nations climate change conference COP-21. Paris sees this as an opportunity for cities and local governments to reaffirm their role in emissions reduction. In March 2015, the mayor of Paris hosted the mayors of other European capitals to put in place common initiatives. A further meeting will be held on the eve of COP-21, with more than one thousand mayors expected to attend. Paris also acts through other networks such as the Compact of Mayors (since 2014), in Europe the Covenant of Mayors (since 2009), and C40 (since 2007).

Businesses in Paris can sign up to the Paris Climate Action Partnership Agreement, a web platform to promote their actions to mitigate climate change and to exchange best practices. As of August 2015, 12 large companies had signed up, committing to reduce their emissions by more than 500 $ktCO_2$. Similarly, *Acteurs du Paris Durable* is a platform to connect and recognise citizen and stakeholder leaders on climate change and sustainable development, with more than 200 000 Parisians signed up (Mairie de Paris, 2015).[4]

Low-energy and affordable housing

The *Carnet Logement* for 2014-20 sets the aim of building 10 000 homes per year, with priority for lower income and middle classes, and transforming 200 000 m² of empty offices into housing (Mairie de Paris, 2015). For new buildings, the Paris Climate and Energy Action Plan objective is 50 kWh/m^2/year of primary energy. That level is equivalent to the BBC-Effinergie+ label, i.e. consumption 20% lower than the relevant thermal regulations (*RT 2012*) for housing (30% lower for offices). This level of performance for large building complexes is an economic attraction, as performances are generally better than those demanded by international labels such as Leadership in Energy and Environmental Design (LEED) or Building Research Establishment Environmental Assessment Methodology (BREEAM).

[4] See http://parisactionclimat.paris.fr/en and http://acteursduparisdurable.fr.

For renovation of existing buildings, the target is 80 kWh/m²/year (equivalent to the BBC-Effinergie renovation label). In some end-uses, such as heat, Paris requires up to 30% more than the national regulatory framework. A parallel objective is for social housing to achieve a 30% reduction of energy consumption by 2020 compared to 2004.

The *Copropriétés: Objectif climat!* measure run by the Agence Parisienne du Climat supports co-owned buildings in carrying out energy performance works. The measure finances 70% of the cost of a thermal audit, paid for by the City of Paris, ADEME (the French energy efficiency and environment agency) and the region.

The Paris administration checks the condition of all Paris building facades once every three years, i.e. almost 25 000 buildings per year. The city has started to leverage this by letting residents know when high energy efficiency improvement potential has been identified.

Urban planning for energy efficiency

Planning in Paris is intended to favour more density and reduced environmental impact. The requirements of the 2007 climate action plan were incorporated into urban planning specifications. Key provisions include limiting road transport, with rules on parking and the identification of sites on the banks of the Seine for goods transit platforms; maintaining building density; and creating green spaces around and on buildings. Specific development areas include passive and low-energy buildings in the Frequel-Fontarabie district and the creation of a 10-hectare park in the Clichy-Batignolles area.

Towards transport that improves the climate and air quality

The 2007 climate action plan included pre-defined objectives for transport, the main one being a 60% reduction in emissions from inner-Paris travel between 2001 and 2020. In 2009, a 7% saving in transport emissions had been achieved compared with 2004, and 12% since 2001. Since then, Paris has launched a voluntary policy of reduced car use (25% fewer vehicle km in ten years) and associated emissions, more and better public transport (including tram and local bus routes, bus lanes and extension of metro lines), and promotion of more active means of travel (i.e. cycling). Paris also actively supports the actions of the Île-de-France Transport Union (STIF) in its far-reaching programme to improve public transport.

The French government has introduced incentives for drivers to trade in older (manufactured before 2001) diesel cars for new hybrid or electric vehicles. Paris banned the most polluting diesel vehicles from its municipal fleet from July 2015 with a goal of complete removal of diesel vehicles made before 2011 by 2020. For businesses, the city will pay up to 50% of the cost of a new, clean van and get banks to give concessional loans for the other 50%. Since September 2015, the cost of a monthly metro pass is the same for commuters from the suburbs as for central Paris, making this alternative form of transport more attractive to car commuters and others.

A strategy to promote cycling was announced in April 2015 with the goal of tripling the number of journeys by bike by 2020, with the share of journeys by bike rising from 5% to 15%. The strategy has a budget of USD 170 million (EUR 150 million) over five years. Bike lanes will double from 730 km in 2013 to 1 400 km by 2020, zones with a speed limit of 30 km/hour will be expanded, and more parking facilities and financial aid for bike purchases will be introduced. There is also a plan to promote walking in new development projects (Paris is already a highly walkable city).

Box 9.3 Air pollution in Paris

The density of economic activity in Paris, especially road transport, generates nitrogen dioxide (NO_2) levels that are twice the regulatory limits. The region's particulate matter (PM 2.5) level also remains above the regulatory threshold of the World Health Organization.

The PM 2.5 level has been falling but there have been a number of peaks in recent years, partly linked to weather patterns but mainly due to exhaust from diesel cars, SUVs and trucks. France, like many other European countries, effectively subsidises diesel fuel by making it cheaper than gasoline, with the result that Paris has a high concentration of diesel vehicles. Many employees also benefit from tax reductions for fuel and on the purchase of company cars.

Although diesel engines are in general more fuel-efficient than gasoline engines, the extra air pollution they cause has been an important driver of policies and programmes to improve the energy efficiency of the transport system overall. In response to air pollution episodes, the city takes temporary measures to make public transport free (encouraging use of more efficient transport modes) and impose alternate-day vehicle usage by licence plate numbers. Longer term, Paris is working to promote alternatives to the car, reduce speed limits, reduce the share of diesel vehicles in the municipal vehicle fleet, place restrictions on the most polluting vehicles and provide support to the cleanest ones, and work towards a more coherent policy at the level of MGP. At national level, the key policy change will be the removal of subsidies to diesel.

Current energy efficiency market activity

Between 2004 and 2009, there was a 6% reduction in energy consumption. Of that, actions under the Paris Climate and Energy Action Plan since early 2008 are estimated to have resulted in about 130 GWh of savings. This stimulated investment of USD 725 million (EUR 640 million), creating 1 300 local jobs and 420 jobs elsewhere.

Buildings

Around 22 000 homes have been helped to carry out an energy audit under the *Copropriétés: Objectif climat!* measure (260 audits since 2008). As of October 2014, 44 co-owned buildings (4 000 homes) had voted to carry out USD 12.5 million (EUR 11 million) of energy renovation, of which USD 4.5 million (EUR 4 million) was for external insulation. The annual energy saving is estimated at 6.7 GWh/year. In 2015, assistance to co-owned buildings will evolve with the launch of *Alliance Co'pro*, a platform run by the Agence Parisienne du Climat with the City of Paris, ADEME and Paris-IDF.

As of 1 October 2014, 370 Paris co-owned buildings were signed up to the CoachCopro platform (24 000 apartments). The majority are in the early stages of their project. The platform is also being rolled out in neighbouring regions (Mairie de Paris, 2015).

The *1 000 Energy-Consuming Buildings Plan* (*Plan 1 000 immeubles énergivores*), launched in 2015, will expand the coverage of municipal measures leading to improvements in building energy performance. The chosen co-owned buildings are offered assistance and specific aid for works. For the year 2015, USD 1 million (EUR 0.9 million) of operating expenses are planned, to cover in particular the cost of advertising and marketing this new measure, as well as the first energy audits. Negotiations are underway with the ANAH (housing agency) to determine its contribution to the financing of the plan.

This preparatory work will allow investments to be supported from 2016. In 2015, USD 5.9 million (EUR 5.2 million) is to be spent on the launch of the *1 000 Energy-Consuming Buildings Plan* and on the already launched *Opérations programmées d'amélioration de l'habitat*.

Paris has invested more than USD 45 million (EUR 40 million) in renovating occupied social housing units under its Climate and Energy Action Plan (40% of the total cost). These renovations are expected to result in 30% energy savings, equivalent to the annual consumption of almost 7 500 housing units (Table 9.4). Tenants generally have energy bills 75% lower than the average (Mairie de Paris, 2012a).

Table 9.4 Social housing unit renovations financed under the Paris Climate and Energy Action Plan and energy savings generated, 2009-14

	2009	2010	2011	2012	2013	2014
Total renovations	4 297	4 754	3 329	4 210	6 321	5 442
Primary energy savings generated (MWh/year)	35 200	58 500	34 600	38 900	..	..

Source: Mairie de Paris, 2012b and Mairie de Paris, 2015.

In addition, 70 000 m^2 of public buildings have been renovated to the standards of the Climate and Energy Action Plan. The provisional budget for 2015 dedicates USD 5.6 million (EUR 5 million) to the modernisation of heating and ventilation of municipal facilities, improving their energy performance. An amount of USD 5.9 million (EUR 5.2 million) was dedicated to repairs and modernisation of heating in 2014, in addition to USD 4.4 million (EUR 3.9 million) for maintenance. Modernisation should achieve an annual saving of 0.7 GWh (Mairie de Paris, 2015).

Retrofitting of 600 primary schools in Paris is underway through Energy Performance Contracting. Already, the largest ESPC in France, involving the renovation of 100 Paris schools over two years, has resulted in a reduction of 34% of their energy consumption. Savings of 10.7 GWh per year are expected for this first contract (Mairie de Paris, 2015). The city of Paris has budgeted USD 3.4 million (EUR 3 million) in 2015 for ESPC in primary schools. With this investment and European support, it is planned to retrofit all Paris primary schools. The renovation of 200 more schools has already been agreed.

The annual renovation rate of service sector buildings in general ranges from around 0.4% for healthcare facilities to 2.2% for office buildings. Office buildings are easier to deal with (Mairie de Paris, 2014).

During the period 1995-97, 16 patents related to building energy efficiency were lodged in Paris-IDF. This rose to 62 patents during 2005-07 (Kamal-Chaoui and Plouin, 2012). Paris-IDF was home to 43 000 jobs in the areas of consultancy, environmental engineering and energy efficiency in 2008 (Kamal-Chaoui and Plouin, 2012). In 2013, the city of Paris supported 103 companies in the "eco" sector.

Transport

Between 2001 and 2011, the equivalent of 2 200 million vehicle-km were avoided due to the Paris mobility policy, representing USD 23 million (EUR 20 million) in saved fuel expenditure. The number of metro journeys per year has increased by 16% in ten years and the number of bicycle journeys has more than doubled. Car journeys within Paris have declined by 25% in ten years.

Paris is also host to two flagship rental schemes: Autolib for electric cars since 2011 and Vélib' for bicycles since 2007. Vélib' has around 283 000 annual subscribers (a 72% increase since 2009) and about 36 million trips are made each year. Autolib has more than 2 500 vehicles in service and 873 stations (507 in Paris). The latest available data show 132 000 drivers and four million rentals since 5 December 2011. That is more than 36 million km travelled. There are more than 10 000 rentals per day and more than 53 000 Autolib subscribers. The Autolib network has also led to the provision of 470 recharge points available for private electric cars to use. A further 180 points are planned for 2015, which will give Paris one of the most dense electric car charging networks in Europe. Eventually all Autolib stations will include charging points for private electric cars (Mairie de Paris, 2015). A third scheme, for electric scooters, has been announced and is set to launch early in 2016 with the gradual deployment of 1 000 scooters.

The effect of this energy efficiency market activity in the transport sector extends beyond the administrative borders of Paris. For example, at least 30 neighbouring towns have Vélib' stations, 46 authorities are members of the Autolib' association and 60% of users of the T3 tramway line are not Parisians. A new transport network to serve greater Paris is planned, involving an investment of USD 36 billion (EUR 32 billion) over 15 years (EUR 25 billion for a new rail line, the *Grand Paris Express*, and EUR 7 billion for the modernisation of existing networks). Paris's contribution to the STIF budget has almost doubled over the past decade, reaching USD 425 million (EUR 374 million) in 2014 (Mairie de Paris, 2015).

Public lighting

Energy savings in public lighting by replacing lightbulbs and obsolete lights reached 18% in July 2014 compared to 2004, or 27 GWh, equivalent to the consumption of a French town of 300 000 inhabitants (Mairie de Paris, 2015). Energy consumption for public lighting in Paris in 2013 was 129 GWh, a drop of 7.5% in one year, resulting in an energy bill of USD 17.6 million (EUR 15.6 million). In 2014 that declined even further to 121 GWh (Mairie de Paris, 2015); in 2004, it had been 153 GWh. In the 2015 budget, USD 24 million (EUR 21.5 million) is projected to be spent on improving lighting energy performance. USD 9.4 million (EUR 8.3 million) has been set aside for the maintenance of traffic lights in the framework of the energy performance market.

District energy

In 1927, Paris created a concession to develop a network to deliver steam for heating buildings. The goal was twofold: 1) to reduce the city's coal and wood use in order to minimise fire risk and improve air quality; and 2) to reduce the need for thousands of people to deliver coal or wood to the streets of Paris. After World War II, the city became a 33% shareholder in the Paris Urban Heating Company (*Compagnie Parisienne de Chauffage Urbain*, CPCU), which 90 years later still operates the Paris **district heating** network. The CPCU is 64% owned by Engie (previously GDF Suez) (UNEP, 2015).

Today, the network is the third-largest heating grid in the world and continues to flourish using the underground tunnels and pipelines that already serve the Paris metro system. CPCU's 475 km network has 5 620 customers and connects the heat demand equivalent of 470 000 households (including all of the city's hospitals, half of all social housing units, and half of all public buildings, including the Louvre). It also interconnects 13 towns, including Paris. Heat is produced at eight facilities – including two co-generation facilities and three waste-to-energy plants – that have a combined generating capacity of 4 GW and produce 5.5 TWh of heat and 0.7 TWh of electricity annually (UNEP, 2015). The CPCU buys the waste heat and uses it in the district heating network – a good example of energy recovery.

Because the city has a large (33%) stake in the CPCU, it is able to influence the company's policy objectives. The network now aims not only to provide affordable, reliable heat but also to reduce the city's CO_2 emissions by lowering primary energy use and enabling a greater share of renewable heat. Through the city's stake in the CPCU, the network is also being developed to incorporate new social housing. The concession contract sets a maximum price for heat delivered and the city can also enforce a special low price for those in social housing.

The combination of city ownership and the use of a concession model has allowed Paris to maintain a high degree of control over district heating development, while also benefiting from the efficiency improvements and capital investment contributed by the private sector. In addition to providing cheaper heat, the CPCU provides Paris with an annual dividend of USD 2.3 million (EUR 2 million) and an annual concession fee of USD 7.9 million (EUR 7 million). It had revenues of USD 488 million (EUR 432 million) as of March 2014. CPCU expects to achieve its 2020 target of 60% renewable or recovered energy in the district heating network (UNEP, 2015).

At the regional level, district heating networks supply 50% of heating. There are 127 networks in Paris-IDF spread over 1 421 km supplying 13.6 TWh of heat, for 9 376 MW of installed power (Kamal-Chaoui and Plouin, 2012).

The Climespace **district cooling** network is the largest in Europe and was also the first (beginning in 1971, with the concession contract dating from 1991). It uses electric chillers to produce the cooling, which has led to 35% less electricity used, a 50% improvement in primary energy efficiency (saving 25 GWh/year), 65% less water used, and 50% less CO_2 emitted compared to an equivalent stand-alone cooling capacity. In 2014 the system distributed 407 GWh of water to cool over 5 million m^2. The system produces 35 $kgCO_2$ per MWh of cooling, reducing emissions by 20.6 $ktCO_2$ per year.

Climespace (also part of the Engie group) has more than 570 clients connected (UNEP, 2015) and 71 km of network. Clients include offices, commercial and public buildings. Residential buildings are not connected to the district cooling network in Paris as the residential demand for cooling is not as high as in hotter countries. Today, the total nominal cooling capacity installed is 285 MW, with capacity development ongoing (about 25-30 new clients and 14 MW of capacity per year) (UNEP, 2015).

Climespace has annual revenues of about USD 85 million (EUR 75 million). The network uses ten production plants and three cold storage sites. The total investment (sites and network) so far is of the order of USD 450 million (EUR 400 million). Its Bercy cooling plant alone has a capacity of 44 MW, supplying more than 40 clients, mostly offices, along 10 km of network.

As with other production sites in the Climespace network, the Bercy plant has “free” cooling capacity in the form of water from the river Seine, resulting in a 34% increase of the average coefficient of performance of the plant's chillers. Free cooling was a strategic decision by Climespace to improve network energy efficiency and help achieve the Climate and Energy Action Plan. While it is limited by river water temperatures, free cooling still provides net benefits to the system (IEA, 2014).

Chilled water production by means of free cooling typically occurs in the winter season when river temperatures are low. At the Bercy cooling plant, monthly electricity savings during winter have been as high as 400 MWh of electricity (or nearly 60% of average monthly electricity consumption at the plant during those months if free cooling had not been available). Partial free cooling is also possible at slightly warmer river water temperatures, and a total of 3.2 GWh of electricity was saved at the Bercy plant between January 2010 and March 2013, or roughly 8% of total energy consumption for that period (IEA, 2014).

Total capital expenditure for the Bercy cooling plant was USD 38 million (EUR 34 million), including initial installation and the on-site generators. Approximately USD 395 000 (EUR 350 000) of that investment can be attributed to works associated with the implementation of free cooling using the river Seine. The project was financed using a 20% equity-to-loan ratio with an expected 15-year payback period (IEA, 2014). The Bercy network is currently being expanded to increase connections on the left bank of the river. As a utility company exceeding 400 GWh of energy sold, Climespace needs to comply with the French CEE (*Certificat d'économies d'énergie*) scheme and has to date met the required efficiency targets (IEA, 2014).

Other district cooling networks exist in Paris such as the Dalkia-owned SUC (*Société Urbaine de Climatisation*) network in the La Défense business district. This network also uses free cooling from the Seine and serves 70 high-rise buildings through 6 km of network, and directly or indirectly cools the equivalent of 1 million m^2 of office and hotel space through interconnections to two adjacent district cooling networks (UNEP, 2015).

The United Nations Environment Programme (UNEP) launched the Global District Energy in Cities Initiative at the New York Climate Summit in September 2014, with the aim of accelerating district energy worldwide with a particular focus on markets such as China and India. The city of Paris, Climespace and CPCU are all working with the Initiative to share the best-practise policies and technologies of Paris with cities worldwide. Paris is a champion city of the Initiative and is highlighted in UNEP's *District Energy in Cities* publication (UNEP, 2015) as well as a stand-alone Paris case study on district energy.

Prospects

The Paris Climate and Energy Action Plan will be amended again in 2017 in order to achieve the 2020 objectives and draft the roadmap for the period 2020 to 2050. The Plan is projected to result in savings of 4 TWh per year from 2020 onwards (equivalent to the energy consumption of the 1st to 8th *arrondissements*), with almost USD 565 million (EUR 500 million) in energy bill savings and other co-benefits in areas such as employment and reduced energy poverty (Mairie de Paris, 2012a).

In the buildings sector, oil for heating will continue to be replaced by gas, electricity and district heating, with systems becoming more efficient. Efficiency of air-conditioning systems is also expected to improve, despite increased use. Modal shift away from private cars will be needed in the transport sector. This will involve extending public transport services particularly in the suburbs. More needs to be done in the freight sector as well.

By 2020, the effects of an ambitious energy conservation policy could deliver a cost saving of nearly USD 225 million (EUR 200 million), to reach an energy bill of USD 1.7 billion (EUR 1.5 billion). In the public sector, potential savings are nearly USD 68 million (EUR 60 million) for a bill of USD 488 million (EUR 432 million) (Mairie de Paris, 2014). These efforts will require further investments in energy efficiency.

Challenges

One of the important challenges facing Paris is in the area of building renovation. Co-ownership of apartment buildings makes it difficult for all owners in a building to agree on deep renovation. Moreover, Paris has a high share of historic buildings, which are more difficult to renovate.

Legislative change is needed to make it easier for assemblies of co-owners to vote for renovation works, as is financial innovation to help households absorb the cost. The main measure to support financing of building renovations in France until now, the *crédit d'impôt développement durable* (sustainable development tax credit), has tended to support only light renovations. Paris is testing several ways of supporting co-owned buildings and of promoting the renovation of private apartment buildings.

Many drivers of energy efficiency policy are local: the layout of buildings, the climate, the construction and renovation supply chain, knowledge of the characteristics of the local population such as income, energy resources, etc. For that reason, implementation of national targets is set out at the local level, such as in the Climate and Energy Action Plans. However, the region is characterised by a surfeit of administrations – there are nearly 1 300 local authorities – which creates hurdles for strong horizontal and vertical co-ordination (Kamal-Chaoui and Plouin, 2012). This fragmentation of local authorities slows some energy efficiency actions that would benefit from a co-ordinated spatial approach.

Conclusions

Paris is taking a variety of steps across a spectrum of areas (housing, transport, district energy) to improve the efficiency with which energy is used by the city to support its growth and improve quality of life for its citizens.

More integrated policy making at the level of the newly created Greater Paris Metropolis, especially in planning and transport policy, will support efforts for the city to further improve energy efficiency. Significant investment, both public and private, will be needed. ESCOs and public-private partnerships (as with district energy, and the Vélib and Autolib schemes) are possible ways to encourage this. Yet there is still significant savings potential, notably through renovation of residential buildings. The political commitment shown to date by Paris bodes well for further significant gains in Paris and the MGP.

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10. RUSSIAN FEDERATION

Summary

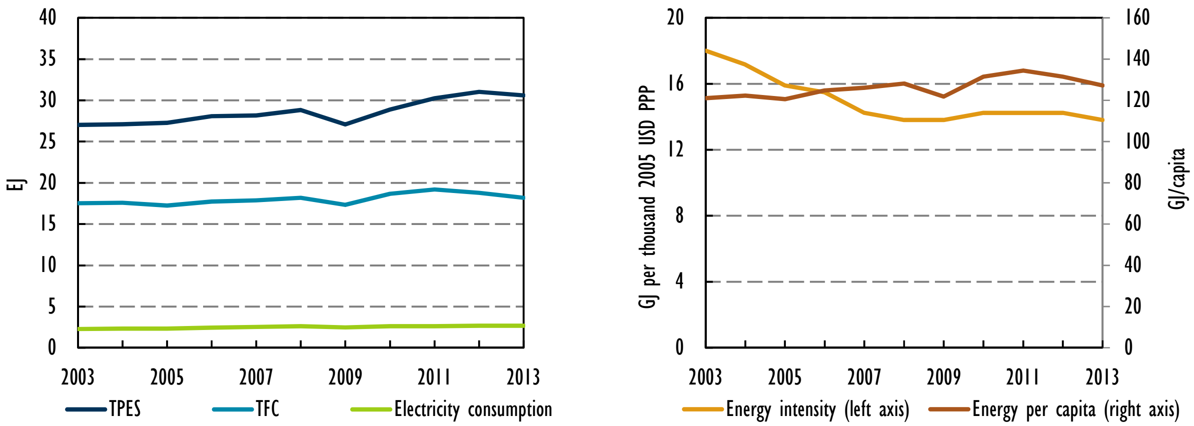
Since 2008, the government of the Russian Federation (hereafter, "Russia") has actively supported energy efficiency in order to diversify the country's economy away from a resource-focused one to an innovation-driven one. This is reflected in its National Energy Strategy for the period up to 2035, which set a target to reduce the energy intensity of the Russian economy by 50% compared to 2010 levels. The federal subsidy programme available for regional energy efficiency development resulted in a number of successfully implemented energy saving projects and raised the profile of energy efficiency.

Russia has a significant potential for further energy savings across a variety of sectors, which in turn provides the opportunity for large amounts of energy efficiency investment. However, in light of current economic conditions, federal funding for energy efficiency projects is being cut, and several laws related to energy efficiency have been postponed. As a result, it is anticipated that in the future regional and local authorities will have to rely on non-state funding in order to continue energy efficiency programmes and investments. The government has taken steps in the right direction by introducing zero duty on imports of energy efficiency products and making the energy service industry more transparent to the public.

Energy profile and context

Between 2003 and 2013, Russia's economy grew at a compound annual growth rate of 3.6%, reaching USD 2 206 billion (2005 purchasing power parities [PPP]). This growth was fuelled largely by the oil and gas sector, which accounted for more than a quarter of GDP in 2013 (World Bank, 2013). In line with energy production, total primary energy supply (TPES) and total final energy consumption (TFC) showed steady growth over the last decade (Figure 10.1); TPES increased by 13% and TFC by 4%. The 2009 economic crisis resulted in a 5% drop for both indicators. This was followed by a swift recovery between 2009 and 2013 with TPES and TFC reaching 30.6 exajoules (EJ) and 18.2 EJ respectively. By the end of 2013, Russia had become the fourth-largest energy-consuming country in the world, representing 5% of the global total.

Figure 10.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2003-13



Note: TPES = total primary energy supply, TFC = total final consumption.

Source: IEA (2014a), *Energy Balances of non-OECD Countries 2014*, OECD/IEA, Paris, DOI: http://dx.doi.org/10.1787/energy_bal_non-oecd-2014-en.

Electricity consumption grew by 112 TWh (18%) over the decade to 2013. This was driven primarily by the strong increase in demand in the service sector, which grew by 95.6 TWh (145%) between 2003 and 2013. The transport sector saw a 20% (15.4 TWh) increase in electricity consumption, accounted for by steady increases in transport by pipeline and rail. Industry consumed 3% more electricity in 2013 than in 2003 (up by 8.4 TWh), while consumption in the residential sector declined by 2% (down by 2.3 TWh).

Since 2003, energy intensity in Russia has fallen by 23%, dropping from 19 gigajoules (GJ) per thousand USD PPP to 14 GJ in 2009, and has remained at around that level ever since (Figure 10.1, right). The 23% reduction is eight percentage points higher than in the European Union and, on average, 11 percentage points higher than among member countries of the Organisation of Petroleum Exporting Countries (OPEC). In spite of Russia's impressive progress in reducing the energy intensity of its economy, it is still more energy intensive than many large emerging economies, such as Brazil (4.6 GJ per thousand USD PPP), India (5.4), China (9.2), and Indonesia (4.2), as well as oil- and gas-producing countries such as Canada (8.0), the United States (6.3), Saudi Arabia (5.9), and Iran (9.2).

Energy intensity improvements are explained partly by structural changes in the economy. Over the decade 2003-13, Russia's service sector grew quickly, reducing the share of energy-intensive manufacturing and industrial activity in total GDP. Since 2006, the service sector[1] has increased by 35% (an increase of USD 175.7 billion PPP), whereas industry saw a 9% increase (USD 50.7 billion PPP) (OECD, 2014).

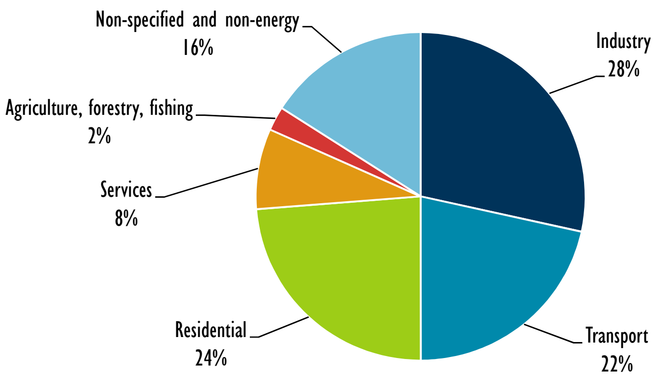
Energy consumption per capita increased by 5.2% over the decade, resulting in part from a decline in population and strong economic growth. Between 2003 and 2013, Russia's population decreased by 1.2% (1.7 million) , whereas gross domestic product (GDP) per capita increased by 48% (Rosstat, 2015).

In 2013, Russia's TFC amounted to 18.2 EJ with the industrial, residential and transport sectors accounting for three-quarters of this (Figure 10.2). Industrial energy demand was driven by production of iron and steel, chemicals, petrochemicals and non-ferrous metals. Industry consumed 73% of coal and peat TFC, 45% of electricity and 37% of heat. Energy demand in the transport sector was dominated by road and pipeline transport. These sectors accounted for half of the TFC of oil products and 21% of natural gas. The residential sector consumed almost half of Russia's final heat (2.1 EJ) and 25% of its natural gas (1.3 EJ).

Between 2003 and 2013, TFC increased by 0.7 EJ. The largest absolute increase (up 1.3 EJ) was in the non-energy sector (Figure 10.3). This was offset by a 1.5 EJ decline in the residential sector, driven by reductions in the demand for heat and natural gas (down 0.8 EJ and 0.6 EJ). Consumption by transport and services rose by 0.4 EJ and 0.6 EJ respectively. Industry saw an increase in demand for natural gas (up 0.3 EJ), which was offset by a decrease in demand for heat (down 0.4 EJ). As result, TFC stayed level for the sector. Oil consumption in the transport sector rose by 0.6 EJ while commercial and public services primarily accounted for the increase in electricity demand (up 0.3 EJ).

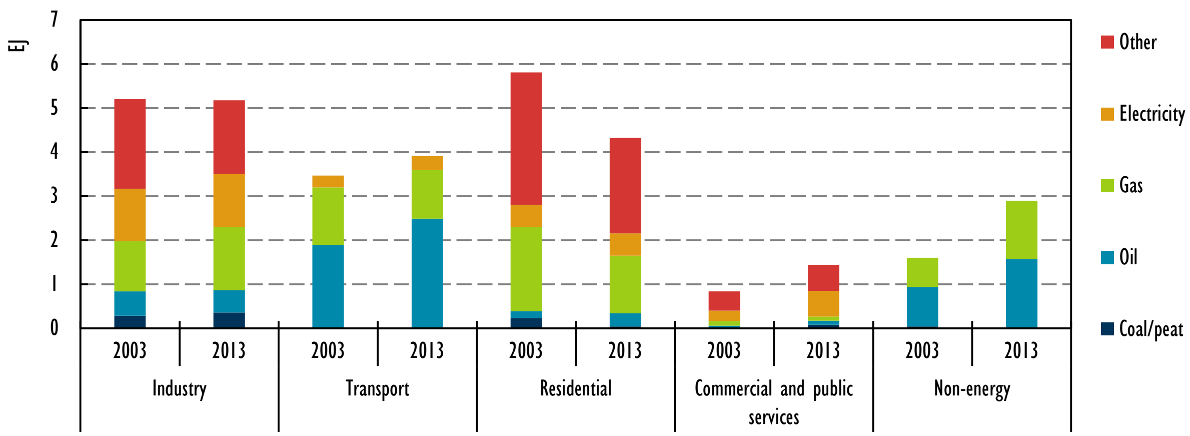
[1] The services sector excludes trade, accommodation, restaurants and communication.

Figure 10.2 TFC by sector, 2013



Source: IEA (2014), *Energy Balances of non-OECD Countries 2014*, OECD/IEA, Paris, DOI: http://dx.doi.org/10.1787/energy_bal_non-oecd-2014-en, (accessed on March 2015).

Figure 10.3 TFC by sector and by energy source, 2003 and 2013



Notes: Transport includes pipeline transport for natural gas. "Other" is made up primarily of heat energy, the large majority of which results from the combustion of fuels although some small amounts are produced from electrically-powered heat pumps and boilers. Heat extracted from ambient air by heat pumps is not included. Non-energy use covers those fuels that are used as raw materials in the various sectors and are not consumed as a fuel or transformed into another fuel.

Source: IEA (2014), *Energy Balances of non-OECD Countries 2014*, OECD/IEA, Paris, DOI: http://dx.doi.org/10.1787/energy_bal_non-oecd-2014-en, (accessed on [March 2015]).

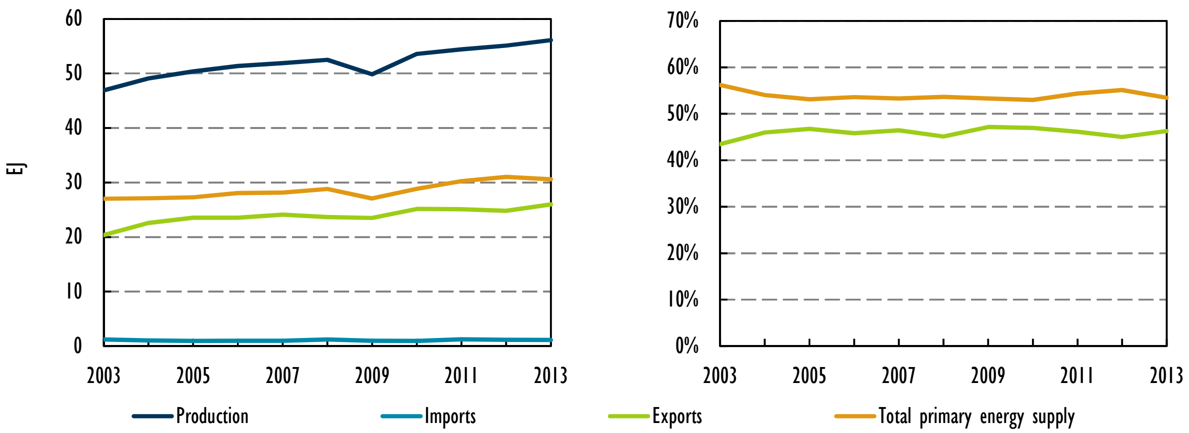
Russia's domestic energy production remains dominated by fossil fuels, mainly natural gas (41% of total), oil (39%) and coal (15%). Between 2003 and 2013, energy production increased by 20%, reaching 56.1 EJ (Figure 10.4, left); this amounted to 10% of total world production. Growth was driven by increasing energy demand for domestic supply and for export, which grew at average rates of 1.3% and 2.5% respectively. Production slowed following the recession, which was reflected in a 5% drop between 2008 and 2009.

Russia exports almost half of its domestically produced energy (Figure 10.4, right). In 2013, exports amounted to 26 EJ (44% of total energy production). Oil and oil products[2] accounted for the majority

[2] Includes crude oil, natural gas liquids (NGL), refinery feedstocks, additives and other hydrocarbons.

(57%) of exports, followed by natural gas (28%) and coal and peat (14%). Domestic energy demand represented 55% of production, totalling 31.7 EJ. TPES was dominated by natural gas (45%), followed by oil (32%) and coal and peat (15%).

Figure 10.4 Production, imports, exports and TPES (left) and share of exports and TPES in production (right), 2003-13



Source: IEA (2014a), *Energy Balances of non-OECD Countries 2014*, OECD/IEA, Paris, DOI: http://dx.doi.org/10.1787/energy_bal_non-oecd-2014-en.

Market driver: Energy efficiency policies and programmes

In 2008, the government began to actively promote energy efficiency improvements. This was marked by the Presidential Decree "On Some Measures for Increasing Energy and Ecological Efficiency of the Russian Economy" (The Government of the Russian Federation, 2008), which was the basis for establishing the Russian Energy Strategy.

Energy Strategy

The Energy Strategy, developed by the Russian Ministry of Energy, targets a 40% decrease in the energy intensity of the Russian economy by 2020 compared to 2010. The strategy is currently being revised with the expectation that the target be extended from 2020 to 2030. The government identifies three main stages required to achieve this target: a major overhaul of the energy sector, development of technological capacity, and a transition from a resource-focused to an innovation-driven economy. The strategy has to be renewed every five years and the latest version, published in 2014, incorporates revised values of Russian economic growth and global energy prices.[3]

Since 2009, Russia's energy strategy specifically includes a Programme for Energy Saving and Energy Efficiency Improvement for the period until 2020 (Minenergo, 2010). The programme defines 2020 targets for decreasing the energy intensity of the Russian economy (by 13.5%),[4] reducing greenhouse gas (GHG) emissions (by 393 million tonnes of CO_2) and increasing the share of renewable energy sources (by 4.5%). The programme is underpinned by Federal Law No. 261 "On Energy Saving and

[3] Russia's economic growth is forecast to increase by 3.8% per year (base scenario) and 2.8% (risky scenario) compared to a GDP growth value of 4.7% per year used in the version for the period up to 2030 (Minenergo, 2009).

[4] In line with Presidential Decree 889, the remaining 26.5% of reduction is assumed to come from structural changes to the economy.

Improving Energy Efficiency" that sets out the legal basis for achieving these targets (FZ-261, 2009). The main measures covered by FZ-261 include phasing out incandescent lamps (100 W by 2011, 75 W by 2013, 25 W by 2014); the introduction of compulsory energy efficiency audits;[5] obligatory integration of energy consumption meters in multifamily residential buildings; and the introduction of energy efficiency standards for buildings. Central to the success of the Energy Strategy is the idea of improved institutional co-ordination between the environmental, infrastructural and innovation realms (Box 10.1).

Box 10.1 Institutional co-ordination

The president and the government are responsible for the development of energy efficiency policy in Russia. However, implementation rests with many different ministries and institutions, each accountable for an area of the energy efficiency domain relevant to their expertise. Notable ministries involved in energy efficiency policy implementation are the Ministry of Economic Development, the Ministry of Industry and Trade, the Ministry of Transport, the Ministry of Energy, the Ministry of Construction, Housing and Utilities, as well as the Russian Energy Agency. The Ministry of Energy is responsible for shaping policies and was in charge of developing the state programme "On Energy Efficiency and the Development of Energy". The Ministry of Energy takes the leading role in co-ordinating regional energy efficiency projects, training and promoting energy efficiency. The Russian Energy Agency is responsible for ensuring progress in the implementation of energy efficiency at the federal and regional levels, and for attracting private investment in energy efficiency projects.

The total investment needed to achieve the 2020 targets was initially estimated at RUB 9.5 trillion (USD 143 billion)[6] (Minenergo, 2010). The government envisaged 0.7% of this funding would come from the federal budget (around RUB 7 billion [USD 105 million] per annum), 7% from regional financing, and the rest to be covered by the private sector (Table 10.1). The annual review published by the Ministry of Energy in 2014 identified the total amount of federal budget allocated to energy efficiency over the period 2013-20 at RUB 90.7 billion (USD 1.4 billion) (Minenergo, 2014).

Table 10.1 Schedule of the programme on energy efficiency in Russia

Delivery period	2011-15	2016-20
Targets	Decreasing the intensity of the economy by 7.4% by 2015	Decreasing the intensity of the economy by 13.5% by 2020
	Reducing primary fuel consumption by 85 Mtoe	Reducing primary fuel consumption by 170-180 Mtoe
	Increasing the share of electricity produced from renewable sources to 4.5% of total electricity production	
Federal budget	RUB 35 billion (USD 525 million)	RUB 35 billion (USD 525 million)
Regional budget	RUB 208 billion (USD 3.1 billion)	RUB 417 billion (USD 6.3 billion)
Private funding	RUB 3 310 billion (USD 50 billion)	RUB 5 527 billion (USD 83 billion)

[5] These include municipal and state-funded businesses as well as organisations whose cost of energy resources exceeds RUB 10 million (around EUR 225 000, January 2014).

[6] The exchange rate used in this chapter is RUB to USD 0.015 but readers should refer to the latest exchange rates recognizing the volatility of currencies.

The implementation of the state programme relies on the participation of the regional and local authorities. Each is responsible for developing energy efficiency strategies for the region and securing private funding.

Regional participation

Regional and local authorities have been given the task of developing energy efficiency strategies for their regions in line with government objectives. The Ministry of Energy provides funding from the federal budget for eligible projects (approximately RUB 5 billion [USD 75 million] per year).[7] Regional authorities then bear the responsibility for securing private funding (a condition for receiving regional subsidies). In order to equip approximately 30 000 regional officials with the relevant skills, the Ministry of Energy is co-ordinating an energy efficiency training programme across the country.[8]

Some regions have already benefited from the successful implementation of the state programme. Since 2008, the city of Kazan has received a total of RUB 505 million (USD 7.6 million) from the Russian Ministry of Energy towards the overhaul of its residential buildings (Giniyatullin, 2014). Today 30% of Kazan's housing stock meets minimum efficiency standards (1 551 houses). In 2013, RUB 98 million (USD 1.5 million) of federal financing was directed towards retrofitting municipal buildings with energy meters and RUB 100 million (USD 1.5 million) for modernisation of outdoor lighting. As a result 434 school yards and 3 576 street lamps have been fitted with energy-efficient bulbs; 60 km of power cable have been renovated; and all high-rise residential buildings are now equipped with energy metering devices. Kazan is expecting to save RUB 11 million (USD 165 thousand) annually on outdoor lighting alone.

The Vladimir region is another such example (Energosovet, 2015). By 2014, the region had total investments of RUB 1.6 billion (USD 24 million) in energy efficiency. Of this, RUB 1.3 billion (USD 20 million) came from private investors, RUB 112.1 million (USD 1.7 million) from the regional budget, RUB 103.1 million (USD 1.5 million) from the federal budget, and RUB 40.9 million (USD 614 thousand) from the local budget. Vladimir is expecting a 12 million kWh decrease in annual electricity consumption, 145 Mtoe decrease in heat demand and 5.6 Mtoe decrease in demand for other fuel. Financial savings from street lighting upgrades have been estimated at RUB 20 million (USD 300 thousand) while RUB 2 million (USD 30 thousand) is expected to be saved from renovated boilers.

Current efficiency market activity

The launch of the Federal Law "On Energy Saving and Improving Energy Efficiency" (FZ-261, 2009) was the starting point for the implementation of energy efficiency improvements at the national level. Recognition of the economic benefits offered by energy savings then became a key driver of energy efficiency market activity in Russia.

Regional project financing

In 2014, the Ministry of Energy dedicated RUB 5 billion (USD 75 million) to energy efficiency programmes in 25 regions (Government of the Russian Federation, 2014). In previous years this

[7] Federal funding over the length of the delivery of programme on improving energy efficiency until 2020.

[8] See http://minenergo.gov.ru/activity/energoeffektivnost/povyshenie-kvalifikatsii/ for more information

amount was slightly higher, at RUB 5.7 billion in 2013 (USD 86 million) (Government of the Russian Federation, 2013) and RUB 5.7 billion in 2012 (USD 86 million). 2011 became a record year with federal funding amounting to RUB 20 billion (USD 300 million). Combined with co-financing by the private sector (RUB 27 billion [USD 405 million]), in total RUB 47 billion (USD 705 million) were directed towards implementation of regional programmes on improving energy efficiency in 55 regions (Minenergo, 2012). These funds were directed towards the installation of efficient lighting systems, modernisation of heating and hot water supply, retrofitting of buildings with metering devices, energy audits and other energy-saving activities such as education and promotion of energy efficiency. Since then, the Ministry of Finance has made a decision to cut federal subsidies towards regional programmes on energy efficiency in 2015 (Novak, 2015).

Industry

The main policies aimed at motivating energy saving within Russia's industry sector include mandatory energy audits and the establishment of a system for monitoring energy efficiency. Government support measures consist of tax incentives, financial support for loan repayments and other mechanisms intended to raise funds for energy efficiency project implementation. For example, as of 1 January 2012, Russian taxpayers subject to corporate property tax are entitled to a three-year exemption for newly introduced assets that are included in the high energy efficiency category (Article 281 of the Tax Code).

In 2012 around 42 regional programmes were active in the industrial sector according to a survey carried out by the Agency of Energy Modelling and Projections following the initiative of the Russian Ministry of Industry and Trade (Zaicev and Saikyna, 2013). Installation of energy consumption meters were the most common measure (in 80% of projects), followed by installation of energy-efficient lighting systems (76%) and optimisation of technological processes (61%). The majority of small and medium-sized enterprises (SMEs) in the industry sector spent approximately RUB 5 million (USD 75 thousand).[9] Only 1.2% of all businesses spent more than RUB 100 million (USD 1.5 million) annually on energy efficiency projects.

Cutting back on domestic consumption enables oil and gas companies to increase their exports while maintaining the same level of production. Gazprom has set targets to reduce energy consumption for its own use[10] by 1.2% and gas losses in core operations by 11.4% by 2020 from 2011 levels (Gazprom, 2013). The company estimates its energy-saving potential at 19.7 Mtoe. Of this, 5.1 Mtoe of energy savings were achieved in the 2011-13 period as a result of integrating higher efficiency equipment.

In an effort to support long-term energy efficiency improvements in Russia's heat and power generation sectors, in 2010 the Ministry of Energy developed a new funding mechanism: "An agreement for capacity supply" (Minenergo, 2015). Under the agreement, energy companies are contracted to invest in the renovation of energy-generating facilities, i.e. decommissioning old stations and building new ones. In return, the government promised a higher tariff for the energy sold by those companies to end-users for a period of ten years, based on an estimated payback period of 15 years.

Buildings

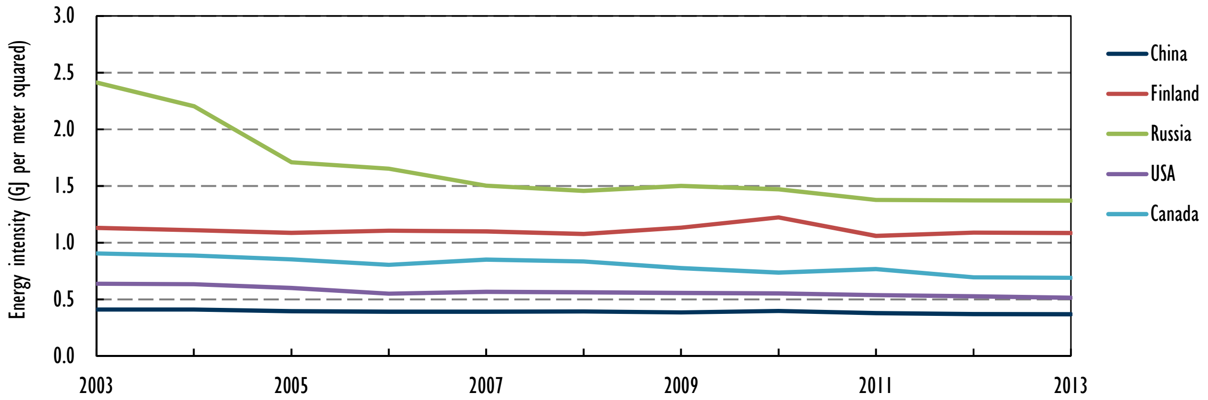
Since 2003, the building sector has witnessed growth in the number of new and renovated buildings. By 2013, almost 200 million square metres (m^2) of new residential floor area had been integrated into the market (Rosstat, 2015). More energy-efficient buildings meant that consumption per m^2 fell

[9] The numbers are based on the average of companies that took part in the survey.

[10] Gas production, transportation, processing, and underground storage.

from 2.41 GJ to 1.37 GJ (a drop of almost 50%) (Figure 10.5). However, when compared to other countries with challenging climate conditions, at 1.37 GJ per m^2 the energy intensity of the residential sector still shows potential for improvement. For example, some countries with similar climates have much lower energy intensities in their residential sectors: Canada (0.69 GJ/m^2), Finland (1.08 GJ/m^2), China (0.37 GJ/m^2), and the United States (0.52 GJ/m^2).

Figure 10.5 Specific energy consumption by residential sector in China, Finland, Russia, the United States and Canada, 2003-13



Source: IEA buildings model, 2015.

Under state law, municipal residential buildings are required to undergo energy efficiency audits (FZ-261). Those buildings that do not comply with energy standards are obliged to undergo a capital overhaul to meet the specified requirements. The residents themselves bear the responsibility for funding and co-ordinating the renovations. As of October 2014, customers are eligible for financial compensation of up to RUB 2 million (USD 30 thousand) in the case of losses incurred as a result of a poorly conducted energy audit.

Since 2014 the set of appliances requiring energy efficiency labels has been extended to include televisions, electric ovens (inclusive of hobs), and lifts (excluding industrial). The labelling scheme is identical to the "A-G" one adopted in the European Union. Following the law on Energy Efficiency, high-power incandescent bulbs are being phased out (FZ-261). In the first half of 2014, 43 million lamps were imported to Russia. This figure is 2.5 times more than the total over the same period in 2013 (17 million) (Svet Consulting, 2014). In order to stimulate the growth of the market for energy efficiency lighting, since September 2015 the Russian government has introduced zero duty on the import of LED bulbs.

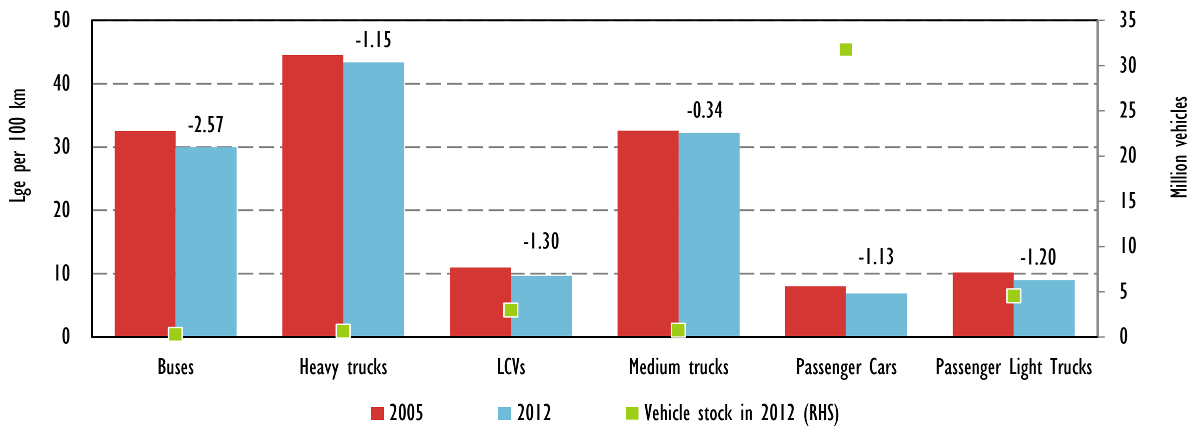
Transport

Road transport is one of the main drivers for energy consumption in Russia. Over the last decade, the number of personal vehicles has doubled (Rosstat, 2015). The state programme entitled "On Energy Efficiency and the Development of Energy" has developed a number of indicators for the transport sector including specific energy consumption in gas and oil pipelines and railroads, light-duty vehicle fuel efficiency, share of hybrid light-duty vehicles and growth in per capita public passenger transport turnover (IEA, 2014b).

A number of projects are emerging in the sector. In 2012, the Ministry of Industry and Trade committed to investing RUB 1.5 billion (USD 23 million) into the research and development of hybrid vehicles by 2020. Under the co-ordination of Mitsubishi, the Russian car manufacturer AvtoVAZ developed the first electric vehicle in Russia ("El Lada"). In 2012, the car, which is primarily aimed at providing taxi services around the resorts of the Caucasian Mineral Waters, was being sold for RUB 1.1 million (USD 17 thousand) (Energosovet, 2012). Regional activity includes investing in electric and hybrid vehicles for personal and public transport. As a result, by 2012 Moscow had seen the installation of 24 electric vehicle charging stations, most of which are available for public use. In order to stimulate the market for electric vehicles, in 2014 the government cancelled duty on imported electric vehicles (Avtovesti, 2014).

Analysis of vehicle fuel economy since 2005 shows a reduction in intensity, in line with other sectors (Figure 10.6). The biggest absolute change is observed for buses, which have seen a drop of 2.57 litres of gasoline-equivalent per 100 km (Lge/100km) since 2005. Taking into account the total vehicle stock, passenger cars contributed most to the decrease in the energy intensity of the transport sector (1.13 Lge/100km, or a 14% drop).

Figure 10.6 New vehicle tested fuel economy, Russia, 2005-12



Source: *IEA Mobility Model* (database), 2015.

Russia's ESCO market

The introduction of obligatory energy audits in 2009 sparked a rapid growth in the number of energy audit companies, and in turn energy service companies (ESCOs) driven by new market opportunities. Since then the market has matured, leaving around 30 companies providing energy services in Russia (Ogorodnikov, 2014). Some of the main players include GPB EnergoEffect,[11] Fenice RUS LLC[12] and TBN Energoservis.[13] Promising opportunities for the market are starting to emerge in the residential sector, where homeowners struggle to secure the funding needed for obligatory renovation under the state programme (Box 10.2).

[11] Energy service company of Gazprombank. See www.gpb-ee.ru/en/.

[12] Russian subsidiary of Italy-based EDF Fenice. See www.fenicerus.ru/en.

[13] Multi-profile company offering ESCO-services. See www.tbnenergo.ru/.

Box 10.2 ESCOs in the residential sector

Approximately 40% of Russia's housing stock requires renovation, which would require an investment of RUB 5 trillion (USD 75 billion) (Pakka, 2014). Since 2009, significant amounts of federal subsidies have been allocated to regional programmes for improving energy efficiency. However, federal funding alone is not sufficient to solve a problem of such scale. Energy service contracts could prove to be a promising option for raising private funding since up-front costs are carried by the investor and not the owner or tenant. The investment is repaid from the energy savings made as a result of project implementation. Energy efficiency improvements offer up to a 25% reduction in utility payments, which in turn reduces government expenditure on utility payment benefits (totalling RUB 326 billion [USD 4.9 billion] a year). Regions have experienced the benefits first hand. For example, in Murmansk, energy service contracts have been implemented for 170 homes since 2013. As a result, heat consumption decreased by 25%. Moscow plans to implement over 800 energy service contracts in the residential sector this year.

Despite the potential benefits, the ESCO market has still not taken off in Russia. One of the biggest challenges is negotiating the contracts. Most of the residential stock requiring repair consists of multi-family residential tower blocks, which are run by associations of homeowners. In order to make any decision with regards to the building, including signing an energy service contract, unanimous agreement is required. This is very challenging considering the number of homeowners and the lack of their awareness of the benefits provided by the energy service industry.

In order to facilitate the development of the energy service market in Russia, the Ministry of Construction, Industry, Housing and Utilities Sector (Minstroy) has introduced the following changes to the current regulations (Menya, 2015):

- Energy service contracts are no longer required to be signed by all homeowners residing in the tower block; the authority for the decision now lies with the homeowner association.
- In order to insure transparency, the costs for energy services are included as a separate payment in the utility bill.
- Undertaking of the energy service contracts will not impact the level of grant payments towards utility bills.

In 2011 the Federal Energy Service Company (FESCO) was created to help improve conditions for the ESCO market. The company is owned 100% by the state and carries all the risks of the initiated projects.

Mobilising international development finance for energy efficiency

Over the last decade, Russia has successfully partnered with various international development banks to invest in energy efficiency projects (Table 10.2). These include the International Finance Corporation (IFC), the European Bank for Reconstruction and Development (EBRD), the Nordic Investment Bank (NIB), the International Bank for Reconstruction and Development (IBRD) and the European Investment Bank (EIB). For example, since 2005 the IFC has invested nearly USD 300 million to fund projects on energy sustainability in Russia and an additional USD 134 million aimed specifically at the residential sector. As of 2012, EBRD's energy-related portfolio in Russia amounted to EUR 3.3 billion (USD 106 million).

Table 10.2 Selected investments made by international development banks in the Russian energy efficiency market

Body	Project	Investment (USD million)
IFC	**UNK Agroprodukt** - Investing in boilers producing heat from sun flour husks	17.3
IFC	**Building Management Company in Rostov-on-Don** - Improving energy efficiency of an apartment building	0.167
EBRD RUSEFF	Wood Processing in Kirov - Switch from conventional fuel to biomass-run boilers, modernisation of equipment	2
RUSEFF	Modernisation of Buildings in Volga region	0.5
NIB	Loan facility with **Vnesheconombank (VEB)** for lending to energy efficiency projects in northwest region of Russia	60
EIB	Loan to **Vneshtorbank (VTB)** Bank to support the development of the private sector and contribute to sustainable social and economic development with focus on energy efficiency	240

The Federation of Finnish Technology Industries. (2014). Energy Efficiency in Russia. Retrieved from https://teknologiateollisuus.fi/sites/default/files/file_attachments/elinkeinopolitiikka_kestava_kehitys_julkaisut_energiatehokkuus_venajalla.pdf.

Prospects for energy efficiency market activity

Russia inherited an inefficient energy infrastructure from its Soviet past when the economy was driven by five-year plans to serve the rapid industrialisation of the Soviet Union. Against a backdrop of abundant energy resources, energy efficiency was a government priority so today there is a large potential to generate energy efficiency improvements. Across all sectors and fuels, the technical energy efficiency potential is estimated at 282.4 Mtoe (Table 10.2);[14] most of this potential is in heat and power generation (Bashmakov, 2009). A more recent assessment by the Center for Energy Efficiency (CENEf) estimates this value at 260 Mtoe (30-35% of TPES),[15] and a realistically achievable energy saving of 195 Mtoe (20% of TPES) by 2020 (IEA, 2014b).[16] This is equivalent to one-third of Russian energy exports in 2012. Achieving this potential could reduce GHG emissions in Russia by 50% (about 800 million tonnes of CO_2 equivalent ($MtCO_2eq$). The investments required to achieve these targets have been estimated at approximately USD 320 billion (Bashmakov, 2009; IFC and World Bank Group, 2008).

A sustainable energy policy framework is developing in Russia driven by the State Programme on Energy Efficiency. However, the Ministry of Economy has recently decided to postpone certain regulations including compulsory energy audits (estimated to cost the government RUB 9 billion [USD 135 million] per year) and terminate regional funding schemes, in part in response to budget concerns.[17] Nevertheless, there is growing recognition of the value of energy efficiency among consumers and industry.

[14] Technical potential assumes that the technology in place is immediately replaced with the best technology available at the time of evaluation.

[15] The energy saving potential has decreased due to implementation of programmes on energy efficiency improvements.

[16] CENEf is a non-profit, non-governmental organisation founded in 1992 to promote energy efficiency and environmental protection in Russia. See www.cenef.ru/art_11207_114.html.

[17] See http://top.rbc.ru/economics/01/06/2015/556c845a9a79476d85be5fff (in Russian only).

Table 10.3 Russia's technical energy efficiency potential, incremental investments needed and potential emissions reduction, 2005

	Technical energy efficiency potential (EJ)	Incremental investments needed (USD billion)	Potential CO_2 emissions reduction ($MtCO_2$)
TPES	11.8	321-352	765.1
Electricity generation	3.9	106	254.3
Heat production	4.5	194	282.5
Fuel production, transformation, transmission, and distribution	1.7	19	29.1
TFC	6.4	188-219	199.2
Agriculture, forestry and fishery	0.1	2	4.9
Industry	1.8	37	61.2
Transport	1.6	124-130	99.1
Public and commercial services	0.7	50-100	7.5
Residential	2.2	25-50	26.5

Source: Bashmakov, I. (2009), Resource of energy efficiency in Russia: scale, costs, and benefits, Energy Efficiency, Vol. 2,No. 4, pp. 369–386. http://doi.org/10.1007/s12053-009-9050-1.

The market for energy-efficient lighting is expected to grow. The market size is estimated to reach USD 881 million by 2016 (three times larger than in in 2013). This has much to do with an introduction of zero duty on import of LED bulbs since 1 September 2015 and the lowering cost of LED products (Svet Consulting, 2014).

The energy service market in Russia could offer a lot of opportunities to drive energy efficiency improvements in Russia when it starts to function as it should. The government is taking steps in the right direction by making the market more attractive and transparent to the public.

Challenges

Transforming Russia’s infrastructure poses a major challenge for the country. Co-ordinating energy efficiency activities across Russia is a significant task considering the size of the country. The municipal centralised heating networks alone amount to 168 000 km, 30% of which is in need of urgent replacement (Rosstat, 2015). Moreover, the energy market in Russia has traditionally been highly regulated. Energy and water bills are calculated on a per-metre or per-person basis, which has translated into a general lack of incentive for the public to conserve energy.

Compliance is one of the biggest challenges yet. For example, 200 000 to 400 000 industrial businesses qualified for compulsory energy audits, but only 38 000 energy certificates were received by the Ministry of Energy. Of those, only 5% were of an acceptable standard – a very small number considering the hefty administrative fine for failure to comply (RUB 10 thousand [USD 150] to RUB 1.5 million [USD 23 thousand] for physical persons and RUB 50 000 (USD 750) to RUB 200 000 (USD 3 000) for legal entities) (Zaicev, V. and Saikina, L., 2013).

Since January 2015, the Russian economy has been in recession. The ruble has depreciated severely from its 2013 value against the dollar and various other currencies, which reduces its ability to finance energy efficiency modernisation investments that involve imports. Access to credit is becoming more expensive and difficult, and institutions such as the EBRD and EIB have stopped lending as a result of sanctions imposed on Russia (Reuters, 2014). Federal subsidies for regional energy efficiency programmes have been cut. Against this backdrop, while the government remains committed to implementing energy efficiency policies, there is uncertainty over the pace of implementation and change.

Conclusion

The government recognises the potential for energy efficiency to become the driving force behind the modernisation of Russia's economy and increasing its competitiveness. Over the last decade, the energy intensity of the Russian economy has shown significant improvement across all sectors. This is partly explained by structural changes in the country's economy; but it is also a result of the vast variety of energy efficiency projects that have been implemented across the country. Government funding has contributed positively to a number of successfully implemented regional programmes across Russia. These programmes have been crucial in demonstrating the benefits of energy efficiency to the Russian public and stimulating further investment. Under the current challenging economic conditions, government priorities are likely to shift away from energy efficiency programmes. Consequently, regional and local authorities, as well as private business, will have to take on a greater share of the initiative needed to promote further energy efficiency improvements in the country. The Russian government is moving in the right direction to stimulate energy efficiency market growth by introducing zero duty on imports of energy-efficient products and making the energy service industry more transparent to the public.

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11. SAUDI ARABIA

Summary

Saudi Arabia has expanded its policies on energy efficiency in many areas. It has developed standards for air conditioners, created labels for consumer appliances and has implemented an average fleet fuel-economy standard for new personal vehicles. These policies are supported by greater institutionalisation of energy efficiency through the creation of the Saudi Energy Efficiency Centre. The programmes of the Centre aim to reduce wasted energy and increase investment in various forms of energy supply, including energy efficiency.

The increased focus on energy efficiency is a response to surging energy consumption in Saudi Arabia. Economic growth, rising per capita income and population growth, stemming in part from the development of its fossil fuel resources, has propelled significant growth in total final consumption (TFC) over the past ten years. In addition to being a major producer and exporter of energy Saudi Arabia is becoming a large domestic consumer of energy. If these trends in domestic energy consumption continue, the country's export sector would be significantly affected.

Energy profile and context

Saudi Arabia is the world's largest producer and exporter of crude oil with abundant hydrocarbon reserves. In 2014, it was first in total crude oil production – 554 million tonnes of oil-equivalent. Energy production between 2003 and 2013 increased by 21% with primary and secondary oil exports increasing by 14% to 445 Mtoe. Unsurprisingly, the fossil fuel sector makes up a huge segment of the Saudi economy; in 2010 revenues from fossil fuel exports and processing accounted for 48% of gross domestic product (GDP) in Saudi Arabia (Gelil, 2015).

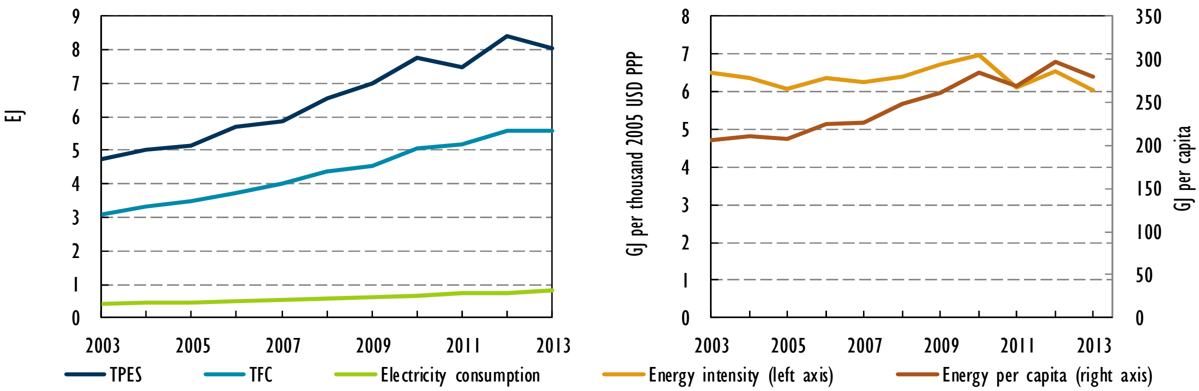
While the availability of primary energy is not an immediate concern, domestic energy consumption is taking up a larger share of total energy production in Saudi Arabia. Total primary energy supply increased by 71% between 2003 and 2013 (Figure 11.1); this was higher than the average growth for other high-income non-OECD countries (56%),[1] members of the Organization of Petroleum Exporting Countries (OPEC) (60%) and countries in the Middle East (69%). Domestic energy consumption as a share of total energy production and energy imports increased from 22% in 2003 to 31% in 2013. Consequently, the ratio of exports to production and imports declined from 77% to 70%.

Total final consumption increased by 82% between 2003 and 2013 reflecting growth in the end-use energy sectors over the decade. Electricity consumption has doubled in the same period reflecting the growth in the residential and services sectors and increasing use of electricity in industry. Electricity consumption per capita has increased 58% over the past decade reflecting a growing demand for electric-powered goods such as air conditioning, appliances and electronics. This growth is in line with the average for Middle Eastern countries. Electricity use per capita in Saudi Arabia is lower than average for the other Gulf States, but it is still more than double the global average.

[1] This is the average for high-income non-OECD countries as defined by the World Bank and for which IEA energy data exists.

The energy intensity of the Saudi economy decreased by 7% between 2003 and 2013 to 6 GJ per thousand 2005 USD; this is slightly below the global average in energy intensity. However between 1980 and 2010, intensity increased by 173%. This bucks a general global long-term trend of decreasing energy intensity; over the same period the OECD countries reduced their energy intensity by 41% and the non-OECD countries by 29%. Total primary energy supply per capita increased 35% during the period and TFC per capita increased 44%, faster than the average for Middle Eastern countries[2] (30%). Meanwhile, the population of Saudi Arabia has grown by 26% (6 million people). The growing economy is supporting an expanding expatriate labour market and high rates of domestic population renewal, which is driving domestic energy growth. Partly as a result of the wealth generated by Saudi Arabia's status as a major oil exporter, the rise in domestic energy demand from has outpaced the increase in total production. This has reduced the share of domestic energy production sent for export.

Figure 11.1 TPES, TFC, electricity consumption, Energy intensity and energy use per capita, 2003-13



Source: IEA (2014a), *Energy Balances of non-OECD Countries 2014*, OECD/IEA, http://dx.doi.org/10.1787/energy_non-oecd-2015-en.

TFC is being driven primarily by growing energy demand both in industry and in non-energy uses; abundant and low-cost crude oil reserves and low tax policies have supported the use of crude oil and natural gas as feedstocks in the petrochemical sector. SABIC, a majority state-owned petrochemical firm is one of the top six producers of petrochemical products globally (Al Shaikh and Chahine, 2011).

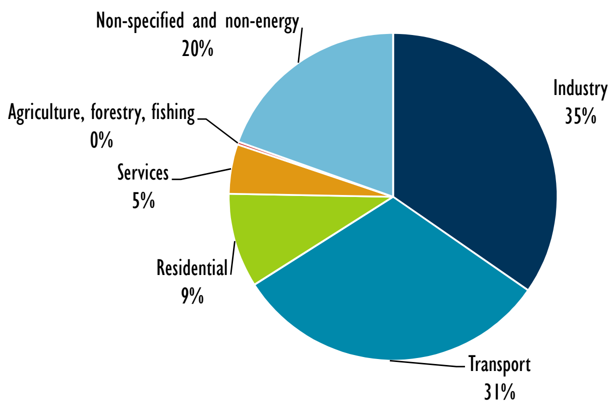
Transport occupies the second-largest share of TFC (31%) in Saudi Arabia highlighting the reliance on personal and heavy-duty road vehicles. Transport energy use increased 81% between 2002 and 2012. The increase in transport energy consumption emphasises the connection between a growing economy, population and energy demand.

Industry comprised the third-largest share of TFC at 35%. In addition to the important role of petrochemical feedstocks, Saudi Arabia has a unique and large source of energy demand: water desalination. Although there are no official data on energy needs for desalination, one paper estimates that energy requirements for desalination were approximately 6.9 Mtoe in 2013 or 15% of total industrial energy consumption (Fath, Sadik, and Mezher, 2013). Energy consumption in agriculture is the smallest share but this does not account for desalination energy needs which

[2] Countries include Bahrain; Islamic Republic of Iran; Iraq; Jordan; Kuwait; Lebanon; Oman; Qatar; Saudi Arabia; Syrian Arab Republic; United Arab Emirates and Yemen.

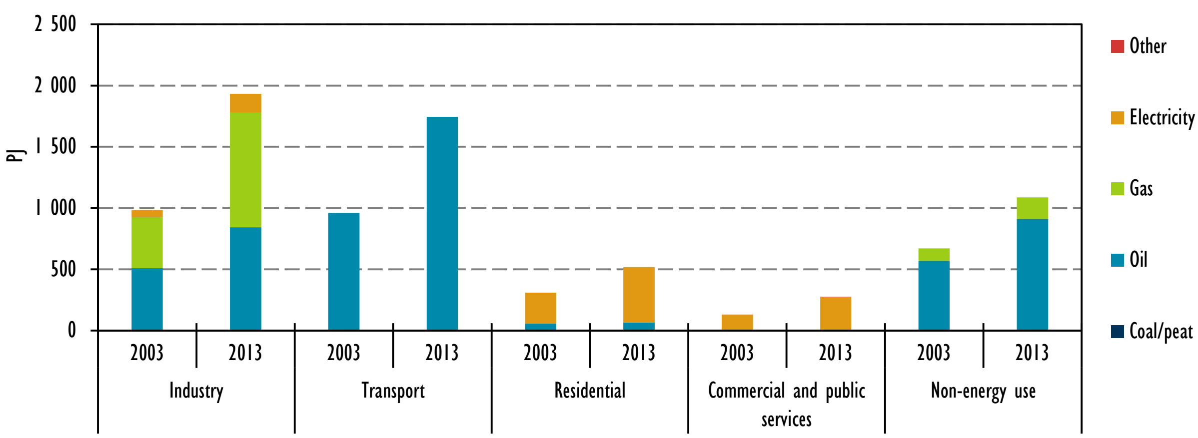
should be attributed mostly to agriculture. Agriculture consumes 90% of all water in Saudi Arabia (Saif, Mezher and Arafat, 2014) meaning that the agricultural sector's energy footprint is arguably much larger than that represented by its direct energy consumption.

Figure 11.2 TFC by sector, 2013



Electricity is the primary energy carrier in the residential and services sectors (Figure 11.3). The reliance on electricity in these two sectors reflects physical conditions in Saudi Arabia with relatively little heating need and a high space cooling load where electricity is the energy carrier of choice for air conditioning. Saudi Arabia also has no distribution infrastructure to service the residential and services sectors with natural gas. This explains the reliance on electricity in these sectors. Growth of electricity consumption was highest in the industrial sector (168%) but electricity consumption also grew significantly in services (111%) and residential buildings (79%). The growth of industrial electricity consumption was likely spurred by desalination. Growth of consumption in residential and commercials buildings was the result of a growing population, a growing services sector and the rapid adoption of space cooling.

Figure 11.3 TFC by sector and by energy source, 2003 and 2013



While Saudi Arabia is a major energy producer it is becoming a major energy consumer as well. The implications of this shift will be felt for decades to come. Domestic energy consumption will continue to compete with exports for a share of production and Saudi Arabia's status as the primary global oil exporter may be challenged with impacts on the global oil market.

Market driver: Energy efficiency policies and programmes

The increasing role of domestic energy consumption has moved energy efficiency policies and programmes up the government agenda. After a long period of neglect, government efforts on energy efficiency follow two basic streams: 1) implementing policies and regulations on equipment such as air conditioners and vehicles with high potential for energy savings; and 2) building and cultivating governance, administrative, professional and market capacity to deliver on energy efficiency goals.

The National Energy Efficiency Plan

Saudi Arabia first focused on energy efficiency in 2003 creating its National Energy Efficiency Programme (NEEP). The programme introduced energy audits for buildings, conducted training, created energy efficiency standards and labels for appliances, developed energy efficiency codes for new buildings and started benchmarking building energy performance. Certain outcomes of the NEEP were aimed at creating a base level of energy efficiency in new buildings using a building component approach.

The Saudi Energy Efficiency Center

The NEEP formally ended in 2010 and was followed by the creation of the Saudi Energy Efficiency Center (SEEC) which instituted a stand-alone administration for energy efficiency in the country. Prior to the creation of the SEEC, the Ministry of Petroleum administered the NEEP (in collaboration with five other government ministries and public corporations). The SEEC is empowered to develop its own energy efficiency plans and to act as a co-ordinator between government ministries and with non-government stakeholders. The main tasks for the SEEC are to develop Saudi Arabia's energy efficiency plans, policies and initiatives, monitor implementation, promote awareness and build capacity in the energy efficiency market (Alabbadi, 2014). In pursuit of these tasks, the SEEC created the 2012 *Energy Efficiency Plan* (EEP) as a follow-up to the NEEP.

The EEP set out to establish a baseline for energy efficiency policy efforts (notably on energy efficiency in key sectors); to bring together key stakeholders from government and business that have important leverage over energy efficiency outcomes within their portfolios; to implement standards for measuring the highest impact; to agree and disseminate energy efficiency labels on appliances; to procure and demonstrate leadership on energy efficiency in government buildings; and to develop the basic infrastructure and capacity to begin monitoring and enforcing energy efficiency objectives.

Energy efficiency standards and mandates

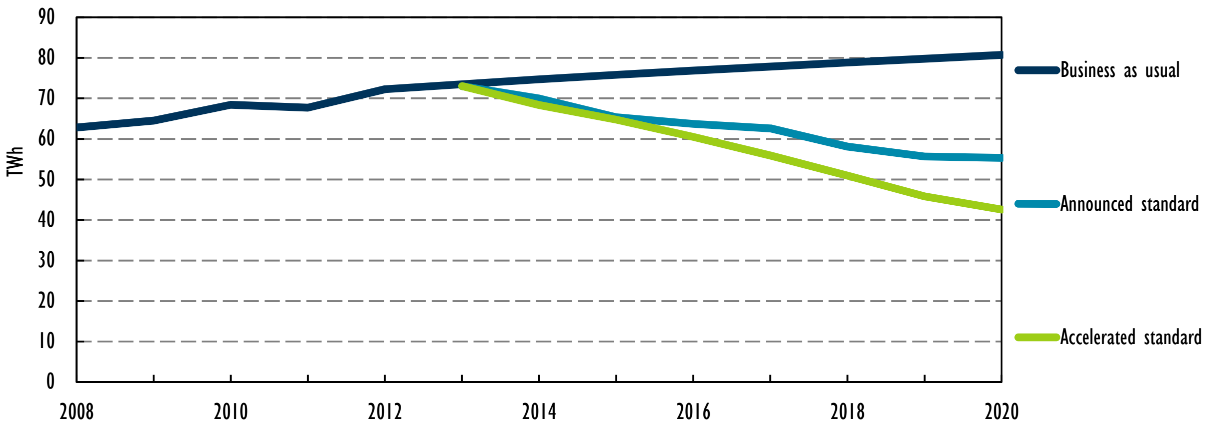
Saudi Arabia has moved forward to develop and implement energy efficiency standards and mandates on key sectors and end-uses linked to their energy saving potential. These standards are focused on high-value actions in buildings and in the transport sector. For example, new buildings are now required to be insulated to a basic level whereas previously there was no insulation requirement (over 70% of all buildings are currently not insulated). The key standards being developed and implemented are described below.

Air conditioning

Improving the efficiency of air-conditioning units is a priority area because of its potential to reduce energy consumption. Residential and commercial buildings consume 84% of all grid electricity generation in Saudi Arabia and, of that building electricity consumption, 65% is used by air conditioners (Al-ghamdi, Al-gargossh and Alshaibani, 2015), approximately 126 TWh in 2012. Recognising this potential, the SEEC developed minimum energy performance standards (MEPS) on air conditioners in 2012. Prior to 2012 energy efficiency standards on air conditioners were ineffective and enforcement was poor; consequently, Saudi air conditioners were less efficient than those in India and Iran. By 2015, the MEPS for small capacity air conditioners will match the energy efficiency rating of air conditioners in the United States (Alabbadi, 2014). This will be a 35% improvement on the average energy efficiency rating of air conditioners in 2012.

The energy savings potential of the new air conditioner standards is large and will lead to significant electricity savings. The IEA estimates that the electricity savings from the announced standard would be 25 TWh by 2020. If Saudi Arabia strengthened its standards to the standard efficiency rating for air conditioners in the European Union then it would save an additional 13 TWh of electricity consumption (Figure 11.4).

Figure 11.4 Electricity consumption by air conditioners in a business-as-usual, announced standard and accelerated standard scenario

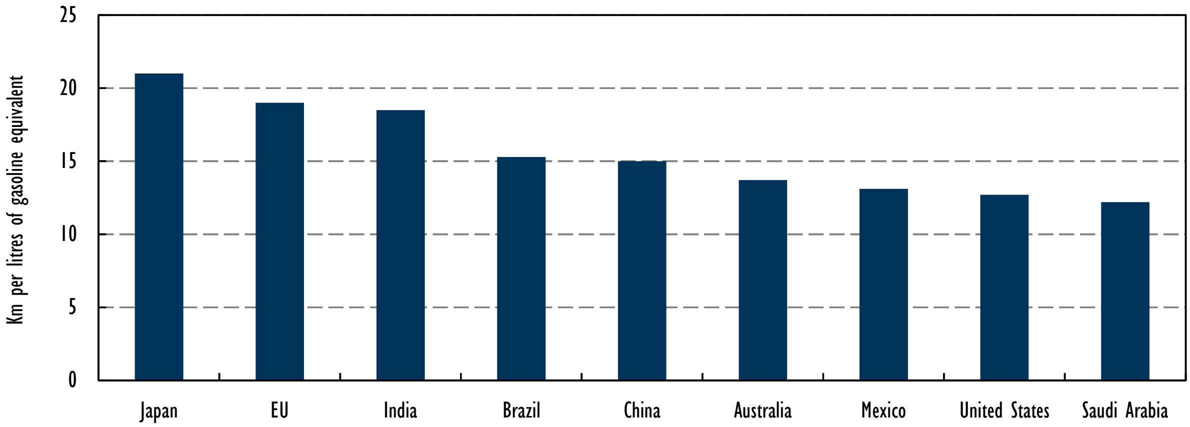


These electricity savings would translate to primary fossil fuel savings in Saudi Arabia's power sector. Power generation in Saudi Arabia is entirely fossil fuel-fired at an average conversion efficiency of 33%. Assuming that electricity savings from the implemented air conditioner standards were applied proportionately to the generation mix, Saudi Arabia would avoid 6.6 Mtoe of primary energy, or 47 million barrels of oil-equivalent. Assuming these avoided barrels were diverted to the export market and sold at the current global crude price of USD 50 per barrel then Saudi Arabia would raise export revenues by 0.9% adding another USD 2.3 billion in revenue. If Saudi Arabia adopted accelerated standards in line with those in the European Union it would avoid 10 Mtoe of primary energy or 71 million barrels of oil-equivalent. This would raise an additional USD 3.6 billion in revenue and returning an additional 1.4% in 2014. For major energy producers and exporters, end-use energy efficiency adds an efficiency premium to export revenues where avoided primary energy is diverted for exported.

Vehicle efficiency

In response to increasing vehicle usage and growing energy consumption per capita in the transport sector, Saudi Arabia has recently applied its first efficiency standards and energy efficiency labels for new light-duty vehicles (LDVs). The average fuel efficiency of new LDVs in 2012 was 12.2 km per litre, lower than in the United States, Mexico, Australia, China, India and the European Union (Figure 11.5). As of January 2015, new vehicle efficiency standards are in force and are estimated to improve average efficiency of new vehicles by 28% by 2020. Standards follow the US corporate average fuel-economy model whereby vehicle distributors must comply with a fleet average rating based on vehicle class and size. Standards have also been developed for used vehicle imports following a MEPS model and based on vehicle class and size. Supporting the vehicle efficiency standards is a labelling scheme which states the efficiency performance of each specific vehicle model categorised by either passenger cars or light-duty trucks. The labels were rolled out in 2014 and evaluate vehicles on a six-point scale of efficiency.

Figure 11.5 Average new vehicle efficiency by country/region in 2012



Source: ICCT (2014), *Global Passenger Vehicle Standards*, International Council on Clean Transportation, Berlin, www.theicct.org/info-tools/global-passenger-vehicle-standards. Alkasabi, S. (2015), *Energy Efficiency in the Transportation Sector: Introduction to the fuel-economy standard and fuel-economy label, Saudi Standards*, Metrology and Quality Organization, Riyadh.

Current energy efficiency market activity

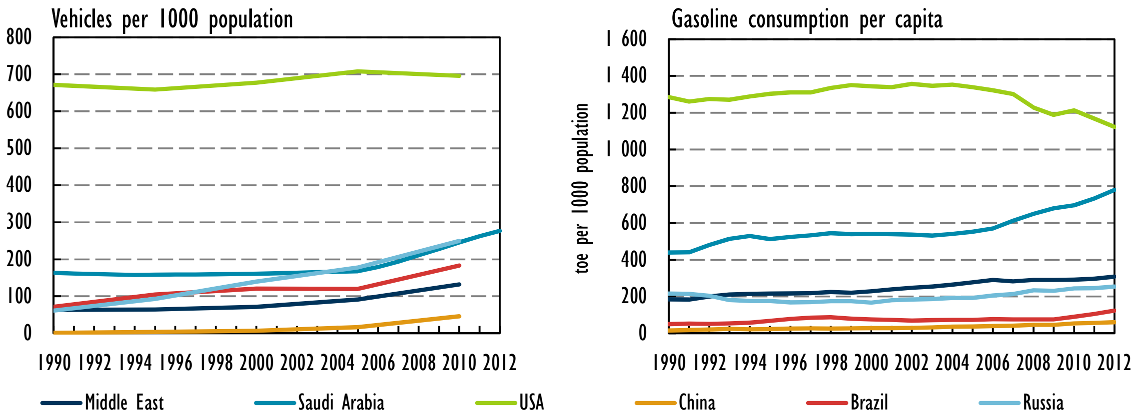
Saudi Arabia's energy efficiency market is still relatively nascent. There are few energy service companies (ESCOs) offering energy efficiency products and services to consumers. As of 2012, there were five ESCOs in operation (Alyousef and Abu-edid, 2012) though the number of companies is likely to have increased as energy efficiency audits have continued to be a government priority through the EEP. All these efforts essentially look to the private market and energy service industries for support. The EEP looks to ESCOs and other energy efficiency financing sources as two of the five enablers for energy efficiency savings along with regulations, better governance and awareness.

In order to encourage more private activity in energy efficiency the government is trying to measure the potential of energy efficiency and to provide private industry with basic data and benchmarks. The government has assessed the market potential of the MEPS that it has developed for commercial and institutional buildings, estimating that they would create a market of SAR 1.2 billion (USD 324 million)[3] (Al-Ajlan, 2009). The government has also contracted with consultants to identify the energy savings potential and its costs and benefits to the electricity system.

Transport

New vehicle efficiency standards were implemented in 2015; at current rates of vehicle adoption, this will require sizeable new investment in energy-efficient vehicles. The vehicle fleet size increased by 69% between 2002 and 2012. An estimated 285 vehicles per 1 000 people in Saudi Arabia constitute more than double the average for the Middle East (Figure 11.7).

Figure 11.6 Vehicle ownership and per capita gasoline use in transport



Note: Vehicles per 1 000 population is an estimate from the IEA Mobility Model.

Energy efficiency in state-owned corporations

State-owned corporations account for a large portion of energy-efficient market activity. Both Saudi Aramco and the manufacturing company, SABIC, have set formal energy efficiency targets and are working with the SEEC to achieve these goals. SABIC has set a target to reduce energy intensity by 25% by 2025. SABIC is looking at system-wide efficiency improvements through energy management systems, process optimisation and heat recovery.

Saudi Aramco, the world's largest oil company, is also keenly interested in energy efficiency improvements and has signed up to the corporate Energy Conservation Policy with the goal of reducing its energy intensity by 2% per year. Between 2012 and 2013 Saudi Aramco reduced its energy intensity by 4.6%. Since implementing its energy management programme in 2000, its investments in energy efficiency have saved 150 ktoe of energy consumption (Saudi Aramco, 2013). The company has conducted over 40 energy assessment studies and has implemented over 350 recommendations from those studies.

In its "Lead by Example" programme, Saudi Aramco has set a target of an improvement of 35% in efficiency for all non-industrial energy uses at the company by 2020. These efficiency improvements will be made in commercial buildings, on its employee residential campuses and among its

[3] SAR to USD exchange rate 0.27.

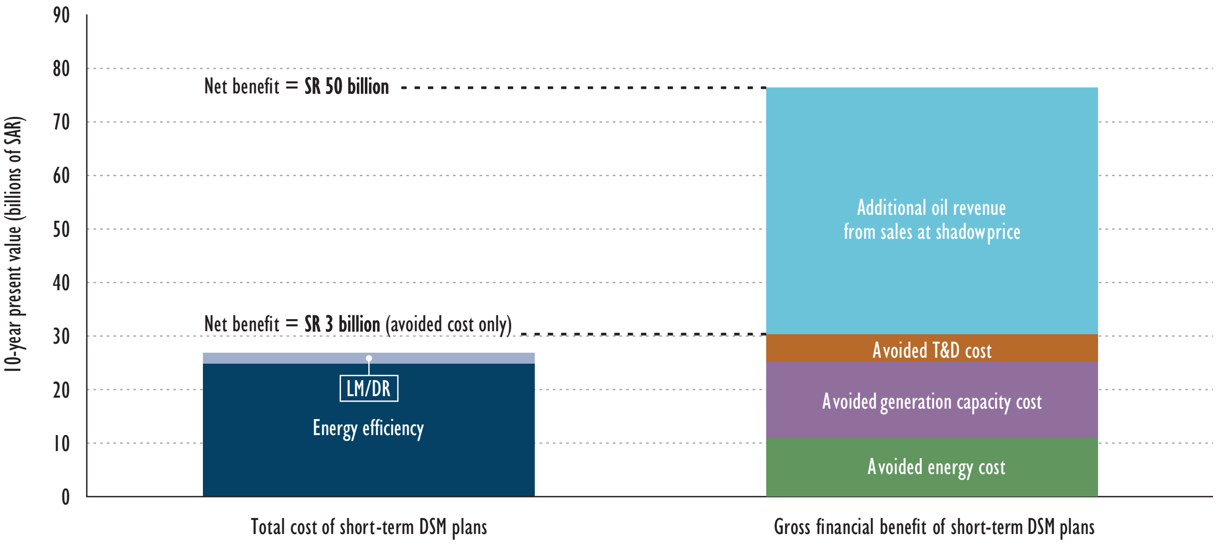
transportation fleet. Efforts are underway to update building standards for all its residential campuses, to install smart meters and to improve water heating insulation. All commercial buildings will have LED and CFL bulbs, upgraded HVAC systems and fuel-efficient vehicles.

Prospects for energy efficiency market activity

A number of cost-effective programming options could save significant amounts of energy, avoid large, new energy supply investment costs, and reorient the primary energy production currently used for domestic energy supply to export markets. One market assessment of the efficiency potential in Saudi Arabia has estimated that the direct financial benefits of a suite of demand-side management programmes, primarily made up of energy efficiency improvement efforts, would save almost SAR 3 billion (USD 810 million) from avoided energy expenditure and infrastructure costs. However, the largest benefit would be in diverting the fuel used for domestic power production to export. Energy efficiency could generate USD 14 billion of new revenues if reduced domestic primary energy consumption was diverted to export markets (Figure 11.8) (Faruqui et al., 2011).[4]

Such potential points to greater market activity in the coming years. There are over 11 million buildings in Saudi Arabia and an estimated 70% of existing buildings have no insulation (Alabbadi, 2012). Insulating buildings will produce significant energy savings – over 4 000 GWh of electricity consumption or 3% of overall residential consumption (Faruqui et al., 2011). There are further significant opportunities to reduce water consumption which will have important impacts on energy efficiency (Box 11.1).

Figure 11.7 The costs and benefits of demand-side management programmes in Saudi Arabia



Note: Outlines the 10-year present value of the cost of energy efficiency programme spending compared to benefits and a international price of oil 5 times higher than the domestic price.

Source: Faruqui, A. et al. (2011), *Bringing Demand-Side Management to Saudi Arabia*, The Brattle Group.

[4] This analysis assumes that export prices are five times higher than domestic oil prices.

Box 11.1 Energy savings potential from water provision

As a desert country with a fast-growing population and economy, the demand for water far outstrips existing natural water resources. Saudi water demand is the third highest per capita in the world, exceeding 20 billion cubic metres (bcm) in 2010 while water from renewable ground aquifers supplies only 2.4 bcm (Kajenthira et al., 2012).

Saudi Arabia contains 17% of the world's desalination capacity (Mezher et al., 2011), producing over 9.1 million cubic meters (mcm) per day in 2006 (Fath et al., 2013). Declining water resources and an increasing population will require capacity increases to 23 mcm per day by 2025 and over USD 100 billion in investment (Fath et al., 2013). The corresponding energy requirements for this expansion will triple by 2025 to an estimated 119 GWh per year (Fath et al., 2013), the equivalent of 44% of total electricity generation in Saudi Arabia in 2012. Desalination is thus a significant source of industrial energy demand both now and into the future, and supply-side and end-use opportunities exist to improve desalination efficiency, thus reducing both water and energy demand.

Saudi Arabia's water is energy intensive, and the country is becoming more dependent on desalination of sea water. Ground-water pumping is estimated to consume 5% of total electricity consumption in Saudi Arabia (Siddiqi and Anadon, 2011). Importantly, most ground water is a non-renewable resource and at current use trajectories, deep ground-water aquifers will dry up over the next 15 to 25 years (Kajenthira et al., 2012). Approximately half of the total renewable water supply in Saudi Arabia is desalinated seawater at 2.28 bcm per year (Saif et al., 2014). In response to increasing water demand and declining aquifers, Saudi Arabia has invested significantly in increasing its desalination capacity.

Water resource efficiency leading to energy savings and improved efficiency is well illustrated in the energy production sectors. One case study at Saudi Aramco, the national fossil fuel company, showed that water recovery and recycling could reduce water use at a natural gas plant by 45% and that should this be extended to Aramco's natural gas production facilities, it could save 23 mcm of water and 1.6 GWh of energy consumption at the facility. This does not include energy inputs into water production (Kajenthira et al., 2012). Water conservation has saved water and reduced input energy needs for water production while improving energy efficiency at the natural gas plant.

Technological improvements will also improve the energy efficiency of desalination plants. One analysis estimates that should efficient technologies be commercialised and invested in, they could reduce energy demand for desalination between 7 and 17% be 2025, saving 21 TWh of electricity (Fath et al., 2013). This depends on the cost-effective deployment of these technologies and on government procurement policies to prioritise efficient plant adoption.

Challenges

One important factor working against improvements in energy efficiency is that the cost of various forms of energy is significantly lower in Saudi Arabia than in many other jurisdictions. The IEA (2014b) estimates that Saudi Arabia is in second place as the country that spends most on energy subsidies (USD 62 billion). Electricity prices range between USD 0.013 and 0.069 per kwh depending on the type of end-user and the time of day (Fattouh, 2013). This compares with average electricity prices of USD 0.215 across 31 IEA countries in 2011.[5] Low electricity prices are not just enjoyed by end-users; fuel prices for power producers in Saudi Arabia are at least 95% lower than international market prices (Fattouh, 2013), lowering incentives for improvements in process efficiency among energy producers.

[5] Based on the IEA's *Energy Prices and Taxes* database, 2015.

Saudi financial institutions are reluctant to offer attractive financing for many efficiency projects and businesses because of the fledgling nature of the market. The standard energy performance contract model, where an ESCO takes on the energy performance risk while financial institutions finance the upgrades and assume the credit risk, is not well developed. ESCOs are typically made to carry both the energy performance and credit risk by offering financing through their own balance sheets (Alyousef and Abu-edid, 2012). However, such market barriers are not unique for Saudi Arabia and there has been progress in reducing similar barriers in other high-income non-OECD countries.

Conclusions

Saudi Arabia is known globally for its role as an energy producer but it is also quickly recognising the importance of producing energy savings through energy efficiency investment. As a rapidly growing but energy inefficient country, Saudi Arabia faces significant stresses to its domestic energy system in the coming years. To avoid the ever-growing allocation of energy production to domestic energy demand, it has taken the first steps to institutionalise energy efficiency as a priority and to create standards that are supported by monitoring and enforcement to achieve energy efficiency objectives.

Saudi Arabia has great potential for energy efficiency savings and investment. Reducing the government's energy production that is channelled to domestic uses would liberate that energy for export markets. Refraining from investment in expensive energy supply infrastructure would also pay for the costs of energy-efficient goods such as air conditioners and building insulation.

There are market opportunities for goods manufacturers and exporters of efficient energy products who can capture the growing domestic market for energy-efficient devices. Opportunities exist for domestic businesses that retrofit buildings, provide energy saving options to industry and consumers and encourage water conservation, as well as improving the system efficiency of water resources. Key to realising these opportunities is a continuing effort in demonstrating efficiency performance, improved pricing signals and other incentives, and the implementation of policies that promote cost-effective efficiency investment.

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12. SEOUL, KOREA

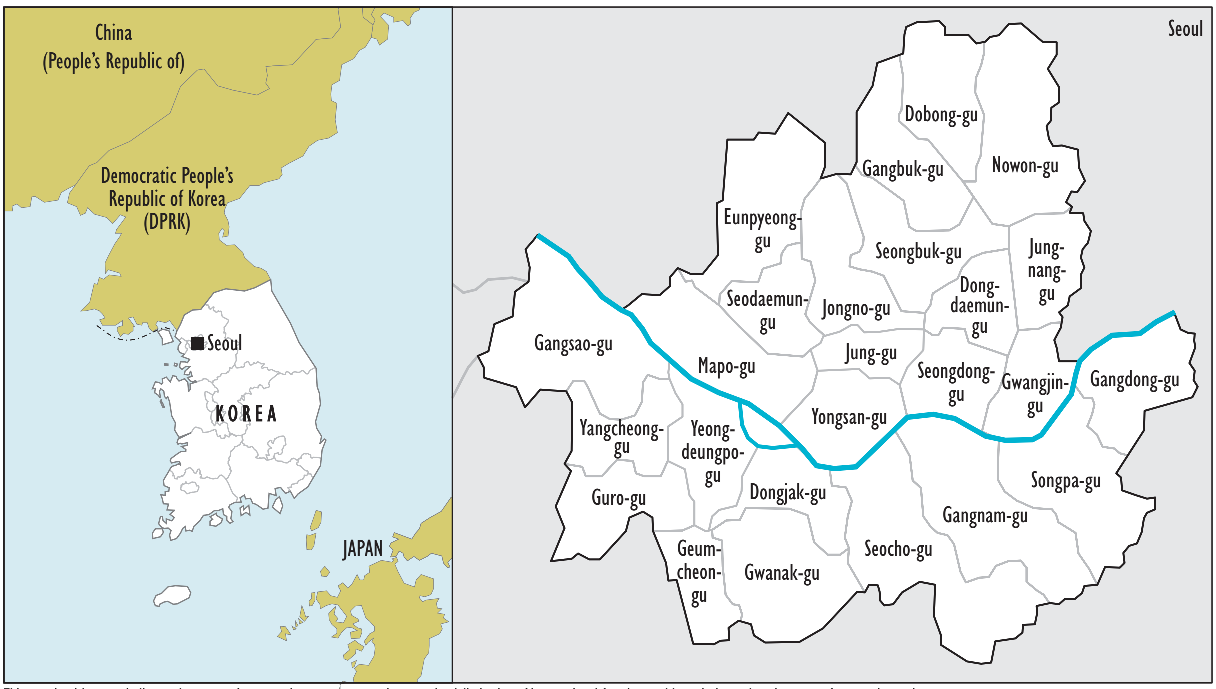
Summary

Seoul has a population of more than ten million and consumes more than 645 PJ (15.4 Mtoe) annually, which was 7.3% of Korea's total final energy consumption in 2013. The Seoul Metropolitan Government (SMG) has carried out its own energy efficiency policies, reinforcing those of the central government. Working under the banner "One Less Nuclear Power Plant" since 2011, the SMG is creating a "sustainable energy virtuous circle eco-system". The One Less Nuclear Power Plant initiative has leveraged KRW 600 billion (USD 509 million)[1] of private capital.

Introduction

Seoul has been the political, economic and cultural centre of Korea for over 600 years. The area of Seoul has been extended to its current size of 605 square kilometres (km^2) through several adjustments and administrative divisions over time and comprises 0.6% of the area of Korea (100 033 km^2). In 2010, Seoul had a population of 10.3 million.

Figure 12.1 Map of Korea and Seoul



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

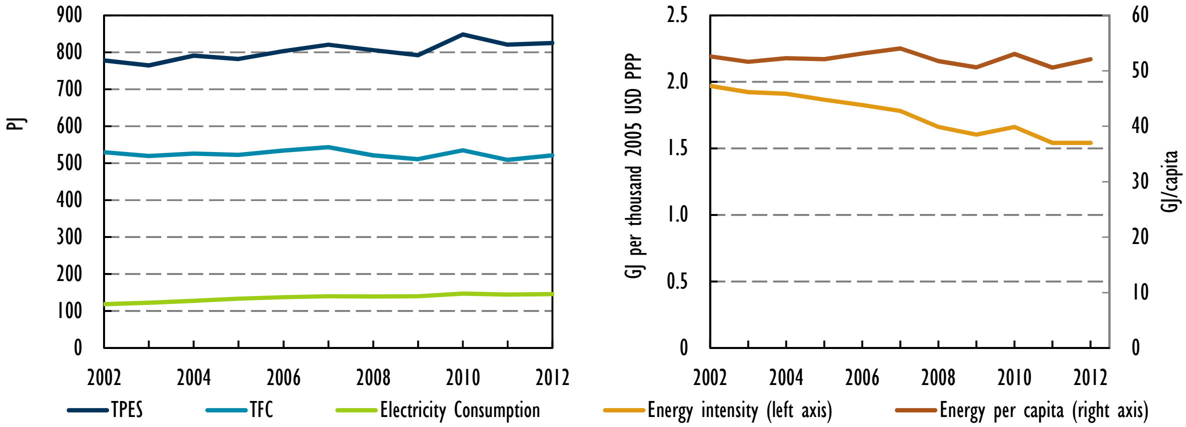
The gross domestic product (GDP) generated by Seoul made up 22.4% of Korea's national GDP in 2013. With its large economic and political impact, Seoul is important as a leading proponent of regional energy efficiency policies in Korea; it also has a huge energy savings potential.

[1] KRW to USD exchange used in this chapter is 0.00086.

Energy profile and context

Seoul's total final energy consumption (TFC) decreased by 1.6% between 2002 and 2012 to 12.5 Mtoe (Figure 12.2), even though GDP grew by 63%. Energy intensity declined by 22% between 2002 and 2012, from 2.0 to 1.5 GJ per USD 1 000 (Figure 12.2).

Figure 12.2 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12



Source: MOTIE and KEEI (2014), *Yearbook of Regional Energy Statistics*. Energy consumption data were adjusted based on IEA energy data for Korea.

Between 2002 and 2010, electricity consumption in Seoul grew by 23% before flattening over the three years from 2010 to 2012. Average daily gas consumption rose from 11.7 million cubic metres (m^3) in 2001 to 13.5 million m^3 in 2011, an increase of 15.7%.

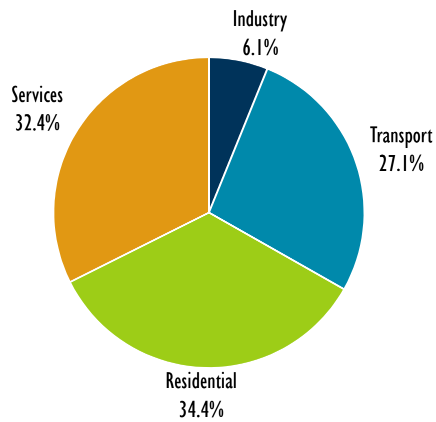
Seoul's electricity consumption varies from season to season, driven in large part by the growing utilisation of air conditioning and space heating using electricity. Of the total electricity consumption in 2012, 35% was consumed during the summer season from June to September; monthly electricity consumption in Seoul peaked in August (10%) and was lowest in October (8%). The service sector is the largest consumer of electricity, using 60% of total electricity consumption; 68% of the sector's total load is for air conditioning.

The buildings sector, which includes both the services and residential sectors, constitutes the largest share of TFC at over two-thirds (Figure 12.3). Energy-intensive manufacturing took up only 6% of TFC in Seoul as these businesses have gradually relocated outside the city boundaries.

Energy consumption has been decreasing in all sectors, with the exception of commercial and public services (Figure 12.4). Energy efficiency improvements in the transport sector have reduced energy intensity in Seoul over the last decade. In 2002, transport made up 34% of TFC; by 2012, its share had fallen seven percentage points, and total energy consumption in the transport sector had been reduced by 27% or 3.4 Mtoe.

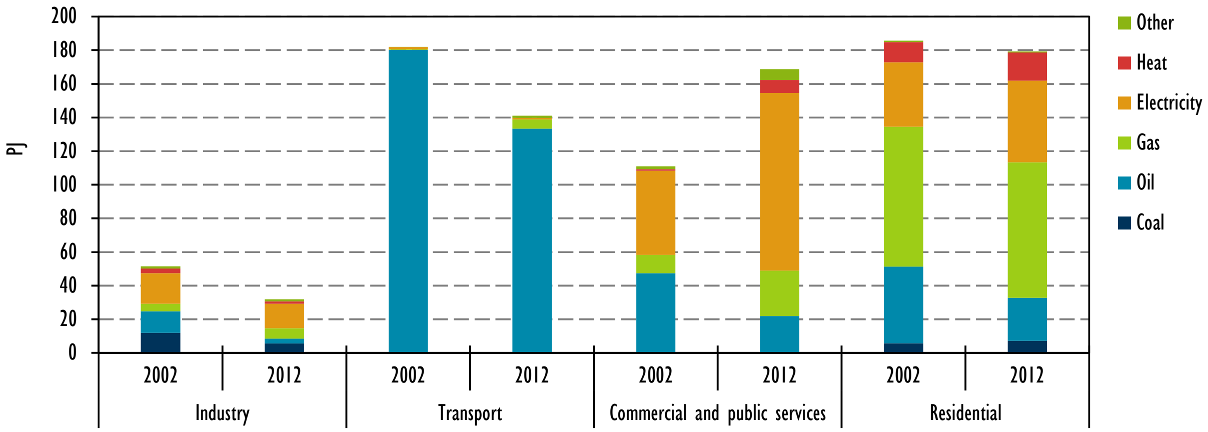
Between 2002 and 2012, the industry sector in Seoul reduced its energy consumption by 38%, mainly because of factory site relocation into the satellite cities. Energy consumption in the residential sector decreased by 3.4% between 2002 and 2012 due to fuel switching in space heating and improvements in the energy efficiency of electrical appliances.

Figure 12.3 TFC by sector, 2012



Source: MOTIE and KEEI (2014), *Yearbook of Regional Energy Statistics*. Energy consumption data were adjusted based on IEA energy data for Korea.

Figure 12.4 TFC by sector and by energy source, 2002 and 2012



Source: MOTIE and KEEI (2014), *Yearbook of Regional Energy Statistics*. Energy consumption data were adjusted based on IEA energy data for Korea.

Market driver: Energy efficiency policies and programmes

The SMG's energy efficiency policies and programmes fall under the framework of the One Less Nuclear Power Plant energy policy. The main energy efficiency measures are focused on building efficiency improvements through retrofits and standards, and improving lighting efficiency.

One Less Nuclear Power Plant

Faced with the high costs of maintaining and expanding the electricity system, along with growing concerns about the safety of nuclear power, in April 2012 the SMG released its energy policy white paper, "One Less Nuclear Power Plant". The target of One Less Nuclear Power Plant was to cut energy consumption by 2 Mtoe by December 2014, roughly the output of one nuclear power plant. The policy is built around engaging citizens in three main pillars: decentralised renewable power generation, energy conservation and improving energy efficiency. Seoul exceeded the target in June 2014, six months ahead of time.

Building on this success, in August 2014, Seoul launched the second phase of One Less Nuclear Power Plant, known as the Seoul Sustainable Energy Action Plan. The quantitative targets of the second phase are to raise the city's electricity "independence" rate by 20% by 2020 and to cut greenhouse gas emissions by 10 million tonnes by the same year.

Building efficiency, retrofits and certification

In 2011, Seoul was the first city in Korea to adopt an energy consumption cap on new buildings. The cap is a design standard for new buildings; developers must demonstrate how their building meets a green certification and energy efficiency standard before obtaining a licence for construction. The government estimates that, compared to business-as-usual practices, the energy consumption cap had saved 165 ktoe by June 2014.

Another important energy efficiency policy applied to buildings is the Building Retrofit Project (BRP). The BRP provides government-backed loans for retrofits. Over KRW 66 billion (about USD 56 million) was lent for retrofitting measures between 2008 and 2014 (Table 12.1). By 2014, the BRP had retrofitted 2 267 buildings, up from 475 buildings in 2011. The availability of financing is a key factor in the high uptake of the BRP; financing mobilises efficiency improvements in medium- to large-sized buildings that require high initial investments. Financial support was increased to KRW 2 billion (USD 1.7 million) for residential and commercial developments comprising two buildings or more and KRW 1 billion (USD 860 thousand) for single buildings. The interest rate for loans was also reduced to 2.0% from 2.75% to facilitate greater uptake of retrofits.

Seoul has also been promoting the Green Building Certification scheme, adopted in 2002 to reduce energy consumption and establish an environmentally friendly living environment. It is applied to newly constructed buildings including apartment buildings, office buildings, school facilities, lodging facilities, multi-purpose buildings, small individual houses and more. When a building is granted a Green Building Certificate, it qualifies for a 5% to 15% exemption on acquisition tax for new buildings, a 20% to 50% reduction on the environmental improvement charge, financial support for other building certification costs, and leniency on the certification of other non-safety related building standards (between a 4% and 12% easing of certification standards, depending on the extent of the building's energy efficiency performance).

The SMG provides energy audit services, auditor training and energy efficiency information seminars. The audit service has been extended to small-sized institutional buildings such as schools and churches to identify energy leakage, reduce building maintenance costs and conserve energy. In 2012, three companies were selected as energy service companies (ESCOs) to provide energy audit services for 108 schools and four churches.

The SMG also provides training for energy consultants and holds Household Energy Clinics for residents to build awareness and understanding of home efficiency measures. The Household Energy Clinic Service sends an energy consultant to households to diagnose building energy consumption and advise on customised ways to conserve energy. Between May and September 2013, 15 845 participating households reduced their energy consumption by an average of 6% compared to the previous year.

LED lighting procurement

Seoul has expanded the market for light-emitting diode (LED) lighting by undertaking large-scale LED lighting distribution projects. These projects include replacing the entire lighting system in subway stations with LED lighting and mandating the installation of LED lighting in newly built public offices.

In 2012, Seoul signed Memoranda of Understanding (MoUs) with the Korea LED Association (KLEDA) and LG Electronics to replace LED lamp lighting under a scheme that enables consumers to use the amount of money saved from conserving energy to repay the installation fee in monthly instalments. Seoul recently signed LED MoUs with three large supermarkets (Homeplus, Emart and Lotte Mart); five large construction companies (Hyundai E&C, Daelim, Samsung C&T, Daewoo E&C, and GS E&C); and the Korea Hospital Association.

Current energy efficiency market activity

Building efficiency

The One Less Nuclear Power Plant initiative leveraged KRW 600 billion (USD 509 million) of private capital and created jobs in the energy efficiency-related manufacturing and installation sectors. For example, Seoul recruited energy consultants with experience in energy audits for commercial buildings and established three co-operatives.

Since 2008, the BRP has leveraged investment of over KRW 716 billion (USD 607 million) in building efficiency improvements (Table 12.1). The programme provided KRW 66 billion (USD 57 million) in loans for both commercial and residential buildings. Individual loans reached USD 1.9 million per project.

Table 12.1 Expenditure and loans associated with the BRP in privately owned buildings

	2008	2009	2010	2011	2012	2013	2014	Total
Total expenditure (KRW billion) [USD million]	28 [24]	57 [49]	35 [30]	71 [61]	120 [103]	172 [148]	232 [200]	716 [616]
Loans (KRW billion) [USD million]	3.3 [2.8]	15 [13]	6.7 [5.7]	4.2 [3.6]	4.3 [3.7]	12 [10]	20 [17]	66 [57]

Source: SMG (Seoul Metropolitan Government) (2014), One Less Nuclear Power Plant – A Hopeful Message of Seoul's Energy Policy, www.ieac.info/IMG/pdf/201305smg-one_less_nuclear_power_plant.pdf.

Window installations made up more than 90% of the energy efficiency measures. The popularity of window efficiency improvements was based on dedicated funding. Loans of up to KRW 10 million were provided to households covering up to 80% of the cost of switching to insulated windows. Other popular projects included improving wall insulation and switching to high-efficiency boilers.

The SMG is affiliated or partnered with a number of businesses that pursue energy efficiency improvements. In 2012, the SMG signed business agreements with four companies (LG Hausys, KCC, Eagon Corp. and Hanwha L&C) to reduce the price of insulated windows by 20%, to guarantee quality and to provide after-sales service. SH Corp, an SMG-affiliated housing and development corporation, allocated funding to shut off standby electricity, switch old pipes, replace lighting with LED lamps and insulate over 95 000 dwellings.

Universities, hospitals and religious facilities – 754 general buildings in all – were included in the initiative in 2013, reducing energy use by about 0.021 Mtoe. Since 2008, the SMG has carried out energy efficiency projects for buildings on 1 152 medium-to-large buildings that consume large amounts of energy.

LEDs and lighting

Starting in 2010, Seoul began replacing building lighting with LEDs by increasing the distribution of LED lighting from 200 000 in 2011 to 6.8 million in 2014. Approximately 10% of the 3 640 apartment complexes had switched by 2013, changing 430 000 lamps to LED lighting. This reduced electricity consumption by 61 320 MWh with a saving of KRW 8 billion in electricity bills annually. Seoul has also replaced lighted signage with LEDs. Starting in 2011, the city installed over 3 000 LED signs and has been progressively replacing obsolete 100 W sodium lamps used for security purposes with 60 W LED lights. A total of 10 782 lamps have been replaced over the period 2012-14. Since 2008, Seoul has replaced 124 000 higher-capacity 250 W streetlights with low-capacity 150-250 W lamps.

The switch to LED lighting is having material benefits for consumers. In April 2013, an apartment in Yangcheon-gu replaced 100% of its 400 parking lot lamps (45 W incandescent lamps) with LED lamps (12 W light-bulb type); seven months after replacement it had more than recovered the KRW 7 million costs of replacement, having reduced its electricity bills by KRW 10 million.

Energy-efficient transport investment

The SMG has been promoting a car-sharing service (Nanum-Car) in order to reduce car ownership, which is associated with increasing traffic congestion and high transport energy consumption. Within one year of its launch in 2012, 160 000 citizens had joined the service as members. In January 2013, to implement car sharing in downtown areas, business agreements were signed with two companies (Green Point Consortium and SoCar). That service started in February 2013, and currently there are 749 rental vehicles in operation across 470 parking lots in Seoul, or 1.6 Nanum-Car (sharing) vehicles per parking lot. The Nanum-Car service has also provided electric vehicles since July 2012, when agreements with three companies (LG CNS, KT Rental and Korail Networks) were signed. The electric vehicle service started in May 2013; currently, there are 184 vehicles in 83 parking lots throughout Seoul.

The SMG encourages the use of public transport and has invested in public transport infrastructure such as exclusive bus lanes, which improve reliability and capacity. Seoul is also expanding the number of transfer facilities such as parking lots or transfer centres, providing an environment where passengers can conveniently transfer from private to public transport.

Prospects for energy efficiency market activity

Seoul is expected to continue its efforts to promote greater energy efficiency, with corresponding support for the underlying required investments:

- For example, the city plans to continue to provide low-interest rate loans for the cost of energy efficiency activities including insulation, as well as providing a customised building energy diagnosis. In addition, Seoul also encourages people to consider energy efficiency at the building design and urban planning stages, which is anticipated to increase energy efficiency spending in future construction. In particular, newly constructed large buildings will be subject to higher review standards for environmental impact assessment, while for standard buildings, a 100% zero-energy design standard will be applied using energy conservation technology and better equipment by 2023.

- Seoul also plans to disclose building energy performance data on the Seoul Real Estate Information Plaza so that consumers can check building efficiency and information on energy consumption before they buy, sell or lease buildings. The SMG seeks to make building energy efficiency a more recognisable and influential market signal and to see building energy performance reflected in the price of buildings.
- Seoul aims to convert 100% of public sector lighting to LED lamps by 2018 by replacing 2.2 million security lights and street lights. During the same period, 65% of lights in the private sector are expected to be replaced with 290 million LED lamps.

Challenges

The fundamental challenge that the SMG is facing regarding energy efficiency is maintaining its energy efficiency policies in the long term. In Korea, general elections are held every five years; when a new regional administration takes office, it tends to have a different energy reduction goal and energy efficiency programmes than the previous administration. The One Less Nuclear Power Plant initiative began after the current mayor took office in 2011, and the plan's title touches upon the issue of nuclear power, a sensitive energy issue both domestically and globally that is the responsibility of the central government, not the regional government. As a result, some stakeholders are uncertain about the longevity of the One Less Nuclear Power Plant policy following the next election cycle. However, energy efficiency and savings remain among the most important policies for both the central and regional governments. Efforts to promote these policies will continue even though the political slogans will differ depending on the government administration in office.

Conclusion

Korea has achieved rapid economic growth over the past 50 years with Seoul at the centre of the country's economic activity. During Korea's development phase, growth was recognised as a virtue. Energy consumption growth was no exception. The experiment of the SMG to reduce traditional energy generation by One Nuclear Power Plant is a big shift, both in awareness and in lifestyle. In order to create a low energy-consuming social structure, energy efficiency programmes need to be seen as a part of everyday life. The success of this initiative is also important because, as a melting pot for ideas and experimentation in energy saving, Seoul provides possibilities for other regions in Korea to follow. Seoul can also provide important examples and lessons for the rest of the world.

References

Ministry of Trade, Industry and Energy (MOTIE) and Korean Energy Economics Institute (KEEI) (2014), *Yearbook of Regional Energy Statistics*, www.keei.re.kr/keei/download/YES2014.pdf.

SMG (Seoul Metropolitan Government) (2014), *One Less Nuclear Power Plant – A Hopeful Message of Seoul's Energy Policy*, www.ieac.info/IMG/pdf/201305smg-one_less_nuclear_power_plant.pdf.

13. TOKYO, JAPAN

Summary

Tokyo leads Japan in both energy efficiency improvements and reductions in energy consumption. The Tokyo Metropolitan Government has achieved impressive results through its policies to improve energy efficiency, especially in buildings. The energy intensity of commercial buildings fell 18% between 2007 and 2012 and improvements in building energy consumption would rank Tokyo third among all International Energy Agency member countries. The success of Tokyo's strategy provides a potentially useful model for policy at the national level. It also provides a strong foundation for Tokyo to pursue further, more ambitious, policy frameworks in its role of leading and demonstrating the ability of energy efficiency programmes to generate positive results at the municipal and national levels, of relevance for Japan and internationally.

Introduction

Tokyo is by many measures the largest city in the world. Functionally, the Greater Tokyo Area (Figure 13.1, left) has a population of 35 million, the same as Canada.[1] The region generated an estimated USD 1.3 trillion of gross domestic product (GDP) in 2010, the largest figure for any city globally, and 36% more than the second-largest city, New York. GDP generated in the Greater Tokyo Area comprises 32% of Japan's national GDP, ranking it 12th of 275 cities worldwide in economic concentration of national output (OECD, 2012). With its large economic and social footprint, Tokyo has an important influence on energy efficiency outcomes in Japan and is a huge market for energy efficiency investment. This chapter describes Tokyo's energy efficiency efforts, its energy efficiency market, and how a mega-city like Tokyo can influence national energy efficiency developments by cultivating city-specific drivers.

Japan is divided into 47 prefectures, whose governments' duties are those considered to be region-wide, such as infrastructure development, as well as ensuring communication between the central government and municipalities. Each prefecture is further divided into local governments, responsible for local services such as healthcare, environmental conservation, planning, sanitation, etc. There are also special municipalities that are permitted by the central government to perform all or part of the tasks usually handled by the prefectures (OECD, 2005).

The Greater Tokyo Area consists of four prefectures. The Tokyo Metropolis Prefecture (Figure 13.1, right) is the most populous of the four. The Tokyo Metropolis Prefecture, with nine million people, and the western suburban Tama region, with four million people, are governed by the Tokyo Metropolitan Government (TMG). This chapter focuses on efforts taken by the TMG in making efficiency improvements within its administrative region.

Although Japan is a highly centralised state, local governments have traditionally had autonomy to formulate and enact energy policies within the framework of climate change and reduction of greenhouse gas (GHG) emissions. Japan's Global Warming Law empowers local governments to create and administer policies to reduce GHG emissions even though it does not formally bestow

[1] Functional boundaries refers to the OECD's definition of functional economic units characterised by linking densely populated urban cores with hinterlands where there is high integration between labour markets (OECD, 2012a).

any powers on local government to do so. The activities of most local governments are limited to information dissemination and persuasion because of overlapping jurisdiction with the central government (Sugiyama andTakeuchi, 2008).

Figure 13.1 Japan (left) and the Tokyo Metropolis Prefecture (right)

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Sources: Kzaral. (n.d.), "Tokyo-Kanto definitions", Tokyo Metropolis, Wikimedia Commons, retrieved from http://commons.wikimedia.org/wiki/File:Tokyo-Kanto_definitions,_Tokyo_Metropolis.png#/media/File:Tokyo-Kanto_definitions,_Tokyo_Metropolis.png. Qrsk075 (n.d.), "Greater Tokyo Area", Wikimedia Commons, retrieved from http://commons.wikimedia.org/wiki/File:Greater_Tokyo_Area.png#/media/File:Greater_Tokyo_Area.png.

Tokyo, as the major commercial and population centre of Japan, has had more success than other local governments in establishing authority over energy policy and efficiency with the power to issue ordinances for climate-based policy. Tokyo has been a leading jurisdiction for the implementation of climate policy, implementing Japan's first emissions trading system in 2008 after resistance from some businesses. Policy generated by cities such as Tokyo is facilitated by the size and capacity of the TMG, which oversees 13 million people.

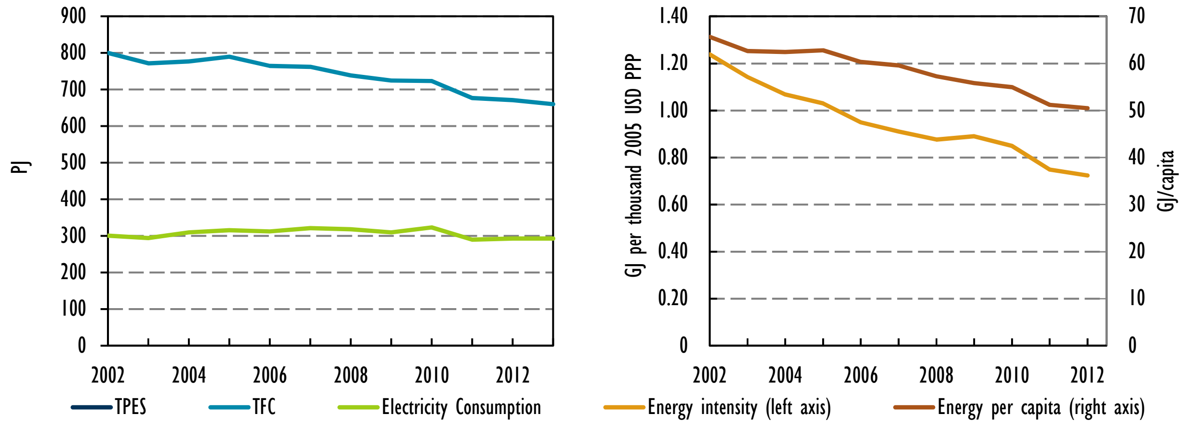
Energy profile and context

In Tokyo, total final energy consumption (TFC) declined 14% between 2003 and 2013, to 660 petajoules (PJ) (Figure 13.2), despite a 4.5% increase in municipal GDP over the same period. Tokyo's economy has become more service-oriented, which has helped reduce energy demand and consumption. The share of value added provided from services grew from 83% to 87% between 2001 and 2012; goods-producing industries declined from 17% to 13%.[2]

[2] Services include wholesale and retail trade, finance and insurance, real estate, transport, information and communications and other public and private services. Goods producing includes agriculture, mining, manufacturing, construction and electricity and water utilities.

While electricity demand has remained essentially stable, it increased its share of TFC from 38% to 44% between 2002 and 2013. The increase in the share of electricity is the result of significant erosion in demand for other fuels, namely oil products. Consumption of oil products was down 36% between 2002 and 2013 and natural gas consumption was down by 3%.

Figure 13.2 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12



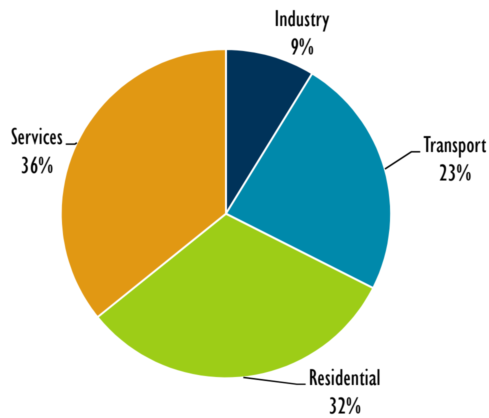
Source: Energy data were provided by the Tokyo Metropolitan Government.

Tokyo's energy consumption of 50 gigajoules (GJ) per capita is half of the Japanese average. Low per capita energy consumption stems from the composition of the city's economy (high levels of service-oriented output and relatively low levels of industrial production), high residential density and provision of public transport. Tokyo has lower energy consumption per capita than other less dense cities. Tokyo's final energy consumption per capita was the fourth lowest among cities over 10 million people, behind Sao Paulo, Istanbul and Chengdu, while having GDP per capita that is 60-80% greater than those cities in 2005 (Grubler et al., 2012). Of the top 20 largest cities by population, Tokyo had the 7th lowest TFC per capita while having the fifth highest density and GDP per capita (Grubler et al., 2012).

Tokyo experienced a significant reduction in energy intensity between 2002 and 2012. Energy intensity declined by 42% from 1.2 to 0.7 GJ per 1 000 USD. Intensity improvements paused between 2008 and 2010, coinciding with the recession, but then recommenced the pre-recession trend after 2010. If Tokyo were a country, it would have ranked second among all OECD countries for this improvement of energy intensity (behind Slovakia).

Two-thirds of TFC is from building energy use with industry and transport combining to make up the other third (Figure 13.3). The share of building energy use reflects Tokyo's urban form as a centre of commercial economic output and residential dwellings. Industrial activity has been pushed out of the urban core to neighbouring prefectures where land values are lower and where industrial activity does not conflict as directly with urban populations. Industry reduced energy consumption by 28% in Tokyo between 2002 and 2012; this was more than double the national rate of 12%.

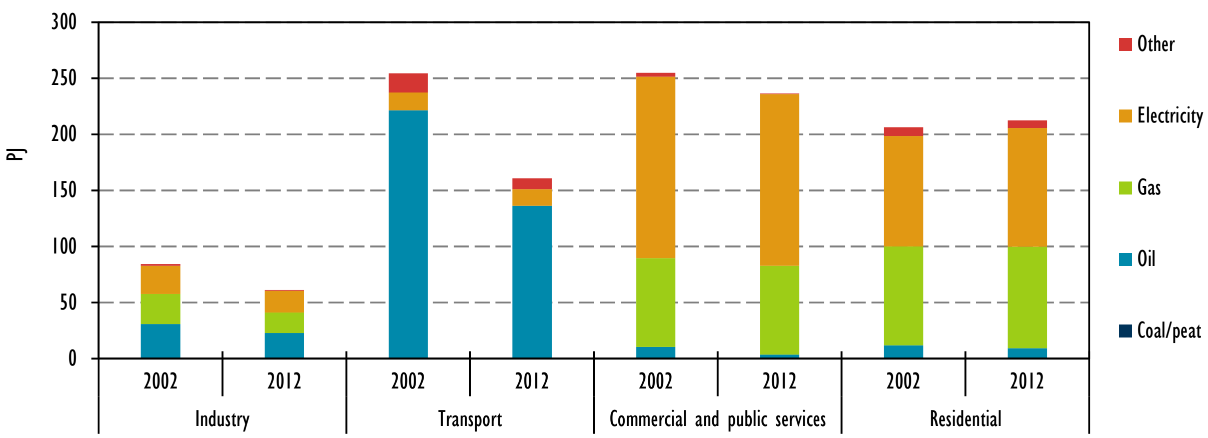
Figure 13.3 TFC by sector, 2012



Source: Energy data were provided by the Tokyo Metropolitan Government.

Energy efficiency improvements, densification and the expansion of public transport have dramatically reduced energy consumption in the transport sector. In 2002, transport energy made up 32% of TFC; by 2012 its share had fallen nine percentage points and total energy consumption in the transport sector had been reduced by 35% (Figure 13.4). The reduction in transport energy consumption is a key factor in explaining the reduction in energy intensity in Tokyo over the past decade.

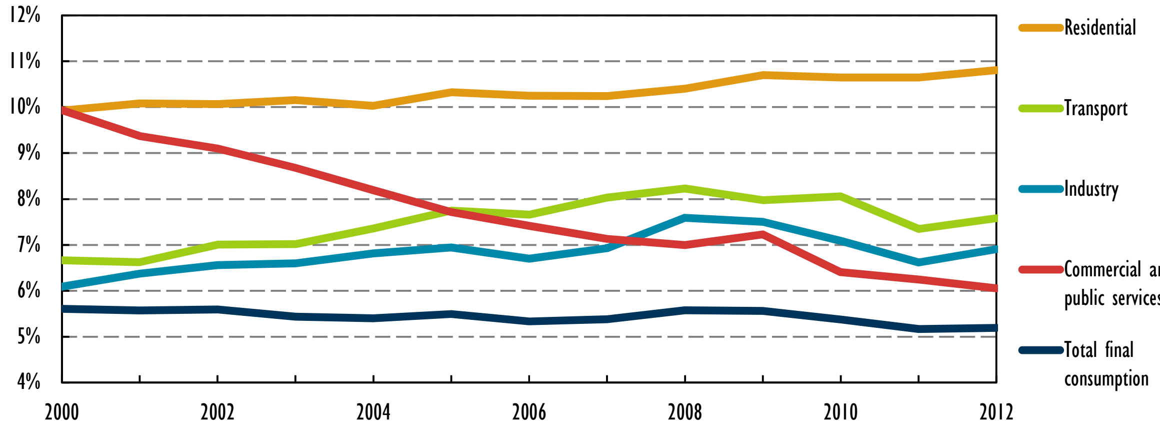
Figure 13.4 TFC by sector and by energy source, 2002 and 2012



Source: Energy data were provided by the Tokyo Metropolitan Government.

Energy consumption in residential buildings increased 3% between 2002 and 2012, but residential energy consumption did not keep pace with the 9% population growth over the same period. Commercial energy consumption declined by 7%; at the same time commercial value added increased by 9%. Commercial energy intensity declined by 37% between 2002 and 2012, from 0.011 toe to 0.007 toe per USD 1 000. The improvement in energy intensity in commercial buildings has driven Tokyo's share of total Japanese commercial building energy use from 10% in 2000 to 6% in 2012 (Figure 13.5).

Figure 13.5 Share of Tokyo in Japanese TFC by sector



Sources: Energy data for Tokyo was provided by the Tokyo Metropolitan Government. IEA (2014), IEA *World Energy Statistics and Balances* (database), DOI: http://dx.doi.org/10.1787/data-00512-en, (accessed on 30 June 2015).

The improvement in commercial energy intensity was the main factor in the reduction of Tokyo Prefecture's share of national TFC from 5.6% to 5.2% between 2002 and 2012. Tokyo's share of energy consumption is comparatively small in relation to the share of its population (10.4%) and economy (23.2%) in Japanese totals. Tokyo's population share grew from 9.5% in 2002 to 10.4% in 2012, which partly explains the growth in the share of residential energy and transportation consumption. The share of industrial energy consumption in national industrial consumption also grew by one percentage point. Tokyo is the most densely populated city in Japan with 4 070 people per square kilometre (km^2) and 33% more dense than the second ranked city, Naha (OECD, 2012). Tokyo's population density has not changed significantly over the period meaning that energy efficiency adoption through policy and markets has been a key reason for the reduction in commercial building energy share compared to the rest of Japan.

Market driver: Energy efficiency policies and programmes

Energy efficiency performance in Tokyo is the product of policy implemented both nationally by the Japanese government and by the TMG. For example, the national government's Top Runner programme is helping to improve energy efficiency outcomes in Tokyo. Depending on the product category, Top Runner has led to efficiency improvements of between 22% and 99% (IEA, 2013). These technologies are invariably deployed and used in Tokyo and their efficiency gains improve Tokyo's energy performance.

Tokyo's energy efficiency objectives are related to its normal business of zoning and approvals for urban development and its Climate Change Strategy. The following section outlines how Tokyo increases energy efficiency through its normal business functions as a municipality with jurisdiction over land-use issues and through its dedicated energy efficiency policies.

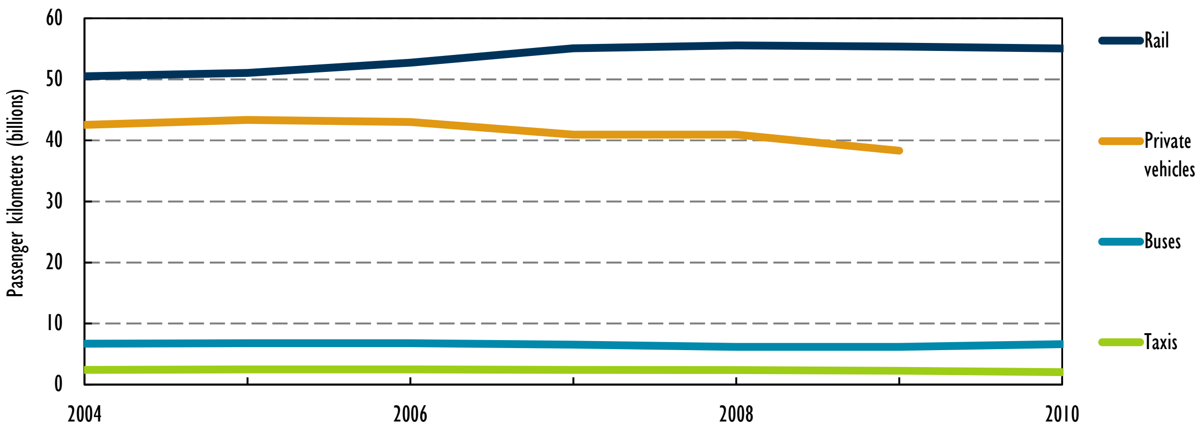
Land-use planning

The TMG's land-use planning powers allow it to shape the city by developing it in a way that shapes energy intensity in the region. The TMG has worked with developers to prioritise the development of dense multi-residential units. This policy focus has led to improved energy intensity in various sectors. For example, the energy intensity of residential buildings in Tokyo is low compared to other

OECD countries and it continues to decline. Between 2005 and 2013, the average energy consumption per square metre (m^2) in Tokyo's residential buildings declined by 7% to 0.44 GJ. Tokyo's low energy consumption per unit is a product of a number of factors including floor space per capita and the relatively large share of buildings that are multi-residential units.

The TMG's urban policy and zoning also help to connect Tokyo's urban development with public transport, which is prioritising less energy-intensive modes of travel. Rail transport had a 55% share of total inland transport in Tokyo in 2008 (TMG, 2012). The share of public transport is increasing in the region; between 1998 and 2008, the share of bus and rail travel increased seven percentage points and between 2004 and 2009 an additional 4.9 billion passenger kilometres of travel were added to the rail system (Figure 13.6).

Figure 13.6 Passenger kilometres by mode in Tokyo Prefecture



Note: Calculated with data from TMG and includes additional transport from the Metro Subway, Metropolitan lines and private railways.

Source: TMG (2012), www.toukei.metro.tokyo.jp/tnenkan/2012/tn12q3e004.htm.

Tokyo's Climate Change Strategy

The TMG has established a target to cut 25% of its GHG emissions by 2020 from 2000 levels, primarily using energy efficiency. The strategy prioritises the use of market mechanisms such as the "cap and trade" system to achieve emissions reductions and looks to market actors as the main enablers and compliance tools to deliver GHG savings. The Climate Change Strategy is focused on achieving efficiency improvements in the buildings sector. The strategy incorporates three main policies: 1) the Cap and Trade Program for large emitters, 2) the Green Building Program for new residential buildings including standards, labelling and performance certificates and 3) the District Plan for Energy Efficiency.

Cap and Trade Program

The TMG has been operating the world's first city-level cap and trade programme since 2010. The programme covers 1 300 large emitters– facilities with more than 1 500 kilolitres of crude oil-equivalent of energy consumption annually. With this threshold the programme covers 40% of commercial and industrial sector emissions (Nishida, 2012). The strategy focuses on both commercial and industrial firms with the aim of achieving building energy efficiency improvements. The TMG states that the Cap and Trade Program is the policy tool they use to address energy use in existing buildings and to incentivise energy efficiency investments (TMG, 2011).

Facilities are treated as buildings or sites with direct energy consumption. Facilities are broken down between business facilities such as office buildings and commercial complexes, institutional buildings such as schools, hospitals and public buildings and industrial facilities. The GHG reduction target is more stringent for business facilities, which were required to achieve an 8% reduction in GHG emissions between 2010 and 2014 and a 17% reduction between 2015 and 2019. Industrial facilities have to achieve a corresponding reduction of 6% and 15%.

Facilities that have already achieved significant energy savings and top-performing energy-efficient buildings are eligible to certify their performance to have their emission reduction obligation halved. Certification requires that each building go through an assessment and approval process whereby it must comply with 74 specific items across three categories: 1) general management of energy systems and conservation; 2) energy efficiency of building shells and equipment; and 3) operational management of energy use. In addition to the 74 specific actions they need to undertake, facilities have to then comply with an additional 126 of 154 optional actions across the three categories.

Tokyo Green Building Program

The Tokyo Green Building Program started in 2002 and is the component of the Climate Change Strategy focused on achieving energy efficiency improvements in new buildings. The programme targets new buildings with a floor area over 5 000 m^2 (representing an estimated 40% of new building stock) (Nishida, 2013). New buildings in the programme must have an environmental performance evaluation and publish a building environmental plan. The evaluations assess the building's energy consumption including its insulation, equipment and auxiliary and energy efficiency management systems. Each component is assessed on a scale of one to three. The evaluation and plan must be published on the TMG website before applying for a building permit (TMG, 2011). The programme has since been expanded to include labelling schemes for condominiums and energy performance certificates of commercial buildings.

District Planning for Energy Efficiency

The District Planning for Energy Efficiency policy aims to deploy more energy-efficient district heating and integrated community energy systems. By using the TMG's planning authority, Tokyo gains access to energy supply decisions that are typically made exclusively by the national government. The motive for this strategy is to improve energy efficiency and reduce carbon emissions but also to improve Tokyo's energy security. Energy security in the region was considerably stressed in the aftermath of Japan's 2011 earthquake and tsunami. Increasing the amount of domestic energy produced adds diversity and resilience to its energy mix; in addition, improving the energy efficiency of the energy supply improves energy security as outlined in Chapter 1.

The initiative focuses on property developments larger than 50 000 m^2. The TMG is aiming to build on the popularity of large transport-oriented developments around subway stations by leveraging this type of development to produce more energy-efficient and low-carbon outcomes. The plan requires that developments above the threshold qualifying floor area submit a plan on energy conservation for the development 180 days prior to application for the building permit. The energy conservation plan asks developers to approach building efficiency both from the demand and the supply sides. Improved efficiency can come from district heating and cooling systems, which in Tokyo use 44% less primary energy than individual systems (UNEP, 2015).

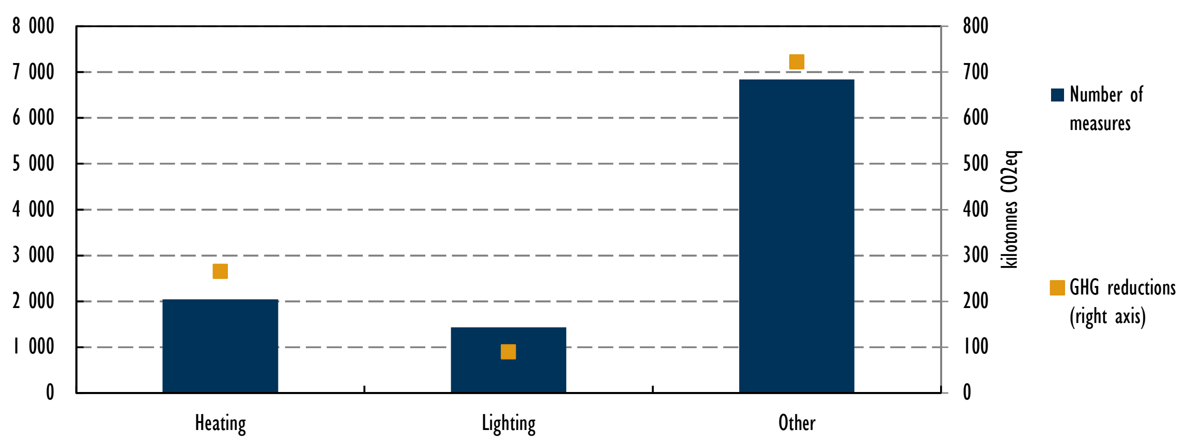
Current energy efficiency market activity

Data on current energy efficiency market activity such as investment, employment and business development for energy efficiency in Tokyo is limited. National policy makers and industry have long seen energy efficiency as a win-win economic development tool. Industrial giants such as Mitsubishi recognise the potential market provided by energy-efficient goods. A number of policies and programmes are having a clear impact on businesses that design, produce and install energy-efficient solutions.

Cap and Trade Program investments

Tokyo's Climate Change Strategy has provided incentives for building managers, factory owners and property developers to implement energy efficiency measures. Almost all the actions taken to comply with the Cap and Trade Program have been made by investing in energy efficiency (Figure 13.7). The largest number of actions has been in miscellaneous efficiency improvements – anything from adopting building energy management systems and energy visualisation meters to demand-control systems to various site-specific building shell and insulation improvements. Heating efficiency is the next largest area of focus for facilities. Investments include replacing heating systems with high-efficiency options such as heat pumps, variable air-volume air conditioning, heat exchangers and high-efficiency fans. Lighting is another important area of efficiency improvement. Most lighting improvements have been made by adopting higher efficiency bulbs but investments have also been made in lighting control equipment. In total, over 10 000 actions have been taken by the owners of 1 300 facilities, achieving reductions of 1 million tonnes of GHG emissions.[3]

Figure 13.7 Measures taken to comply with the Tokyo Cap and Trade Program and GHG emission reductions, 2010-14



Source: TMG (2015), *Tokyo Cap-and-Trade Program achieves 23% reduction after 4th year*, Tokyo Metropolitan Government, Bureau of Environment.

Instead of tracking actual investment, performance on energy efficiency outcomes provides a proxy for energy efficiency investment. In the Cap and Trade Program, over 90% of all facilities have exceeded their reduction targets. The programme has been so successful that more than 100 facilities have reduced their energy consumption enough to fall under the 1 500 kilolitres

[3] No data have yet been reported on the value of the investments made for the 10 000 actions.

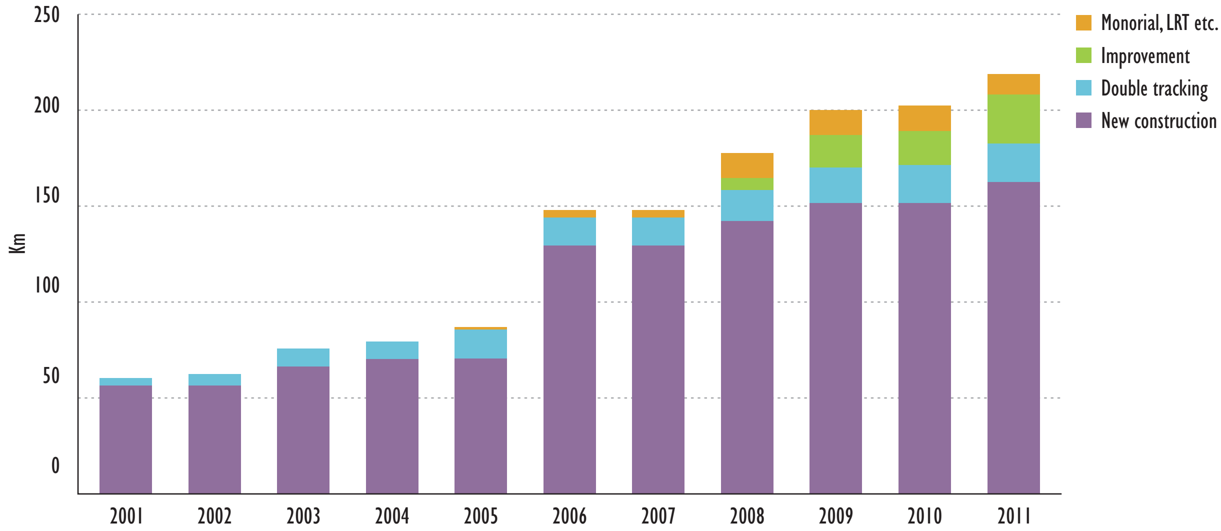
threshold for exiting the programme. Obligated facilities have reduced their final energy consumption by 15% from 2005 levels and by more than 7% since the programme was implemented. Final energy consumption among the facilities covered was five percentage points lower than the national average (TMG, 2015).

Urban development in buildings and transport

In addition to the Cap and Trade Program, urban development in Tokyo is a significant source of investment capital that is improving energy efficiency in the city. Tokyo has prioritised the development of dense multi-residential units with commercial shopping centred on public transport links. The popularity of rail for intra-urban transport has been facilitated by private markets working in concert with policy makers.

These developments have been highly profitable and their construction has facilitated the expanded use and development of the rail system in Tokyo. What were traditional rail operators are now fully integrated urban development corporations. One of the largest of these corporations is Tokyu Corporation which had net profits of USD 587 million in 2006 with real estate development and transport revenues accounting for an equal share of profits (34%) and the remainder coming from retail sales and shopping in their developments (Calimente, 2012). The model of private building and rail development co-ordinated through TMG policy has proven successful, to the point that 221 km of new or improved rail track was added to the region between 2000 and 2011 (Figure 13.8) (Kato, 2014).

Figure 13.8 Length of new rail network development in Tokyo Metropolitan Area, 2000-11



Source: Kato, H. (2014), *Urban Rail Development in Tokyo from 2000 to 2010*, OECD/ITF Publishing, Paris.

Prospects for energy efficiency market activity

The prospects for energy efficiency investments are uncertain, in part as Tokyo has successfully exploited previous opportunities. This is illustrated by the commercial buildings sector, which achieved important intensity improvements as central Tokyo added or began constructing 807 new commercial buildings and 11 million m^2 of floor space (Nomura Research Institute, 2014). This new space provided additional opportunity to introduce more efficient building stock. However, estimated additional new floor space to be built from 2012 to 2017 is projected to be 29% less than in the period from 2007 to 2012 (Nomura Research Institute, 2014) limiting the potential for energy savings over the previous period. The region is also in the process of trying to decentralise the Tokyo core across the prefecture to neighbouring prefectures recognising the adverse impact of the rapidly urbanising city core on neighbouring regions (Vogel, 2000). This move may lower the demand for new office space and reduce the energy savings potential as employment moves to regions with under-utilised existing office space.

Challenges

Co-ordination across the vast metropolitan area is important to support energy efficiency efforts. However, as a local government, the breadth of the TMG's authority extends only to its political boundaries; the functional boundaries of Tokyo extend much more widely. The integrated nature of the region is highlighted by commuting patterns between Tokyo Prefecture and the three neighbouring prefectures. Tokyo Prefecture's population swells by 2.5 million every day as commuters from adjacent prefectures enter for work. Without consistent planning across neighbouring regions, efficiency efforts may suffer from leakage. The TMG is aware of this issue and seeking ways to broaden the impact of its programmes; for example, discussion is already underway to extend the Cap and Trade Program to the metropolitan area. This will require political decision-making and co-ordination, which can present some uncertainty for investors.

Conclusion

The TMG provides useful lessons for cities worldwide. Progress in developing energy efficiency policies and markets in Tokyo demonstrates the important role that subnational governments can play. Tokyo has mobilised considerable investment and effort by focusing on policies that target its largest energy-consuming sectors. The Climate Change Strategy shows how cities can move forward with innovative market-based policies to achieve notable energy efficiency improvements and climate change mitigation. The close relationships between local governments and large energy consumers can provide important insights to facilitate more effective policies.

Regional and local governments such as TMG do have the capacity to influence energy use and energy efficiency along with their more traditional roles of planning, zoning, service delivery and municipal governance. Energy efficiency improvement was not a main objective of Tokyo's long history of prioritising dense urban development along public transport lines even though it was achieving system-scale efficiency improvements. As the region focuses more on improving energy efficiency, the market for efficiency looks like it will continue to expand with the TMG expanding its dedicated policies and building upon its previous successes.

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14. UNITED KINGDOM

Summary

The United Kingdom has a comprehensive range of policies driving investment in energy efficiency. The Department of Energy and Climate Change estimates that, in 2014 alone, demand-side energy policies saved an estimated USD 6 billion (GBP 4 billion British Pounds)[1] from energy and transport fuel bills for households and businesses (DECC, 2015a).

In the residential sector, investment continues to be driven by supplier obligations, with energy companies expected to spend around USD 1.4 billion per annum on energy efficiency over the period of the current Energy Company Obligation: January 2013-April 2017.

In the non-residential sector, the Green Investment Bank has allocated USD 300 million between 2012-13 to energy efficiency funds with a total capitalisaiton of USD 600 million. More opportunities to invest may arise as companies and public sector organisations undertake audits under the Energy Savings Opportunities Scheme.

In 2013 the energy efficiency supply chain invested between USD 710 million and USD 1.1 billion, employed between 136 000 and 164 000 people, and had a turnover of between USD 43.3 billion and USD 48.9 billion.

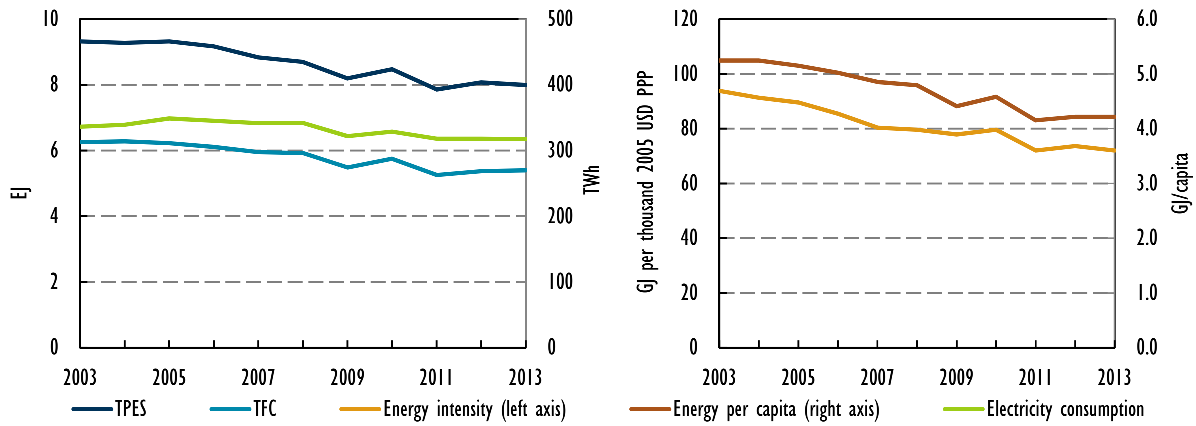
Energy profile and context

Between 2003 and 2013, total final energy consumption (TFC) in the United Kingdom decreased by 20 million tonnes of oil-equivalent (Mtoe) (14%) and total primary energy supply (TPES) decreased by 32 Mtoe (14%). In 2013, the electricity generation mix was comprised of coal (36%), gas (27%), nuclear (20%), renewables (15%) and other sources (2%). The United Kingdom's electricity consumption decreased by 6% between 2003 and 2013, reversing trends seen in previous decades (see Chapter 4 for a detailed discussion of electricity demand in the United Kingdom and other countries).

Energy intensity fell by 18.2 % between 2003 and 2013, moving from 0.11 toe per thousand (2005 USD PPP GDP) to 0.09 toe per thousand (2005 USD PPP GDP) (Figure 14.1). This is considerably lower than the International Energy Agency member country average of 0.13 toe per thousand 2005 USD PPP (in 2013).

[1] Using an exchange rate of USD 1.52 = GBP 1.

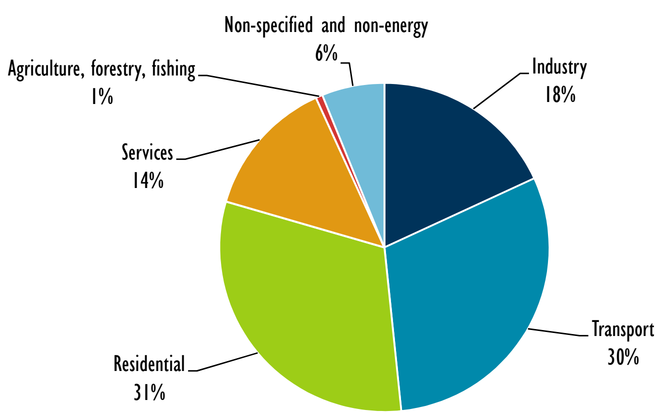
Figure 14.1 UK TPES, TFC, electricity consumption, energy intensity (TPES/GDP) and energy use (TPES) per capita, 2003-13



Source: IEA (2013), "Energy balances", *Energy Projections for IEA Countries* (database), http://dx.doi.org/10.1787/data-00473-en, (accessed on 1 May 2015).

The residential and transport sectors form the largest share of TFC (31% and 30% respectively), followed by industry (18%), services (14%) and other sectors (7%) (Figure 14.2). Between 2003 and 2013, all sectors showed a decrease in TFC except the services sector, which increased by 1 860 Mtoe (12%). Industry consumption decreased by 9 460 Mtoe (29%), transport decreased by 3 210 Mtoe (8%) and the residential sector decreased by 1 860 Mtoe (12%).

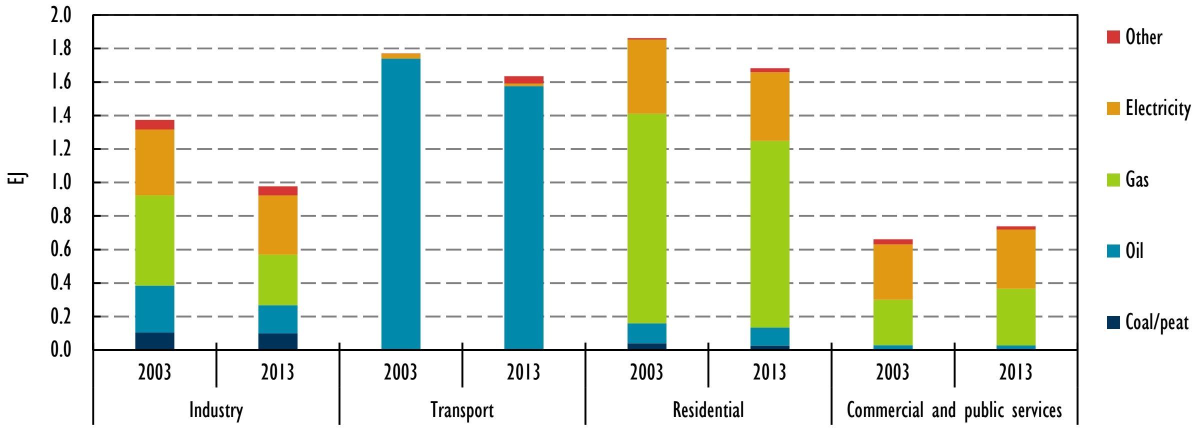
Figure 14.2 UK TFC by sector, 2013



Source: IEA (2013), "Energy balances", Energy Projections for IEA Countries (database), http://dx.doi.org/10.1787/data-00473-en, (accessed on 1 May 2015).

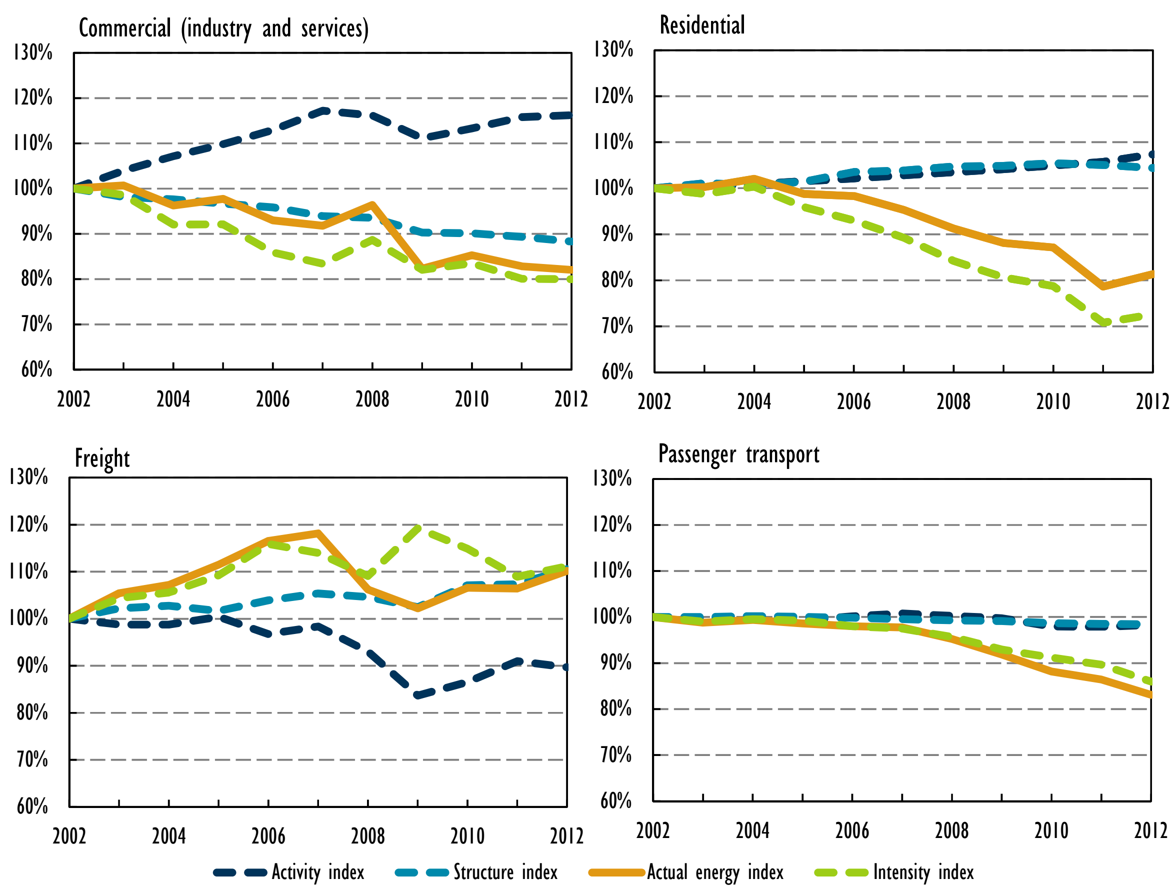
In the industrial sector, electricity formed the largest share of TFC in 2013 (84 Mtoe), followed by gas (72 Mtoe), oil (40 Mtoe) and coal/peat (24 Mtoe). In the transport sector, oil dominated (376 Mtoe). Two-thirds of residential TFC is of gas (267 Mtoe), with electricity (98 Mtoe) accounting for much of the remainder. In the service sector, electricity and gas account for virtually all TFC and had similar shares in 2013 (84 Mtoe and 81 Mtoe respectively). Between 2003 and 2013 there was a noticeable fall in both the absolute level and sector share of gas in both the industry and residential sectors (Figure 14.3).

Figure 14.3 UK TFC by sector and by energy source, 2003 and 2013



Source: IEA (2013), "Energy balances", *Energy Projections for IEA Countries* (database), http://dx.doi.org/10.1787/data-00473-en, (accessed on 1 May 2015).

Figure 14.4 Decomposition of UK energy use (TFC), 2002-12



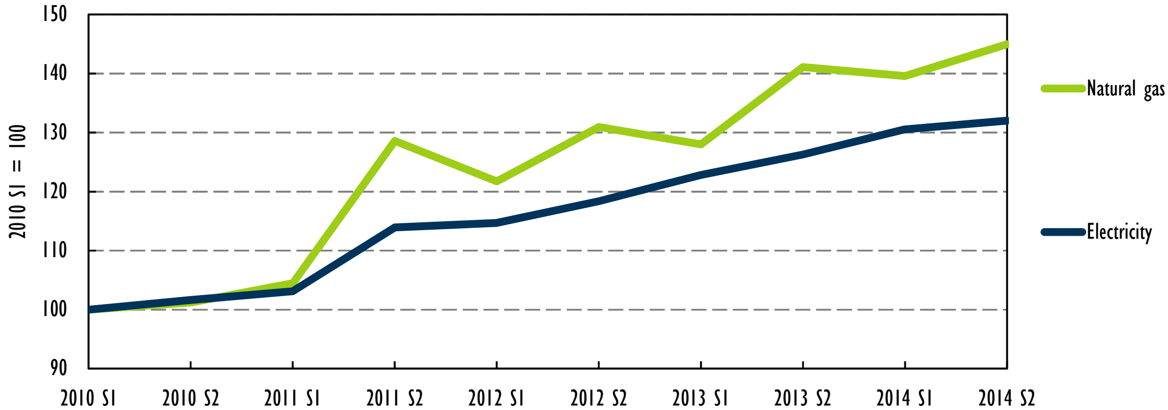
Source: Analysis based on the IEA *Energy Efficiency Indicators Database*.

Energy efficiency has had an important impact on reducing UK energy use across all sectors, most notably in the residential sector, where policies such as supplier obligations (discussed in this chapter) and regulations on new buildings have helped to drive down TFC by 20% since 2002. Indeed, had population not grown, and had the structure of the residential sector remained unchanged, TFC would have fallen by around 30% owing to efficiency gains.[2] In the industrial and services (commercial) sector TFC has also fallen by 20%, with the combination of efficiency and structural change more than offsetting the impact of the increase in gross value added (GVA); in this sector the efficiency effect is twice the size of the structural effect. In the transport sector the efficiency effect is small, with efficiency improvements in the passenger transport sector, most likely driven by the improved efficiency of vehicles, being offset by an increase in energy consumption per tonne kilometre in the freight sector Figure 14.4).

Energy prices for residential consumers

Energy prices are typically an important potential driver of investment in energy efficiency. UK residential electricity prices are slightly lower than the EU average but almost double the US average (EIA, 2014). Over the period 2010-14[3] the price for domestic consumers rose from USD 0.17 to USD 0.23 (GBP 0.11 to GBP 0.15)/kilowatt hour (kWh), a 32% increase. Gas prices have risen by over 40% since 2010 and are slightly lower than the EU average at USD 20.6 (GBP 13.5)/gigajoule (GJ) (Eurostat, 2015). Figure 14.5 shows how these prices have evolved since 2010. The increase in prices since the start of the decade is likely to have increased interest in investment in energy efficiency, although the very low rates of value added tax of 5% paid by households for electricity and gas is likely to have had a dampening effect; UK residential energy prices contain the smallest tax component in the European Union (Eurostat, 2015).

Figure 14.5 Gas and electricity price indices for residential consumers[4] in the United Kingdom, 2010-14



Source: Eurostat (2015), "Electricity and natural gas price statistics", DOI:http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_and_natural_gas_price_statistics#Natural_gas_prices_for_industrial_consumers, (accessed on 23 June 2015).

[2] See Chapter 2 for an explanation of the decomposition analysis underpinning the estimates presented here.

[3] First half of 2010 to second half of 2014.

[4] Household consumers correspond to Band DC: 2 500 kWh < Consumption < 5 000 kWh (electricity) and Band D2: 20 GJ < Consumption < 200 GJ (natural gas), industrial consumers correspond to Band IC: 500 MWh < Consumption < 2 000 MWh (electricity) and Band I3: 10 000 GJ < Consumption < 100 000 GJ (natural gas).

Market driver: Energy efficiency policies and programmes

The United Kingdom has a comprehensive set of policies and programmes driving energy efficiency investments across a variety of sectors of the economy. In 2013 alone, the full range of UK demand-side energy policies is estimated to have saved GBP 4 billion from energy and transport fuel bills for households and businesses (DECC, 2014a). One key policy suite has been targeted at encouraging retrofits in the residential sector, where the United Kingdom has been at the forefront of implementing innovative programmes aimed at tackling the barriers to investment.

Building retrofit policies in the residential sector

The retrofit element of the UK residential energy efficiency market is dominated by supplier obligations. Recent market activity has been supported by the Carbon Emissions Reduction Target (CERT) (2008-12) and the Community Energy Saving Programme (CESP) (2009-12), which were replaced in 2013 by the Energy Company Obligation (ECO) (current legislation period: 2013-17). The new scheme initially focused more on solid wall insulation and "hard to treat" cavity wall insulation, with the largest element of the scheme, the Carbon Emissions Reduction Obligation (CERO), excluding the insulation of properties with "easy to treat" cavity walls and loft insulation. The exclusion of these cheaper measures from the CERO was ended in April 2014, as the government sought to ease pressures on consumer bills and ensure ECO provides value for money by reforming the CERO to allow more measures to qualify, reducing the stringency of the obligation in terms of carbon savings and a number of other changes to reduce the costs of compliance. The ECO also has a significant focus on alleviating fuel poverty through the Affordable Warmth element, which sees the delivery of insulation and efficient heating systems to qualifying households.

The United Kingdom's supplier obligations have been supplemented by a number of other policy instruments that support investment in the market:

- The Green Deal Home Improvement Fund was set up as part of a package to counterbalance the scaling back of the ECO and provides an alternative subsidy source to households wishing to invest in solid wall insulation or the installation of multiple efficiency measures.
- Energy companies are mandated to roll out smart meters across Great Britain by 2020.
- Legislation has been passed requiring dwellings and commercial buildings let in the private rented sector to have at least an "E" Energy Performance Certificate rating from 2018, a change that should already be having an impact on the market as property owners prepare to comply.
- Green Deal assessments by certified assessors provide independent advice to potential household investors.
- The government has set up a brokerage platform to enable the energy efficiency supply chain (Green Deal Providers) to sell energy efficiency improvements to obligated energy suppliers.
- Between January 2013 and July 2015, the government-backed energy company Green Deal Finance Company (GDFC), provided an on-bill financing route for energy efficiency measures where savings equaled or exceeded the cost of financing them (the GDFC is now closed to new business – see below).

Current energy efficiency market activity

The UK energy efficiency market is seeing investment from government, businesses and households, as well as the supply chain. This section examines market activity across the economy and looks in detail at investment trends in the residential sector.

Residential sector investment

In the residential sector investment is driven by the policy framework set out above. Supplier obligations have been particularly important, with the CERT and the CESP leading to annual expenditure by energy companies of USD 1.9 billion (GBP 1.3) billion over the period 2009-12 on energy efficiency (Rosenow, 2012), while the reformed ECO is expected to lead to energy company expenditure of around USD 1.4 billion (GBP 0.9 billion) per annum during the 2013 to 2017 period (DECC 2014b). Energy companies can meet their obligations either through in-house operations or through contracts with the wider energy efficiency supply chain, which can be made either bilaterally or through the government's brokerage platform. The platform facilitates price transparency and competition in the residential energy efficiency market, allowing new players to enter the market for ECO compliance. Since the inception of the ECO in 2013, over USD 650 million (GBP 430 million) worth of contracts have been traded on the platform (DECC 2015b).

The spending by energy companies through supplier obligations over the period to 2014-17 is being supplemented by around USD 750 million (GBP 500 million) worth of central government funded energy efficiency schemes,[5] most notably the Green Deal Home Improvement Fund, which funds investment in solid wall insulation as well as the installation of multiple measures in any property type (DECC, 2014c). In addition, the UK government is experimenting with novel approaches to targeting energy efficiency investment where it is most needed, including a recently announced scheme that links energy efficiency to improved health outcomes (Box 14.1).

Box 14.1 Energy efficiency as "medicine on prescription": One of the multiple benefits

The UK government recognises the multiple benefits of energy efficiency, including the impact that more energy-efficient housing can have on health outcomes. In 2015, as part of the United Kingdom's Fuel Poverty Strategy (DECC, 2015c), the government announced USD 1.5 million (GBP 1 million) of funding to a selection of local "warmth on prescription" schemes, delivering energy efficiency boilers, insulation and double-glazing to fuel-poor patients presenting to health professionals with diseases exacerbated by cold, damp housing. The schemes will provide evidence on ways in which national schemes can be delivered successfully at local levels; information barriers can be overcome to the take-up of energy efficiency, for example through health sector referrals; and the potential for cross-government activity to tackle issues that cut across departmental boundaries. This latter point is particularly important to the energy efficiency market; evidence that energy efficiency can prevent health sector spending on traditional treatment holds the potential to unlock new resources to fund projects in the medium term.

The *Energy Efficiency Market Report 2013* (IEA) highlighted the development of Green Deal Finance (GDF) as a novel funding mechanism in the UK residential energy efficiency market. GDF enabled households to finance, or part-finance efficiency improvements through loans that are tied to the electricity bill as opposed to the individual, and can be passed on to the next owner or tenant in the event that the originator of the loan moves house before the end of the loan's term. These loans are offered to consumers by Green Deal Providers, who in turn may opt to secure third-party finance from – for example – the GDFC. The product had a slow start following its launch in 2013, but

[5] Schemes include both those aimed at the residential sectors and those aimed at financing public sector finance (Salix Finance).

demand picked up from mid-2014 and in 2015 around 500 new Green Deal Plans[6] were being confirmed each week, with the total number of plans reaching over 14 000 in May 2015 (DECC 2015b). However, with the growth in plans not accelerating at the pace needed to justify further public investment, the government decided not to increase its senior loan facility to GDFC (the primary, and as yet only, source of third party finance), meaning that GDFC is not currently accepting new applications for finance (GDFC, 2015).

Under the new private rented sector (PRS) regulations, as of April 2018, landlords will only be able to let properties that have at least an "E" Energy Performance Certificate (EPC) rating (DECC 2015d).[7] This development will focus investment on the 400 000 least energy-efficient properties in the PRS, with EPC ratings below "E", with the market already gearing up to ensure that landlords comply with the new regulations. As the property market becomes more accustomed to energy efficiency regulations and EPC ratings, it may also lead to energy efficiency being more clearly factored into property prices (Box 14.2).

Box 14.2 Capturing the value of energy efficiency in property prices

Recent research commissioned by the UK government (DECC, 2013c) suggests that there is a positive relationship between energy ratings and dwelling price per square metre. In a study that examined the relationships between EPC ratings and property values, it was found that, compared with less efficient dwellings rated "G", "F and E" rated dwellings sold for a premium of 6%, dwellings rated "D" sold for 8% more, higher efficiency buildings rated "A, B and C" sold for 10 to 14% more.

At present, 53 million smart electricity and gas meters are being rolled out by energy suppliers across Great Britain's residential and small and medium-sized enterprise sectors, with the rollout scheduled for completion in 2020. In 2013, a licence worth approximately USD 266 million (GBP 175 million) over 12 years was awarded to a data and communications company, which has signed contracts with three companies worth USD 3.3 billion (GBP 2.2 billion) to develop and operate data systems and provide communications services (DECC, 2013d).

Commercial sector energy efficiency finance

UK Green Investment Bank (GIB) funds projects such as building retrofits, infrastructure development such as street lighting projects and efficient on-site generation such as combined heat and power (CHP). This supplements long-standing energy efficiency policies in the commercial sector such as Climate Change Agreements (focused on energy-intensive industry), the Carbon Reduction Commitment Energy Efficiency Scheme (focused on non-energy intensive medium-sized and large businesses), as well as the recently announced Energy Saving Opportunities Scheme (the United Kingdom's energy audit policy covering large businesses' energy use).

[6] A Green Deal Plan includes all the measures to be installed in a property and the information on future charges. A plan is "live" once all measures are in place. A new plan is recorded once the householder has obtained a quote from a Green Deal Provider and confirmed they wish to proceed.

[7] There are a number of exemptions to the regulations, most notably that measures that are not cost effective, based on the Green Deal's Golden Rule, do not need to be installed.

The GIB's investment strategy has focused on developing financing products to accelerate the development of the energy efficiency market in the United Kingdom. Since 2012-13, the GIB has committed USD 300 million (GBP 200 million) to funds worth USD 600 million (GBP 400 million) in total. Along with GIB direct investments, those funds have been invested in energy efficiency projects with a total transaction size of USD 139 million (GBP 91 million) so far (UK GIB, 2015). These investments cover projects (Table 14.1).

Table 14.1 UK GIB investments (USD millions) since 2012-13

	Total investment size	GIB investment quantity
Building retrofits	58.5	28.3
On-site generation	46.7	22.0
Infrastructure	30.6	16.4
SME energy efficiency platform	3.0	0.8
Total	**138.8**	**67.5**

Source: UK GIB (Green Investment Bank) (2015), Summary of Transactions, UK GIB, London, www.greeninvestmentbank.com/media/44778/gib_transaction-table_220615.pdf, (accessed 23 June 2015).

In the public sector, the government-backed company, Salix Finance, has provided interest-free loans totalling USD 570 million (GBP 375 million) over the last ten years (Salix Finance, 2015). The company is able to recycle loan repayments into new energy efficiency investments. Between 2014-15 DECC has provided Salix with USD 83.0 million (GBP 54.6 million) of additional loan funding to improve the energy efficiency of hospitals, schools and other public sector buildings (DECC, 2013b). Salix also receives funding from Department for Education, Higher Education Funding Council for England and the Devolved Administrations.[8]

Energy efficiency supply chain

The UK energy efficiency supply chain is a large employer in its own right, and is investing significant sums in business development. The most recent report on the energy efficiency sector in the United Kingdom (BIS, 2015), which takes a narrow approach to defining the sector,[9] estimates that the energy efficiency sector[10] employed between 136 000 and 164 000 people, and had a turnover of between USD 43.3 billion (GBP 28.5 billion) and USD 48.9 billion (GBP 32.2 billion) in 2013.[11] The sector as a whole contributed GVA of between USD 15.4 billion (GBP 10.1 billion) and USD 18.1 billion (GBP 11.9 billion) to the UK economy. Among the subsectors that comprise the energy efficiency sector, insulation (which includes manufacturing and specialist retrofit installation) is the largest (Figure 14.6), with a turnover of USD 8.4 billion (GBP 5.5 billion), GVA of USD 3.0 billion (GBP 2.0 billion) and employing 36 000 people.

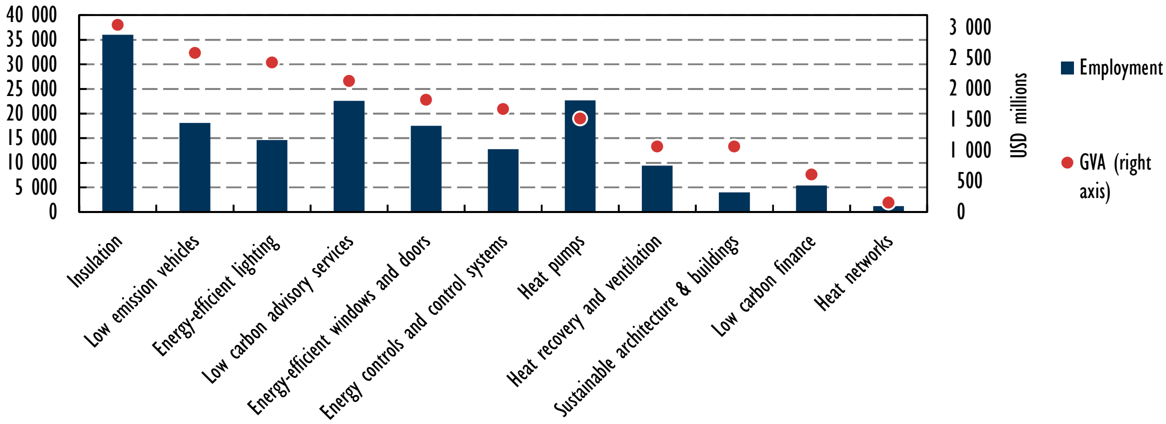
[8] Between 2014-15 DECC also co-sponsors the RE:FIT programme, providing public sector bodies with a streamlined procurement framework to assist them in making energy efficiency improvements.

[9] The report only includes in the energy efficiency products sector, those products which could demonstrate a step change in performance, thereby limiting the scope of products and technologies included. Condensing boilers and efficient white goods, for example, were excluded on this basis. In addition, the survey-based methodology used is likely to have underestimated the size of the energy efficiency sector, as only those businesses that self-identified as "active in low carbon" were included in the analysis.

[10] The energy efficiency sector comprises elements of the energy efficiency products, low carbon heat, low carbon services and low carbon vehicles subsectors identified in *The Size and Performance of the UK Low Carbon Economy* (BIS, 2015).

[11] The ranges are determined by the extent to which low carbon services are assumed to relate to energy efficiency (0-100%). Low carbon services consist of low carbon finance and low carbon advisory services.

Figure 14.6 Energy efficiency supply chain employment and GVA by subsector, 2013

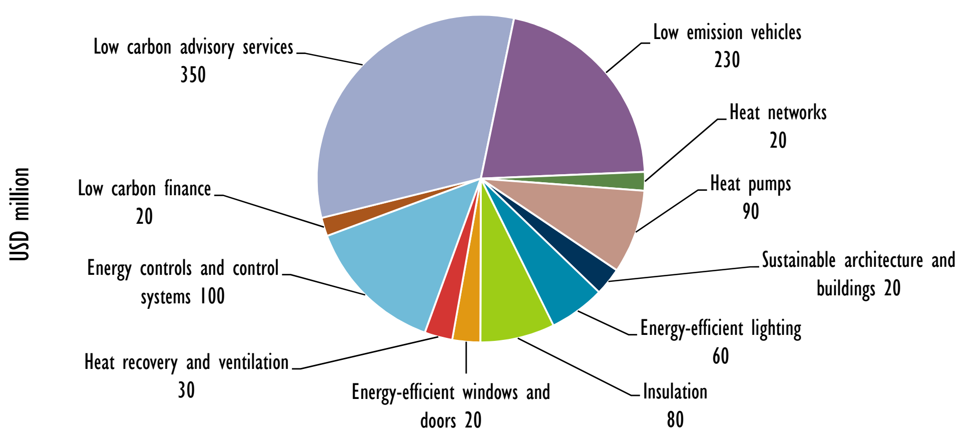


Source: BIS (Department of Business, Innovation and Skills) (2015), "The size and performance of the UK low carbon economy – report for 2010 to 2013", BIS, London.

At the aggregate level, the energy efficiency sector has seen a relatively modest expansion over the period 2010-13, with employment and GVA rising at compound annual growth rates of 0.8% and 1.1% respectively. Insulation, the largest subsector, was a significant driver of this positive trend, seeing compound annual growth rates of 3.2% in employment and 3.9% of GVA over the same period. Across the subsectors, energy-efficient lighting, low emission vehicles and sustainable architecture and buildings have the highest ratios of GVA to employment. This most likely reflects these subsectors' relatively low labour intensity and, in the case of lighting, the premium prices received by LEDs (BIS, 2015), although these are now falling.

Business investment across the 11 energy efficiency subsectors identified above is estimated to have been between USD 710 million (GBP 470 million) and USD 1.1 billion (GBP 710 million), depending on the proportion of low carbon services investment that is allocated to energy efficiency. The largest amount of investment was undertaken in the low carbon advisory services (USD 350 million), low emission vehicles (USD 230 million) and energy controls (USD 150 million) subsectors (BIS, 2015). Investments were made in a number of different areas, including capital equipment, R&D and intellectual property development (Figure 14.7).

Figure 14.7 Energy efficiency supply chain investment by UK subsector (USD millions), 2013



Source: BIS (Department of Business, Innovation and Skills) (2015), "The size and performance of the UK low carbon economy – report for 2010 to 2013", BIS, London.

Prospects for the energy efficiency market

In the medium term there is significant room for the energy efficiency market to grow. The United Kingdom has been quick to embrace energy efficiency as an important tool to support national energy security and economic objectives, adjusting relatively rapidly to its changing position as a historical energy exporter (driven in the 1960s-90s by its North Sea petroleum reserves) to a net energy importer. Energy efficiency is expected to remain a government area of focus.

The UK Energy Efficiency Strategy (DECC, 2013b) estimated that 196 TWh of TFC could be avoided in 2020 through socially cost-effective investments. The United Kingdom expects to see around 87 TWh of avoided final energy consumption in 2020 from measures qualifying to meet the European Union's Article 7 target under the Energy Efficiency Directive alone, primarily through new build and retrofits in the buildings sector, driven by building regulations and supplier obligations (European Commission, 2014). This avoided energy consumption is in addition to the impacts of UK policies in place to meet the minimum requirements of previous EU Directives.

Table 14.2 Avoided TFC by year from UK policies, TWh

	2014	2015	2016	2017	2018	2019	2020
Residential	15.6	21.8	27.6	33.7	39.8	45.4	50.8
Commercial	11.9	15.2	22.3	26.6	28.9	35.0	39.0
Transport	0.1	0.1	0.3	0.4	1.7	2.0	2.3
Total	**28**	**37**	**50**	**61**	**72**	**82**	**92**

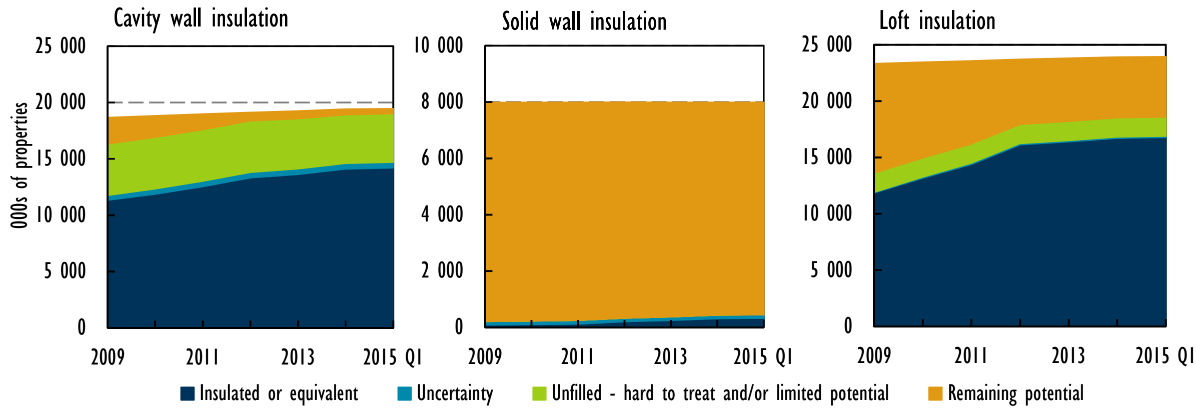
Source: European Commission (2014), "Communication of the United Kingdom's approach and analysis for complying with the requirements of Article 7 of the Energy Efficiency Directive", (revised June 2014), European Commission, Brussels.

In the energy-intensive sector, significant investment is expected to occur in addition to the action that can be attributed to policy. Recently, the United Kingdom's most energy-intensive industry sectors signed Climate Change Agreements that are expected to save 100 TWh over the period 2013-20, relative to baselines agreed with the UK government (DECC, 2013a). Outside current policy coverage, significant potential remains in the commercial (industry and services) sector, particularly among small and medium-sized enterprises; 36 TWh of electricity saving potential has been identified in 2020, primarily in lighting, space heating, low temperature processes, appliances and industrial pumps and motors (DECC, 2012b).

The United Kingdom has made significant progress in improving efficiency in the residential sector, and while significant potential remains, the nature of that potential has changed. Since 2002, the energy intensity of residential space heating has fallen by more than 30% (see Figure 2.4).[12] This has been driven in part by regulations (on gas boiler replacement and new build) and in part by the retrofitting of relatively old and inefficient housing stock, in particular the insulating of lofts and cavity walls. Over 70% of cavities and lofts are now well insulated and only 3% of cavities are both not insulated and categorised as "easy to treat" (DECC, 2015e). This equates to around 500 000 properties, which is less than the total number of cavity wall properties filled in 2012 alone. On the other hand, only 4% of the 8 million solid wall properties have had their walls insulated (Figure 14.8).

[12] IEA-18 for which comprehensive data are available: Australia, Austria, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, New Zealand, Spain, Sweden, Switzerland, United Kingdom, and United States.

Figure 14.8 Remaining potential and properties insulated in Great Britain, 2008-14



Notes: 1. Great Britain includes England, Scotland and Wales. The United Kingdom includes Great Britain and Northern Ireland. 2. "Insulated or equivalent" includes cavity wall properties with a thermal performance equivalent to having insulation. 3. "Uncertainty" refers to properties which may or may not be insulated. 4. "Unfilled – Hard to treat" includes cavity wall properties that are unfillable, or that have a timber frame wall type with both a studwork cavity and a masonry cavity (in this wall type the studwork cavity contains insulation and the masonry cavity does not contain insulation), and lofts which are unfillable (this can occur in properties with a flat roof or in properties where the roof has a very shallow pitch which makes the loft space inaccessible). 5. "Unfilled – Limited Potential" refers to cavity wall properties that are not fully insulated but are likely to have relatively good thermal performance and were built between 1983 and 1995 for England and Wales, and between 1984 and 1991 for Scotland. 6. "Remaining potential" includes some solid wall properties that would be too costly to treat or are within conservation areas. 7. Figures for 2013 and 2014 are provisional.

Source: DECC (2015d), *Private Rented Sector Energy Efficiency Regulations (Domestic)*, DECC, London.

Challenges

In the short term, the residential retrofit market is focused on the delivery of cavity wall and loft insulation installations, driven by demand from energy companies to meet their obligation cost-effectively. However in the medium term, given the diminishing number of "easy to treat" retrofitting measures available, the UK insulation market will need to adapt to a changing environment, in which effort will switch from relatively cheap cavity wall insulation to more costly solid wall insulation, which can require between 10 and 20 times more investment for similar sized properties (DECC, 2012a).[13] In the non-residential sector, while the Energy Saving Opportunities Scheme provides new investment possibilities through addressing the information barrier for companies, the overall policy landscape is complex, and demand is uncertain from those businesses for which energy represents a relatively small proportion of overall costs.

Recent changes to United Kingdom's supplier obligations and publicly funded residential energy efficiency schemes have forced the energy efficiency market to adapt. How the public programmes evolve and the private sector is motivated to expand expenditures on energy efficiency will be important factors in determining the evolution of the market over the next few years.

Conclusions

The United Kingdom's policy framework has driven significant investment in energy efficiency, most notably through the ECO, alongside the effective operation of building regulations. The United

[13] Based on the costs of insulating a typical 80 m^2 3-bed semi-detached property.

Kingdom has also implemented a number of innovative policy responses to barriers to energy efficiency investment in the buildings sector, such as the regulation of the PRS, the setting up of the GDFC and the GIB, and the Energy Saving Opportunities Scheme. The United Kingdom has through its variety of programmes (including its use of energy efficiency to address health and other social issues) emerged as a leader in developing programmes to promote energy efficiency and that exploit its benefits. The degree of continued public sector commitment to this area can be anticipated to be a major factor that will drive the size and impact of investments in this area.

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ANNEX A: GLOSSARY AND UNITS

Glossary

Activity effect

The activity effect is one of the three factors influencing TFC used in the decomposition analysis. Activity refers to the basic human or economic actions that drive energy use in a particular sector. It is measured as value-added output in the industry and services sectors, as population in the household sector, as passenger-kilometres for passenger transport, and as tonne-kilometres for freight transport.

Avoided TFC

Avoided TFC is an estimation of the amount of energy that was not consumed from energy efficiency improvements. Avoided TFC is estimated using decomposition analysis to isolate the role of energy efficiency improvements on TFC. The analysis (drawing from information in the IEA's energy efficiency indicators database) makes a hypothetical counter-factual scenario using actual changes in the economy (including GDP and its composition), population and adoption and use of energy consuming technologies, but assumes the efficiency in each sector and/or end-use did not improve from the 1990 base year. The difference between the hypothetical TFC in the counter-factual scenario and actual TFC is avoided TFC.

Avoided TPES

Avoided TPES is an estimate of the amount of primary energy not consumed; this is derived from avoided TFC. Avoided TPES is estimated by expanding electricity savings into its primary fuel inputs, taking into account the efficiency of generation.

Decomposition analysis

Decomposition analysis quantifies the impact of different driving forces or factors on TFC. Decomposition analysis in this report distinguishes among three main components affecting energy consumption: aggregate activity, sectoral structure and energy intensities. These energy intensities are used as a proxy for energy efficiency improvements – the 'efficiency effect'. See Chapter 2 for a fuller description.

Efficiency effect

The efficiency effect is one of the three factors influencing TFC in the decomposition analysis. In the IEA decomposition analysis changes in energy intensities are calculated at as disaggregated a level as possible, so that changes in energy intensities can be used as a proxy for changes in energy efficiency.

Energy efficiency (EE) adjusted TFC

EE adjusted TFC accounts for the hypothetical savings in energy consumption from energy efficiency improvements. Energy efficiency savings are added to actual TFC to demonstrate the amount of energy being avoided from efficiency to lower fuel consumption.

Energy intensity

A measure of energy use per unit of economic output (e.g. GDP or value-added); it can also refer to energy use per unit of physical output (e.g. energy use per tonne of cement produced) or activity (e.g. energy use per passenger kilometer travelled).

Energy productivity

Energy productivity is the amount of economic or other output per unit of energy consumed; it is the inverse of energy intensity.

Energy Self-Sufficiency

Energy self-sufficiency is defined as the ratio of domestic energy production to TPES (production/TPES).

Energy Self-Sufficiency - Adjusted

Adjusted energy self-sufficiency amends the energy self-sufficiency ratio to include the avoided TFC from energy savings. Adjusted energy self-sufficiency is: (production + avoided TPES)/(TPES + avoided TPES). This ratio provides the amount of energy service demand that is being met by domestic resources including energy efficiency.

Energy Service Demand

Energy service demand is a concept used to measure the purpose for which end-users consume energy. Energy is consumed to satisfy a need for services such as heating, production of goods or transportation. Energy service demands is met5 through a combination of energy supply and energy efficiency outcomes.

Energy Service Companies (ESCOs)

An entity that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in doing so. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria.

Structure Effect

Structure effect is one of the three main factors influencing TFC in the decomposition analysis. Structure represents the mix of activities within a sector, e.g. shares of production among of each subsector in industry, the changing sizes of homes in the residential sector, or the modal share of vehicles in passenger and freight transport.

Total Final Consumption (TFC)

TFC is the sum of consumption by the different end-use sectors; it excludes conversion losses from the transformation sector (power plants, oil refineries, etc.), energy industry's own energy use and other losses. TFC is broken down in energy demand in the following sectors: industry (including manufacturing and mining), transport, residential and services buildings, and other (including agriculture and non-energy use).

Total Primary Energy Supply (TPES)

TPES is the total amount of energy supplied to the energy system. Total primary energy supply is made up of primary energy production + imports – exports +/- stock changes. Stock changes reflect the difference between opening stock levels on the first day of the year and closing levels on the last day of the year of stocks on national territory. A stock build is a negative number, and a stock draw is a positive number.

Units

EJ: exajoule (10^{18} joules)
PJ: petajoule (10^{15} joules)
GJ: gigajoule (10^{9} joules)
MJ: megajoule (10^{6} joules)

Mtoe: million tonnes (megatonne) of oil equivalent
ktoe: thousand tonnes (kilotonne) of oil equivalent
toe: tonne of oil equivalent

kWh: kilowatt hour (10^{3} watt hours)
MWh: megawatt hour (10^{6} watt hours)
GWh: gigawatt hour (10^{9} watt hours)
TWh: terawatt hour (10^{12} watt hours)

Mt: megatonne (10^{6} tonnes)
Gt: gigatonne (10^{9} tonnes)

pkm: passenger kilometres
tkm: tonne kilometres

km^2: square kilometres

$GtCO_2$: Gigatonnes carbon dioxide
$ktCO_2$: kilotonnes carbon dioxide
tCO_2: tonne carbon dioxide
CO_2: carbon dioxide

NO_2: nitrogen dioxide

U: rate of heat transfer through a building element in W/mK

GBP: Great British pound
BRL: Brazilian real
EUR: Euro currency
KRW: South Korean won
MXN: Mexican peso
RUB: Russian ruble
SAR: Saudi Arabia riyal
USD: United States dollar

2005 USD PPP GDP: USD equivalent in 2005 purchasing power parity

Table A.1 General conversion factors for energy

Convert to: ***From:***	**PJ** multiply by:	**Mtoe**	**TWh**
PJ	1	41.868	3.6
Mtoe	0.0238845897	1	0.0859845228
TWh	0.27778	11.63	1

Abbreviations

2DS	2 Degree Scenario of the IEA's Energy Technology Perspectives
6DS	6 Degree Scenario of the IEA's Energy Technology Perspectives
AC	Air conditioner
ACEEE	American Council for an Energy-Efficient Economy
ADEME	Agence de l'Environnement et de la Maitrise de l'Energie (French Environment and Energy Management Agency)
ANAH	Agence nationale de l'habitat (France housing agency)
ANEEL	Brazilian Energy Regulator
ARRA	American Recovery and Reinvestment Act of 2009
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BCAP	Building Codes Assistance Project
BNDES	Brazilian Economic and Social Development Bank
BREEAM	Building Research Establishment Environmental Assessment Methodology
BRP	Building Retrofit Project - Seoul
C40	Cities 40, network of large cities
CAFE	Corporate Average Fuel Economy
CERT	Carbon Emissions Reduction Target – United Kingdom
CERO	Carbon Emissions Reduction Obligation – United Kingdom
CESP	Community Energy Saving Programme – United Kingdom
CDG	Paris-Charles de Gaulle airport
CDM	Clean Development Mechanism
CEE	Certificat d'économies d'énergie (France)
CFL	Compact-fluorescent lamps
CONUEE	National Commission for the Efficient Use of Energy (Comisión Nacional para el Uso Eficiente de la Energía)
COP	Conferences of the Parties (UNFCCC climate change conferences)
CPCU	Compagnie Parisienne de Chauffage Urbain (Paris Urban Heating Company)
CPI	Consumer price index
CRT	Cathode-ray tube
DOER	Massachusetts Department of Energy Resources
ECO	Energy company obligation – United Kingdom
EEGM	Energy Efficiency Guarantee Mechanism
EEI	Energy efficiency indicators database
EEMR	Energy Efficiency Market Report
EEO	Energy efficiency obligation
EEP	Energy Efficiency Plan – Saudi Arabia
EPBD	Energy Performance of Buildings Directive
EPC	Energy performance certificate

EPE	Energy Research Agency - Brazil
ESCO	Energy service company
ETP	Energy Technology Perspectives
ESPC	Energy savings performance contract
EU	European Union
EV	Electric vehicle
FIDE	Trust Fund for Electricity Savings - Mexico
FNDCT	National Fund for Scientific and Technological Development - Brazil
FSE	Sustainable Energy Fund (Fondo de Sustentabilidad Energética)
GDF	Green Deal Finance – United Kingdom
GDFC	Green Deal Finance Corporation – United Kingdom
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GIB	Green Investment Bank – United Kingdom
GVA	Gross value added
HVAC	Heating, ventilation and air conditioning
HDV	Heavy-duty vehicle
ICC	International Code Council
ICT	Information and computing technologies
IDB	Inter-America Development Bank
IDF	Île-de-France
IEA	International Energy Agency
IECC	International Energy Conservation Code
INDC	Intended Nationally Determined Contribution
IoT	Internet of things
ISIC	International Standard Industrial Classification
KfW	Kreditanstalt für Wiederaufbau (German government-owned development bank)
LAERFTE	Law for Renewable Energy Use and Energy Transition Financing (Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética)
LASE	Law for the Sustainable Use of Energy (Ley para el Aprovechamiento Sustentable de la Energía – LASE)
LDV	Light-duty vehicle
LED	Light-emitting diode
LEED	Leadership in Energy and Environmental Design
LNG	Liquefied natural gas
LPG	Liquid petroleum gas
MassCEC	Massachusetts Clean Energy Center
MGP	Métropole du Grand Paris
MEPS	Minimum energy performance standards
MME	Ministry of Mines and Energy – Brazil
NAFIN	Mexican National Development Bank (Nacional Financiera)
NEEAP	National Energy Efficiency Municipal Public Lighting Project (Projecto Nacional de Eficiencia Energética en Alumbrado Público)
NEEP	National Energy Efficiency Programme – Saudi Arabia

OECD	Organisation for Economic Co-operation and Development
PAEEM	Programme for Energy Efficiency and Savings in Enterprises (Programa de Ahorro y Eficiencia Energética Empresarial)
PAESE	Programme of Energy Savings in the Electricity Sector (Programa de Ahorro de Energía del Sector Eléctrico)
PDE	Ten-Year Energy Expansion Plan – Brazil
PEE	Energy Efficiency Programme – Brazil
PM	Particulate matter
PNE	National Energy Plan – Brazil
PPP	Purchasing power parity
PROCEL	National Electricity Conservation Programme – Brazil
PRONASE	National Programme for Sustainable Energy Use (Programa Nacional para el Aprovechamiento Sustentable de la Energía)
PRS	Private rented sector
RATP	Régie Autonome des Transports Parisiens
RDD&D	Research, development, demonstration and deployment
RGR	Global Reversion Reserve – Brazil
SDG&E	San Diego Gas and Electric
SE4ALL	UN Sustainable Energy for All
SEEC	Saudi Energy Efficiency Center
SENER	Ministry of Energy (Secretaría de Energía)
SHF	Federal Mortgage Society (Sociedad Hipotecaria Federal)
SME	Small and medium-sized enterprises
SMG	Seoul Metropolitan Government
STB	Set top box
STIF	Île-de-France Transport Union
SUC	Dalkia-owned Société Urbaine de Climatisation
T&D	Transmission and distribution
TFC	Total final consumption
TMG	Tokyo Metropolitan Government
TPES	Total primary energy supply
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	UN Framework Convention on Climate Change
US DoD	United States Department of Defense
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
ZEB	Zero energy building

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ENERGY EFFICIENCY
Market Report 2015

Energy efficiency improvements over the last 25 years saved a cumulative USD 5.7 trillion in energy expenditures. This virtual supply of energy generates multiple benefits for governments, businesses and households, including greater energy security from reduced dependence on energy imports and billions of tonnes of greenhouse gas emissions reductions.

Strengthening our understanding of the energy efficiency market and the prospects over the medium term is becoming increasingly important. The 2015 *Energy Efficiency Market Report* (*EEMR*) evaluates the impact of energy efficiency in the energy system and assesses the scale and outlook for further energy efficiency investment using detailed country-by-country energy efficiency indicator data and IEA expertise.

This year's report includes an in-depth look into the buildings energy efficiency market and the electricity sector. Energy efficiency investments in the buildings sector totalled between USD 90 billion in 2014. In the electricity sector, energy efficiency has proved critical in flattening electricity consumption in Organisation for Economic Co-operation and Development member countries, driving utilities to adapt their business models.

Promoting and expanding energy efficiency markets is a worldwide phenomenon, and *EEMR 2015* presents a number of case studies at the national, state and municipal level. These include examinations of Latin America's two largest economies, Brazil and Mexico, which are looking to efficiency to boost productivity and social development. Energy-exporting countries like Saudi Arabia and the Russian Federation are also increasingly turning to efficiency to increase exports and reduce the costs of growing domestic energy consumption. In addition to national governments, major urban areas such as Tokyo, Seoul and Paris are increasingly enabling energy efficiency investment.

Market Trends and Medium-Term Prospects