

ENERGY EFFICIENCY Market Report 2014



Market Trends and Medium-Term Prospects

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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:

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International Energy Agency

9 rue de la Fédération
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FOREWORD

The weight of evidence is increasingly difficult to ignore: energy efficiency has played, and continues to play, a sizeable role in the development of the global economy. The avoided energy demand from the long-term improvement in the energy efficiency of energy-using stock is larger than the total final consumption of any one fuel. In an age of increasing energy prices, and greater shares of income spent on energy, energy efficiency is a critical response. In seeking to understand the market dynamics that are achieving energy efficiency improvements, the International Energy Agency (IEA) recognises that energy efficiency is increasingly becoming a commodity for all types of energy consumers and producers.

Building on last year's inaugural report, the *IEA Energy Efficiency Market Report 2014* goes further in evaluating the global energy efficiency market to understand the role of energy efficiency in shaping the energy system. We estimate that the market is very large, between USD 310 billion and USD 360 billion in 2011, and is expected to grow. We introduce six methods to evaluate the size of the market, which all confirm the magnitude of the market estimated in the *Energy Efficiency Market Report 2013* at USD 300 billion.

In addition to estimating the size of the market, this report uses the IEA energy efficiency indicators database to systematically track, evaluate and report on energy efficiency developments between jurisdictions and over time, with the aim of helping policy makers to evaluate progress and market actors to identify opportunities. This year's report builds on the indicators used last year to show progress on energy efficiency for all major energy-consuming sectors. It also adopts a new methodology to decompose the role of efficiency on energy demand for 18 IEA member countries that have comparable data. The results are compelling: efficiency has had an important role in moderating energy demand over the past decade.

Also new this year, the report evaluates developments in financial markets, where energy efficiency is establishing itself as an important segment with an increasing array of products and financiers. Efficiency is a priority area of interest for development and green banks. Commercial banks act as multipliers of public finance, and are also the largest lenders on their own account. The financial sector is starting to perform an aggregation and securitisation role, and energy service companies are delivering energy efficiency using a range of new business models. The barriers to energy efficiency finance were being lowered almost in real time during the production of this report. Transparency and reporting will be important for investor confidence, and policy makers can support energy efficiency finance by encouraging the development of appropriate standards and principles.

The report also looks at the transport sector, where market investment is being driven by stricter fuel economy standards for passenger vehicles, and more recently for freight. This is being complemented by investment in other modes, such as urban rail transport, with the resulting modal shift generating important changes in the efficiency of the transport sector.

We have long known that energy efficiency has been an important but mostly invisible component of the energy system. As the global energy system undergoes continued and significant change, from the economic development of huge emerging markets to the imperative of decarbonising global energy supply, energy efficiency will continue to be a key lever. This report is a further contribution to a better understanding of its current position in the energy system, and what its role can be in the future.

This report is published under my authority as Executive Director of the IEA.

Maria van der Hoeven

Executive Director

International Energy Agency

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TABLE OF CONTENTS

Foreword	3
Acknowledgements.....	4
Executive summary	16
Part 1. The market for energy efficiency.....	23
1. Towards a better estimation of the global energy efficiency market.....	24
Summary	24
<i>Energy Efficiency Market Report 2014: Approach to evaluating the energy efficiency market</i>	24
Savings generated by energy efficiency: The market's output	25
Energy efficiency: Still the first fuel.....	26
Estimating investment in the energy efficiency market	28
Method 1: Estimate using gross capital formation	29
Method 2: Estimate based on changes in energy intensity	30
Method 3: Estimate based on the Long-term Industrial Energy Forecast (LIEF) model	31
Method 4: Estimate based on a Monte Carlo simulation	31
Method 5: Estimate based on leveraging	32
Method 6: Estimate based on the <i>World Energy Investment Outlook</i>	33
Conclusion: Towards improved market valuations.....	33
References.....	34
2. What the numbers say: Tracking energy efficiency progress	35
Summary	35
Introduction: The role of indicators in supporting our analysis of the energy efficiency market	35
Global trends: Energy intensity continues to decline	37
The energy intensity improvements necessary to achieve IEA scenarios.....	38
Energy efficiency: Metrics to isolate the impact of efficiency indicators	39
The energy efficiency effect in 18 IEA member countries	41
Energy efficiency patterns for individual consumers.....	44
Disaggregating and decomposing residential energy use.....	44
Energy efficiency indicators for passenger transport energy use.....	48
Energy efficiency's impact on affordability of energy services for individual consumers	50
Energy efficiency patterns of business and public services	52
Disaggregating and decomposing energy use in freight transport.....	52
Industry and services.....	53
Conclusion	56
References.....	57
3. The market for energy efficiency in transport: A focus on the land-based Sub-sector.....	59
Summary	59
Introduction.....	60

Improving energy efficiency in transport: The “avoid, shift and improve” paradigm	60
How energy efficiency investments relate to avoid, shift and improve outcomes	62
Market actions that improve vehicle efficiency.....	62
Market actions to promote a shift for efficiency improvements.....	62
Market actions to avoid passenger travel.....	63
The transport market: Overall context and drivers for efficiency	63
Demand for transport	63
Transport sector expenditure	64
Drivers for improving energy efficiency in transport	65
Improving energy efficiency of passenger vehicles: Trends and market developments.....	67
Trends in passenger transport	67
Trends in passenger transport efficiency	67
Driving energy efficiency for passenger LDVs: The pre-eminent role of fuel economy standards..	70
The energy efficiency market for passenger vehicles	71
Improving the energy efficiency of freight vehicles: Trends and market developments.....	74
Trends in land-based freight efficiency.....	74
Fuel cost: A key driver for energy efficiency in freight.....	76
Energy efficiency standards for HDVs: An emerging tool	77
Ways to improve energy efficiency in freight	77
Shift: The impact of modal investments on energy efficiency.....	78
Trends in transport infrastructure investment and impact on modal share	78
The <i>shift</i> market: Levels and benefits of investment in efficiency infrastructure	81
Conclusions: Medium-term prospects for efficiency markets in transport.....	82
References.....	82
4. Energy efficiency finance	86
Summary	86
Introduction.....	86
Public finance	88
Public finance institution initiatives: Financing domestic investments	89
Development finance: Cross-border investment financings.....	92
International climate finance	96
Carbon finance	97
Private finance.....	99
Commercial banks.....	99
Institutional investors.....	101
Rio+20: Private sector Voluntary Commitments on energy efficiency.....	101
Selected financing structures, techniques and intermediaries.....	102
EPC and ESCOs.....	102
Bonds: Green and other	104
On-bill financing: PACE and other programmes.....	107
Conclusions and prospects.....	108
References.....	109

Part 2. Country energy efficiency market profiles.....	113
Introduction	114
5. Canada	115
Energy profile and context	115
Energy efficiency market activity	117
Market driver: Energy efficiency policies and programmes	117
Current energy efficiency market activity	119
Prospects for energy efficiency market activity	121
Challenges	123
Conclusions.....	123
References.....	124
6. China	125
Energy profile and context	125
Energy efficiency market activity	127
Market supply: Potential for energy savings.....	127
Market driver: Energy efficiency policies and programmes	128
Current energy efficiency market activity	130
Prospects for energy efficiency market activity	132
Challenges	133
Conclusions.....	133
References.....	133
7. European Union	135
Energy profile and context	135
Energy efficiency market activity	136
Market drivers: Energy efficiency policies and programmes	136
Current energy efficiency market activity	138
Prospects for energy efficiency market activity	143
Challenges	143
Conclusions.....	143
References.....	143
8. India	145
Energy profile and context	145
Energy efficiency market activity	147
Market driver: Energy efficiency policies and programmes	147
Current energy efficiency market activity: Focus on lighting.....	148
Prospects for energy efficiency market activity	148
Challenges	150
Conclusions.....	150
References.....	150

9. Indonesia	151
Energy profile and context	151
Energy efficiency market activity	153
Market supply: Potential for energy savings.....	153
Market driver: Energy efficiency policies, programmes and prices	153
Energy efficiency market activity and prospects	154
Challenges	156
Conclusions.....	156
References.....	156
10. Ireland.....	157
Energy profile and context	157
Market variable: End-use energy prices.....	159
Energy efficiency market activity	159
Market supply: Potential for avoided energy use	159
Market driver: Energy efficiency policies and programmes	160
Current energy efficiency market activity.....	161
Prospective energy efficiency market activity	164
Challenges	164
Conclusions.....	165
References.....	165
11. Italy.....	166
Energy profile and context	166
Energy efficiency market activity	168
Market driver: Energy efficiency policies, programmes and investments.....	168
Current energy efficiency market activity.....	169
Prospective energy efficiency market activity	171
Challenges	172
Conclusions.....	172
References.....	173
12. Japan.....	174
Energy profile and context	174
Energy efficiency market activity	176
Market supply: Potential for energy savings.....	176
Market driver: Energy efficiency policies and programmes	177
Market activity	178
Prospects for efficient lighting	180
Prospects in other areas.....	180
Challenges	180
Conclusions.....	181
References.....	181

13. Korea	183
Energy profile and context	183
Energy efficiency market activity	185
Market supply: Potential for avoided energy use	185
Market driver: Energy efficiency policies and programmes	185
Current energy efficiency market activity	186
Challenges	187
Conclusions.....	188
References.....	188
14. The Netherlands	189
Energy profile and context	189
Market variable: End-use energy prices.....	191
Energy efficiency market activity	192
Market supply: Potential for energy savings.....	192
Market driver: Energy efficiency policies and programmes	192
Current energy efficiency market activity.....	193
Prospective energy efficiency market activity	195
Challenges	195
Conclusions.....	196
References.....	196
15. Thailand	198
Energy profile and context	198
Energy efficiency market activity	200
Market supply: Potential for energy savings.....	200
Market driver: Energy efficiency policies and programmes	200
Market activity	202
Prospective energy efficiency market activity	204
Challenges	205
Conclusions.....	205
References.....	206
Part 3. Annex and list of acronyms	207
Annex: Energy use and intensity data	208
List of acronyms	213
LIST OF FIGURES	
Figure ES.1 Energy efficiency savings compared to TFC in selected regions and countries, 2011	17
Figure ES.2 Changes in aggregate TFC relative to 2001 levels decomposed by factors for 18 IEA member countries, 2001-11	17
Figure ES.3 Hypothetical energy consumption without energy efficiency and cumulative savings from energy efficiency improvements for a set of 18 IEA member countries, 2001-11 ..	18

Figure ES.4	Decomposition of TFC between 2001 and 2011 for 18 IEA member countries relative to 2001 levels	18
Figure ES.5	Increase in the weighted price of one unit of energy for individual consumers in 18 IEA member countries, 2001-11.....	19
Figure 1.1	Energy savings from energy efficiency and energy consumption by energy source in 11 IEA member countries, 1973-2011.....	26
Figure 1.2	Energy savings relative to other fuel and electricity consumption in 11 IEA member countries, 2011	27
Figure 1.3	Energy efficiency savings compared to TFC in selected regions and countries, 2011	28
Figure 1.4	Global demand for energy services and energy supply, 2011-12	31
Figure 1.5	Frequency distribution of Monte Carlo estimates of energy efficiency market	32
Figure 2.1	Energy intensity (TPES per GDP) by region, 2002-13	37
Figure 2.2	Increase in energy productivity (GDP per TPES) by region, 1975 to 2012	38
Figure 2.3	Relationship of TPES to its key drivers (population, energy intensity and per capita GDP) at a global level, and scenarios to 2030	39
Figure 2.4	Changes in aggregate TFC relative to 2001 levels decomposed by factors for 18 IEA member countries, 2001-11	42
Figure 2.5	Hypothetical energy use without efficiency and cumulative energy savings from energy efficiency for 18 IEA member countries	42
Figure 2.6	Energy expenditure savings from efficiency improvements in Australia.....	43
Figure 2.7	Decomposition of TFC between 2001 and 2011 for 18 IEA member countries relative to 2001 levels	44
Figure 2.8	Change in energy intensity of residential space heating as a function of floor area, 2001-11...	45
Figure 2.9	Change in energy intensity of residential water heating as a function of occupied dwellings, 2001-11.....	46
Figure 2.10	Change in energy intensity of residential lighting as a function of residential floor area, 2001-11	46
Figure 2.11	Change in energy intensity of large household appliances as a function of appliance stocks, 2001-11.....	47
Figure 2.12	Changes in aggregate residential energy consumption relative to 2001 decomposed by factors for 18 IEA member countries, 2001-11	48
Figure 2.13	Changes in national residential energy consumption relative to 2001 decomposed by factors for selected IEA member countries, 2001-11.....	48
Figure 2.14	Change in energy intensity of passenger transport, 2001-11.....	49
Figure 2.15	Changes in aggregate passenger transport energy consumption relative to 2001 decomposed by factors for 18 IEA member countries, 2001-11	49
Figure 2.16	Changes in national passenger transport energy consumption relative to 2001 for selected IEA member countries, 2001-11	50
Figure 2.17	Increase in the weighted price of one unit of energy for individual consumers in 18 IEA member countries, 2001-11.....	51
Figure 2.18	Share of disposable income that is spent on energy, 2001-11	51
Figure 2.19	Changes in aggregate freight energy consumption relative to 2001 decomposed by factors for 18 IEA member countries, 2001-11	52
Figure 2.20	Change in energy intensity of freight transport as a function of tonne-kilometres, 2001-11....	53
Figure 2.21	Decomposition of change in national freight transport energy consumption relative to 2001 of selected IEA member countries, 2001-11	53

Figure 2.22	Change in national manufacturing, commercial and public services energy consumption among selected IEA member countries, 2001-11	54
Figure 2.23	Change in energy intensity of manufacturing as a function of value added among selected IEA member countries, 2001-11	54
Figure 2.24	Change in energy intensity of services as a function of value added, 2001-11	55
Figure 2.25	Relative energy intensities of the manufacturing and services sectors in relation to value added	56
Figure 2.26	Change in the relative shares of manufacturing and services contributions to value added, 2001-11	56
Figure 3.1	Transport energy use in OECD member countries and OECD non-member economies, 2002-12	63
Figure 3.2	Current and estimated passenger and freight transport in OECD member countries and OECD non-member economies	64
Figure 3.3	Estimated global expenditure on the transport system, 2000-20	65
Figure 3.4	Oil expenditure on transport.....	66
Figure 3.5	Actual and estimated energy use for land-based passenger transport by mode in OECD member countries and OECD non-member economies	67
Figure 3.6	New vehicle registrations and vehicle efficiencies by vehicle size	68
Figure 3.7	LDV fuel consumption intensity for passenger transport in the United States	69
Figure 3.8	Enacted LDV fuel economy standards.....	70
Figure 3.9	LDV sales in 2011 and average vehicle efficiency of new vehicles by model year	72
Figure 3.10	Example of incremental costs by cumulative energy efficiency improvement for gasoline-powered ICE personal vehicles	72
Figure 3.11	Fuel cost comparison of switching from ICE to BEV cars	73
Figure 3.12	Estimated inland freight energy use and share of total transport energy use, 2010-20 ..	75
Figure 3.13	Average energy use per tkm, 2000-20	76
Figure 3.14	Tested fuel efficiency of HDVs in the European Union	76
Figure 3.15	Example of incremental costs and fuel efficiency improvements to an HDV	77
Figure 3.16	Global average energy use per pkm or tkm by mode, 2010	78
Figure 3.17	Paved road kilometres by region	78
Figure 3.18	Energy consumption of passenger transport by share of foot, bicycle and public transport..	80
Figure 3.19	Annual expenditure on transport infrastructure by mode	81
Figure 4.1	KfW Development Bank commitments to energy efficiency and renewable energy, 2009-13	93
Figure 4.2	Share of development finance for energy efficiency by region by value, 2008-11	95
Figure 4.3	Share of CERs expected from regular CDM projects until 2012 by sector	98
Figure 4.4	Number of private Rio+20 Voluntary Commitments by category and by type of actors involved	102
Figure 5.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12..	115
Figure 5.2	TFC by sector, 2012	116
Figure 5.3	TFC by sector and by energy source, 2002 and 2012.....	116
Figure 5.4	Decomposition of Canadian energy use.....	117
Figure 5.5	Energy per capita and energy intensity in Canada by province	118
Figure 5.6	Total and per capita energy efficiency spending by province, 2010.....	119
Figure 5.7	Estimated costs per unit of delivered energy for new resource types in British Columbia ..	120
Figure 5.8	Sales from electricity exports and number of utility-led DSM programmes	121

Figure 5.9	Federal building code adoption by province in Canada	122
Figure 6.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita in China, 2002-12	125
Figure 6.2	TPES, TFC and electricity consumption in China, 2001-12	126
Figure 6.3	TFC by sector in China, 2012	126
Figure 6.4	TFC by sector in China, 2012	126
Figure 6.5	TFC in China by sector and by energy source, 2002 and 2012.....	127
Figure 6.6	TFC in China by sector and by energy source, 2002 and 2012.....	127
Figure 6.7	China's energy efficiency investment by sector	131
Figure 7.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12..	135
Figure 7.2	TFC by sector and by energy source, 2002 and 2012.....	136
Figure 7.3	Energy intensity in the European Union and in selected IEA member countries, 1990-2012...	136
Figure 7.4	Share of refrigerator sales in 2005 (left) and 2010 (right) with energy class equal to or greater than A+	138
Figure 7.5	Share of efficient cars (less than 130 g CO ₂ /km) in total sales, 2005 (left) and 2012 (right) ..	138
Figure 7.6	Public investment in energy efficiency by share of GDP for selected member states ...	139
Figure 7.7	Lifetime energy savings achieved by energy efficiency improvements per EUR spent..	140
Figure 7.8	Number of EIB-ELENA PDA facilities by country and by project type, 2010-14.....	142
Figure 8.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12..	145
Figure 8.2	TFC by sector, 2012	146
Figure 8.3	TFC by sector and by energy source, 2002 and 2012.....	146
Figure 9.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12..	151
Figure 9.2	TFC by sector, 2012	152
Figure 9.3	Share of TFC by sector by source, 2002 and 2012	152
Figure 10.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13..	157
Figure 10.2	TFC by sector, 2012	158
Figure 10.3	TFC by sector and by energy source, 2002 and 2012.....	159
Figure 10.4	Decomposition of energy consumption in Ireland.....	159
Figure 10.5	Energy and carbon dioxide savings and target trajectory to Ireland's 20% energy savings target for 2020	160
Figure 10.6	Number of homes receiving energy efficiency measures by scheme, 2009-13	162
Figure 11.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13..	166
Figure 11.2	TFC by sector, 2012	167
Figure 11.3	TFC by sector and by energy source, 2002 and 2012.....	167
Figure 11.4	Imports as share of Italian energy consumption	168
Figure 11.5	Decomposition of energy use in Italy.....	168
Figure 11.6	Principal instruments and achieved/expected energy savings.....	171
Figure 11.7	Expected savings by end-use sector.....	171
Figure 12.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13..	174
Figure 12.2	TFC by sector, 2012	175
Figure 12.3	TFC by sector and by energy source, 2002 and 2012.....	175
Figure 12.4	Decomposition of energy demand in Japan.....	176
Figure 12.5	Lighting fixtures market in Japan, 2007-12	179
Figure 12.6	Size of LED lighting fixtures market.....	179
Figure 12.7	Quantity of LED luminaires sold	179
Figure 13.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13..	184

Figure 13.2	TFC by sector, 2012	184
Figure 13.3	TFC by sector and by energy source, 2002 and 2012.....	184
Figure 13.4	Energy demand and targets, 2010-35.....	186
Figure 14.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13..	190
Figure 14.2	TFC by sector, 2012	190
Figure 14.3	TFC by sector and by energy source, 2002 and 2012.....	191
Figure 14.4	Decomposition of Dutch energy consumption	191
Figure 15.1	TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12..	199
Figure 15.2	TFC by sector, 2012	199
Figure 15.3	TFC by sector and by energy source, 2002 and 2012.....	199
Figure 15.4	Share of energy savings potential by sector to 2030	200
Figure 15.5	LED sales in Thailand	204
Figure 15.6	Lighting sales in Thailand	204

LIST OF TABLES

Table 1.1	Total market size of selected energy-using stock	30
Table 1.2	Key 2012 values: GDP, TPES and energy intensity	30
Table 1.3	Range of magnitudes in energy efficiency investment from Monte Carlo simulation	32
Table 2.1	Variables and metrics used for sectoral indicators in the decomposition analysis	40
Table 3.1	Average fuel economy and improvement rates of personal vehicles, 2005-11	68
Table 4.1	Domestic energy efficiency investment and share of total investment by selected public finance institutions, 2010-13.....	89
Table 4.2	MDBs' energy efficiency investment, 2011 and annual average 2008-11 (USD million)...	95
Table 4.3	EPC market size in selected countries, 2013 or latest available	103
Table 5.1	Number of Canadian electric utility energy efficiency programmes by improvement type and policy instrument.....	120
Table 6.1	China's passenger VFE standards (litres/100 kilometres)	129
Table 6.2	Overview of China's energy efficiency investment	130
Table 7.1	EIB funding to EU efficiency projects, 2008-11 (EUR million)	142
Table 8.1	Overview of key energy efficiency policies in India	147
Table 8.2	Sale of lamps by technology.....	148
Table 9.1	Indonesia's energy savings potential by sector.....	153
Table 9.2	Products with standards and labels under development in Indonesia.....	154
Table 10.1	Overview of key government-led energy efficiency investments, 2014.....	164
Table 11.1	Italian energy efficiency policies and measures and their cost-effectiveness, 2005-12..	169
Table 12.1	Number of lamps used in Japan by technology, sector and related electricity consumption (billion), 2011	177
Table 12.2	Electricity savings potential in the lighting sector	177
Table 12.3	Cost and payback periods for replacing different lamp types with LED lamps.....	177
Table 13.1	Demand projection of TFC, 2011 to 2035 (Mtoe)	185
Table 13.2	Energy savings in three BEMS pilot projects (toe)	187
Table 14.1	Estimated energy savings from Energy Agreement measures.....	192
Table 14.2	Summary of government-led investments in energy efficiency market (EUR million)....	193
Table 14.3	Key figures and developments in the EIA.....	194
Table 15.1	Planned distribution of funding per type of activity	201

Table 15.2	Planned distribution of funding per sector (based on the indicated share of primary energy savings target)	201
Table A.1	Total primary energy supply (TPES) by country (Mtoe)	208
Table A.2	Total final consumption (TFC) by country (Mtoe)	209
Table A.3	TPES/GDP PPP by country (toe per thousand 2005 USD)	210
Table A.4	TPES/population by country (toe per capita)	211
Table A.5	Electricity consumption by country (Mtoe)	212

LIST OF BOXES

Box 1.1	The data challenge for energy efficiency	25
Box 1.2	Identifying energy efficiency improvements: The decomposition analysis	26
Box 1.3	Counting multiple benefits	27
Box 1.4	Autonomous versus motivated energy efficiency adoption	29
Box 1.5	The “energy efficiency premium”: Uses and limitations	33
Box 2.1	Chapter structure and differences compared to the <i>EEMR 2013</i>	36
Box 2.2	Regional improvements in energy productivity	38
Box 2.3	What is decomposition analysis?	40
Box 2.4	Energy efficiency reducing energy expenditure in Australia	43
Box 2.5	Residential energy efficiency improvements in selected European countries	45
Box 3.1	Land-based transport: The largest component of the transport system	60
Box 3.2	Examples of avoid, shift and improve	61
Box 3.3	Energy efficiency of the transport system	61
Box 3.4	Industrial capacity investment for energy-efficient vehicles	62
Box 3.5	Lowering fuel intensity trends in the United States, 1984-2011	69
Box 3.6	The Global Fuel Economy Initiative and “50by50” campaign	71
Box 3.7	EV adoption and efficiency	73
Box 3.8	Net benefits of vehicle efficiency in <i>Energy Technology Perspectives</i>	74
Box 3.9	The growing market for cycling infrastructure	80
Box 3.10	<i>Shift and avoid</i> policies: An important part of achieving the efficiencies of the 2DS	81
Box 4.1	Diverse roles for the public sector	88
Box 4.2	De-risking private investments through public sector instruments	89
Box 4.3	Constraints on the supply of energy efficiency finance	100
Box 4.4	Standards and voluntary principles for bonds	106
Box 4.5	Securitisation of PACE loans	107
Box 5.1	Long-Term Energy Plan of the government of Ontario	118
Box 6.1	Air pollution reduction requirements	129
Box 6.2	China’s growing energy service industry	131
Box 8.1	Indian Energy Efficiency Services Limited (EESL)	149
Box 8.2	DELP roll-out in Puducherry	149
Box 10.1	Energy Performance Certificates in Ireland	161
Box 10.2	The Green International Financial Services Centre	163

EXECUTIVE SUMMARY

The *Energy Efficiency Market Report 2014 (EEMR 2014)* estimates that investment in energy efficiency markets worldwide in 2012 was between USD 310 billion and USD 360 billion. Investment in energy efficiency was larger than supply-side investment in renewable electricity or in coal, oil and gas electricity generation, and around half the size of upstream oil and gas investment. Investment in energy efficiency is distributed unevenly across countries and energy-consuming sectors (buildings, domestic appliances, transport and industry).

EEMR 2014 highlights

- In 2011, energy savings from continued improvement in the energy efficiency of 11 IEA member countries equalled 1 337 million tonnes of oil-equivalent (Mtoe). This level exceeded the total final consumption (TFC) from any single fuel source in these countries, and was larger than the total 2011 TFC for the European Union from all energy sources combined. Energy efficiency savings in 11 IEA member countries were effectively displacing a continent's energy demand.¹
- Energy efficiency finance is expanding and innovating, with new funding approaches and business models; there is a notable expansion in funding for development aid projects, as well as in the use of funding vehicles such as energy service companies (ESCOs) and on-bill financing mechanisms.
- Vehicle fuel economy standards now cover 70% of the global passenger light-duty vehicle (LDV) market and will drive the market for more energy-efficient vehicles in the next five years. New standards are estimated to lead to energy efficiency investments of USD 80 billion annually out to 2020 and will save between USD 40 billion and USD 190 billion in fuel costs.
- The market potential for energy efficiency is growing significantly in OECD non-member economies. This is pronounced in the transport sector, where passenger travel is estimated to increase by 90% by 2020 from 2011 levels.

Confirming energy efficiency's place as the "first fuel"

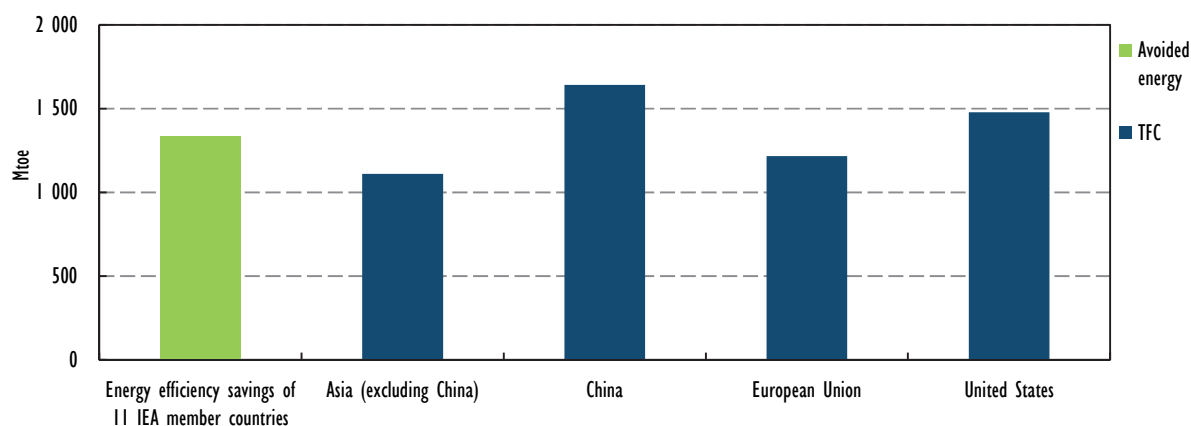
Energy efficiency markets deliver goods and services that reduce the energy required to fuel our economies. Energy efficiency improvements since the 1970s in 11 IEA member countries saved 56 exajoules (EJ) or 1 337 Mtoe in 2011. Avoided energy use was larger than the supply of oil (1 202 Mtoe), electricity (552 Mtoe) or natural gas (509 Mtoe) in 2011; these savings equate to 59% of TFC in the 11 IEA member countries that year. In monetary terms, 56 EJ has a value of USD 743 billion (given an average global price of energy at USD 13.96 per gigajoule [GJ]).²

Energy savings equate to the entire fuel consumption of the European Union

Energy efficiency savings of 1 337 Mtoe in 2011 in these 11 IEA member countries were larger than the combined TFC of the European Union or of Asia, excluding China. These efficiency savings were equal to 80% of TFC in China and 87% of TFC in the United States for that same year.

¹ The 11 countries evaluated are Australia, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Sweden, the United Kingdom and the United States.

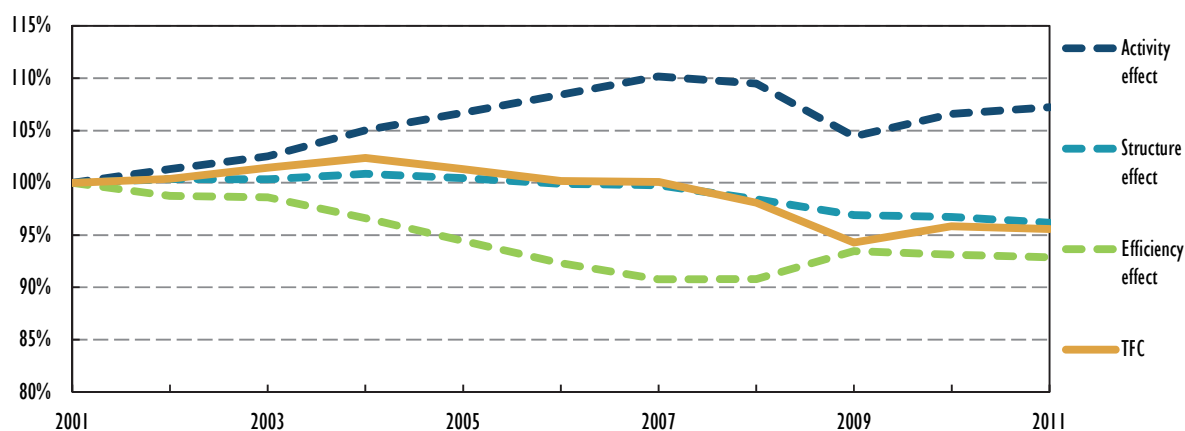
² This assessment draws on a published estimate of 2010 world energy expenditure as USD 6 billion (in constant 2005 USD expressed in purchasing power parity [PPP]). Using IEA energy price data, the calculation converts that 2010 value into 2012 price equivalents, and divides by total primary energy consumption. This generates an average 2012 price of USD 13.96 per GJ. For further information, see Part 1, Chapter 1.

Figure ES.1 Energy efficiency savings compared to TFC in selected regions and countries, 2011

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

What do indicators tell us?

This year's report expands the decomposition of energy demand to 18 IEA member countries (accounting for more than 83% of TFC in OECD member countries and 33% of global TFC). The decomposition finds that energy efficiency had a downward impact on TFC between 2001 and 2011 (Figure ES.2).³ Among the countries analysed, energy demand reduced by 5% between 2001 and 2011. Energy efficiency was the most important factor in this reduction.

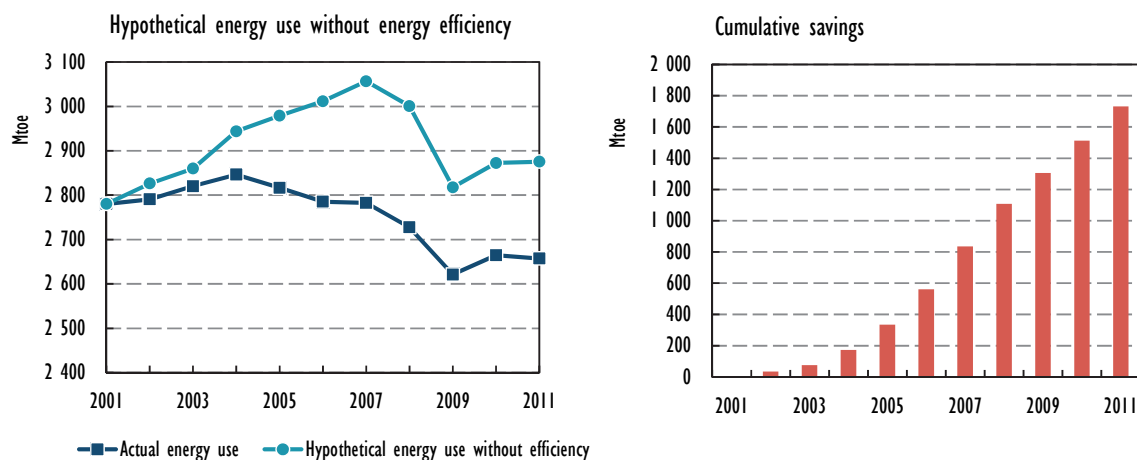
Figure ES.2 Changes in aggregate TFC relative to 2001 levels decomposed by factors for 18 IEA member countries, 2001-11

Notes: Countries comprise Australia, Austria, Canada, Czech Republic, Denmark, France, Finland, Germany, Italy, Japan, Korea, the Netherlands, New Zealand, Spain, Sweden, Switzerland, the United Kingdom and the United States. All values are indexed to 2001 levels.

If there had been no efficiency gains since 2001, TFC in 2011 would have been 218 Mtoe (9 EJ) higher (Figure ES.3). Energy efficiency has consistently reduced annual energy consumption over the past decade. The cumulative savings from efficiency improvements between 2001 and 2011 in these 18 countries was 1 731 Mtoe (72 EJ).

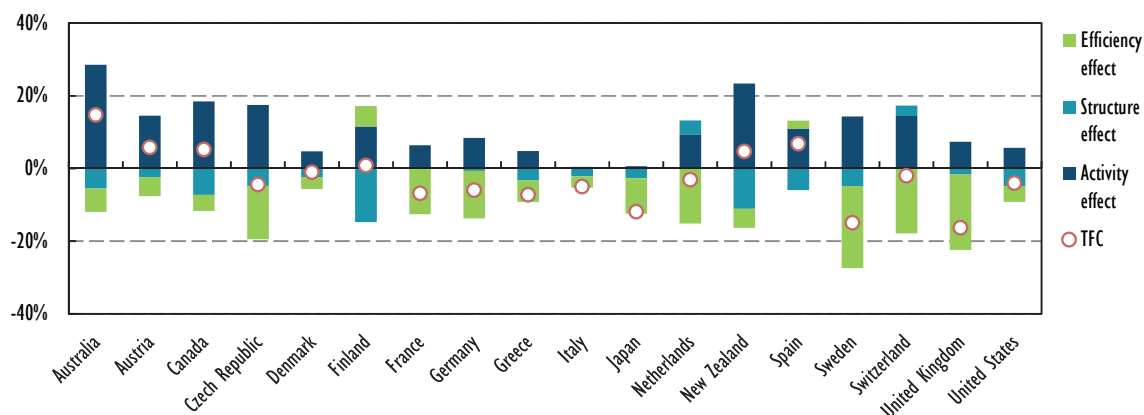
³The 18 countries analysed in the *EEMR 2014* are Australia, Austria, Canada, Czech Republic, Denmark, France, Finland, Germany, Italy, Japan, Korea, the Netherlands, New Zealand, Spain, Sweden, Switzerland, the United Kingdom and the United States. The *EEMR 2013* used a 1990 base year. Only 11 countries had comparable data going back to that time.

Figure ES.3 Hypothetical energy consumption without energy efficiency and cumulative savings from energy efficiency improvements for a set of 18 IEA member countries, 2001-11



At a country level, energy efficiency has served to place downward pressure on TFC in 16 of the 18 analysed countries since 2001, and is the prime mover of the absolute reductions in TFC experienced in 12 countries during this period (Figure ES.4). Of the 12 countries that have reduced TFC since 2001, 8 have experienced energy efficiency effects larger than total increases in activity.

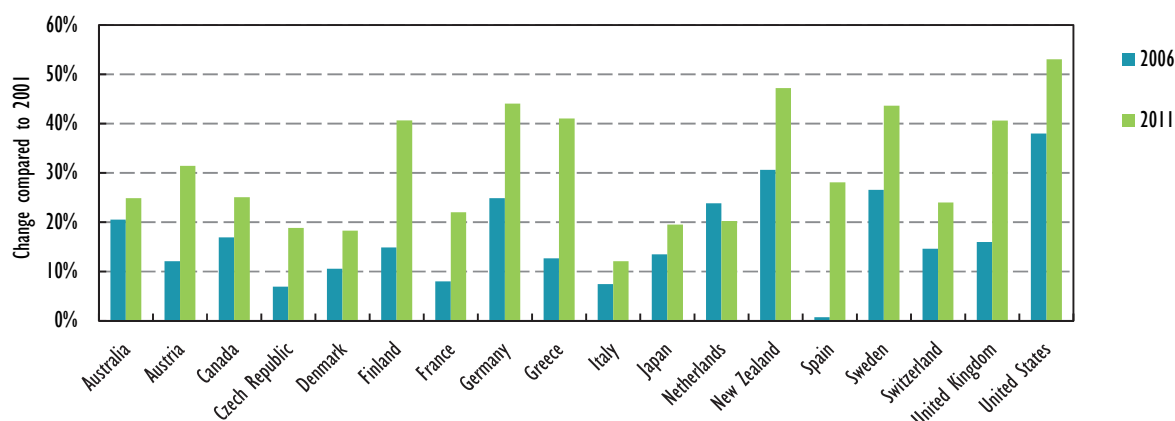
Figure ES.4 Decomposition of TFC between 2001 and 2011 for 18 IEA member countries relative to 2001 levels



Efficiency had the largest percentage improvement in the residential sector, where energy demand reduced by 5% from 2001 levels among the countries analysed. When isolating for the impact of efficiency, energy use would have been 14% lower than 2001 levels. This was driven by efficiency improvements of space heating, water heating, lighting and appliances in residential buildings. Efficiency has more than countered growing populations and preferences for larger dwellings in reducing absolute energy use among the countries evaluated.

Efficiency is reducing energy consumption during a time when energy prices have increased significantly across the countries evaluated. Energy prices increased between 11% and 52% in individual jurisdictions between 2001 and 2011 (Figure ES.5). Energy efficiency and increasing incomes are moderating the impact of increasing prices on households. The share of household income spent on energy has not risen as sharply, and has even levelled off or fallen in some countries between 2001 and 2011.

Figure ES.5 Increase in the weighted price of one unit of energy for individual consumers in 18 IEA member countries, 2001-11



Improved data collection and analysis will help governments and other stakeholders to better track energy efficiency developments, which will in turn support stronger policy design and better identification of market opportunities. Stronger data collection enables a broader and more detailed understanding of how energy efficiency can affect consumption patterns. While the report has been able to draw on improved data from 18 countries this year (as compared to 11 last year), securing better data from an even broader set of countries is important. In addition, better data at a sectoral level, including for industry and transport, can provide better information to allow policy makers and the market to work more effectively to support growth.

Energy efficiency in transport: A huge and growing market

An estimated USD 80 billion is spent per year on investments in energy efficiency in passenger LDVs.⁴ Over the next ten years, passenger LDV purchases, particularly in OECD non-member economies, are expected to offer the largest market opportunity for energy efficiency deployment. Investment in efficient vehicles is expected to represent over 60% of all incremental investment in energy-efficient technologies globally during this period.

The most important short-term driver for energy efficiency investments in passenger vehicles is vehicle fuel economy (VFE) standards, which covered 70% of the global market in 2011, accounting for 50 million vehicles sold that year. Brazil, Canada, China, the European Union, India, Japan, Mexico, Korea and the United States have implemented or updated VFE standards for passenger LDVs that will increase average fuel economy to a range of 3.9 litres to 6.7 litres of gasoline equivalent per 100 kilometres. Standards provide a strong signal for markets to deploy efficient technologies and services over the next 20 years.

Energy efficiency improvements in the transport system could reduce fuel expenditure between USD 40 billion and USD 189 billion annually by 2020 depending on the adoption of new policies and scale of market implementation they achieve. Fuel expenditure is a key driver of transport efficiency investment, with global expenditure expected to reach USD 2.8 trillion in 2020.

⁴This estimate is from the IEA *World Energy Investment Outlook* (International Energy Agency, *World Energy Investment Outlook*, OECD/IEA, Paris).

Trucks and other heavy-duty vehicles (HDVs) account for a growing share of energy consumption in the freight sector, but policies to deploy more efficient HDVs have been less extensive than for passenger LDVs. Japan, Korea and the United States are implementing efficiency-based standards, and standards focusing on greenhouse gases are being implemented in Canada. Energy efficiency market activity for HDVs is likely to intensify in response to new standards and the prospect of high oil prices.

While transport demand is increasing in OECD non-member economies, it is levelling off in OECD member countries, with a corresponding geographical shift in the potential energy efficiency market. Vehicle ownership is levelling off or even declining in OECD member countries, which still have the highest rates of vehicle use and distance travelled per vehicle. Passenger travel demand in OECD non-members is projected to continue to increase – by a further 90% between 2011 and 2020.

Energy efficiency is becoming an established financial market segment

Energy efficiency financing has moved from being a niche to an established financial market segment. This is, in part, the result of the availability of a greater range of financial products, models and intermediaries to facilitate investment.

Large amounts of public finance are being committed to energy efficiency. For example, Germany's public investment bank, KfW, committed a total of EUR 16 billion to energy efficiency in Germany in 2013, and the European Investment Bank (EIB) provided EUR 2.1 billion across the European Union. France's Caisse des Dépôts committed EUR 453 million to energy efficiency in 2012 and the United Kingdom Green Investment Bank provided EUR 181 million. Green investment banks (GIBs) are being established in several countries and are using public capital to leverage private capital, including from institutional investors. Energy efficiency is a target sector for finance in GIBs established in the United Kingdom, Malaysia, South Africa, Australia, Japan, the United Arab Emirates and the United States.

Another important channel for public finance to energy efficiency is through the development aid programmes of bilateral and multilateral agencies. A selection of bilateral and multilateral development banks provided over USD 22 billion in financing in 2012. Bilateral development banks, such as Japan's Bank for International Cooperation, are allocating significant amounts of finance to energy efficiency. Multilateral development banks (MDBs) such as the World Bank, the European Bank for Reconstruction and Development and the Asian Development Bank, are also actively providing energy efficiency finance. MDB finance for energy efficiency under climate mitigation programmes was USD 4.32 billion in 2013.

Financial vehicles are being used to make energy efficiency more attractive to investors. Financial vehicles include the following:

- Specialised entities such as **ESCOs**, which are becoming more active in many countries and implementing new financial models such as energy performance contracting. ESCOs first emerged in the United States in the 1980s, and the market there is already worth more than USD 5 billion a year. The largest market is currently in China, representing over USD 12 billion in 2013.
- **Clean energy bonds**, green bonds, climate bonds and others create new capacity for energy efficiency investment by tapping into fixed income markets. Until late 2013, the green bond market was dominated by MDBs, but corporate green bond issues are now growing very rapidly. For the moment definitions vary widely, but standards and voluntary principles are being developed. Transparent and independent rating systems will be important for further market development.
- **On-bill financing programmes**, such as Property Assessed Clean Energy (PACE), have achieved significant uptake, including in the United States, Mexico and Europe.

Country case studies reveal active and diverse domestic energy efficiency markets

This report highlights the energy efficiency market in 11 geographically and economic developmentally diverse economies, from Korea to Ireland and Canada to India. It documents more than EUR 30 billion of dedicated energy efficiency spending in those countries in 2012. The scale, maturity and drivers of the energy efficiency market vary greatly by country. **India**, for example, is increasingly implementing market-based approaches, whereas **Indonesia** is putting in place basic market-setting standards and labelling programmes. **European Union** member states, including **Ireland, Italy** and the **Netherlands** are putting in place a mix of policies that includes standards, grants, tax deductions, market-based instruments and approaches that leverage public funding with private third-party finance.

Market developments in the 11 economies highlighted in this report include the following:

The light-emitting diode (LED) lighting market is taking off in Japan and Thailand and seeing positive signs in India. In **Japan**, LED sales reached USD 5.2 billion in 2013 and accounted for over 30% of all Japanese bulbs sold that year. The **Thai** LED market has also grown rapidly in recent years, with sales reaching almost USD 15 million in 2011 and growing to USD 38 million in 2013. By 2011, LED lighting had achieved an 8% share of the total Thai lighting market, and has increased to 12% today. **India's** market for LEDs is poised to expand as the country implements a market-based LED roll-out scheme in Puducherry that, once replicated nationally, could lead to the sale and distribution of 33.96 million LED bulbs in 2014 and 3.4 billion bulbs by 2016/17. If this plan is implemented nationally, it could reduce electricity demand by over 50 billion kilowatt hours (equivalent to around 19 000 megawatts of avoided capacity) every year and reduce consumer bills by over EUR 3.1 billion.

The market for energy efficiency improvements in the buildings sector has seen significant government support over the past few years in several of the countries highlighted in this report, including in Ireland, Italy, the Netherlands, Canada and Japan. In **Ireland**, the Better Energy Homes programmes provide financial support to households for energy efficiency investments. These programmes resulted in average annual investment of EUR 230 million in energy efficiency-related construction over the five years (2009 to 2013). **Italy** offered a 55% tax deduction for energy efficiency investments in the residential sector (starting in 2014, the tax deduction has since been increased to 65% for some measures). Between 2007 and 2013, more than 1.8 million applications were approved and around EUR 23 billion of investments were leveraged by households, at a cost of about EUR 13 billion in undiscounted foregone tax revenue. In 2012 alone, more than EUR 2.8 billion was invested in 265 500 energy efficiency measures, which included 2.3 million square metres (m²) of window replacements and 1.2 million m² of rehabilitated solid surfaces. Investments in building insulation in the **Netherlands** have also been growing rapidly at a rate of 10% per year, reaching a value of EUR 680 million in 2012. **Canada** released the Model National Energy Code for Buildings in 2011, which would lead to a 25% energy efficiency improvement compared to the current code for commercial and multi-storey residential buildings, and is predicted to save CAD 70 million for occupants. **Japan** has continued to expand the Top Runner programme, strengthen energy auditing, certification and labelling of buildings, implement more stringent energy performance requirements for new buildings and scale-up efforts to improve the efficiency of the existing building stock.

The energy-saving technology manufacturing and service industries in many countries have been growing, including in Ireland and the Netherlands. In the **Netherlands**, this industry has grown by 9% a year since 1995, with goods and services valued at EUR 4 134 million in 2012. In **Ireland**, exports of

energy efficiency-related products increased from around EUR 100 million in 2010 to over EUR 170 million in 2012 (66% increase). This growth is focused on thermal insulation products and energy-efficient lighting.

The industrial energy efficiency market has benefited from government support in several countries.

In **Ireland**, between 2007 and 2011, the small and medium-sized enterprise (SME) programme of the Sustainable Energy Authority of Ireland supported over 1 470 companies employing the equivalent of approximately 130 000 staff through advice, mentoring and training. In 2012, over 200 SMEs with 2 000 employees and a total annual energy bill of EUR 19.7 million were supported to achieve savings of EUR 2 million. Two schemes in the **Netherlands**, VAMIL and MIA, had budgets of EUR 24 million and EUR 101 million respectively in 2013. The programmes benefit SMEs in particular, with an average investment size of EUR 150 000 for both MIA and VAMIL. Between 2005 and 2010, MIA and VAMIL projects received over 57 000 applications. In **Korea** the government has committed to implement measures to promote the market for smart appliances, energy storage and energy management systems (EMS) using cutting-edge information and communications technology (ICT).

Sub-national governments can drive energy efficiency markets. Much of **Canada's** efficiency programmes and activity occur under provincial government purview. As of 2011, over 200 efficiency programmes and policies were offered through the ten provinces and three territories.

National and supra-national governments can also play a key role in driving energy efficiency markets. **China's** energy efficiency service and investment demands are driven to a large extent by the government's strong and comprehensive energy conservation policies and programmes. During the 11th Five-Year Plan (FYP) of 2006 to 2010, energy efficiency investment surpassed USD 100 billion. Chinese government policies include a variety of administrative programmes, such as mandatory energy savings agreements with large and medium-sized enterprises. China is expected to invest between USD 200 billion and USD 270 billion in energy efficiency between 2011 and 2015 to achieve its 16% energy intensity reduction mandate set in the 12th FYP. In the **European Union**, the European Structural and Investment Funds allocated EUR 5.6 billion to energy efficiency over the period from 2006 to 2013. During the new programme period from 2014 to 2020, energy efficiency funding is expected at least to double.

Some energy efficiency markets are still nascent, but have large potential for growth. Although the market for energy efficiency in **Indonesia** is still in its early days, there is significant potential for growth. Analysis indicates that Indonesia offers more than half of Southeast Asia's energy efficiency investment potential (57%) in the period to 2020. Recent developments in Indonesian energy efficiency policy will help to overcome barriers facing its energy efficiency market.

Strengthening its position as a fuel

Energy efficiency markets are expected to grow worldwide. Energy efficiency is strengthening its position as a fuel option for countries in their efforts to balance supply and demand in support of growth, energy security and environmental objectives. Improving data and analysis are helping to enhance the ability of stakeholders to understand this market – notably in terms of investment inputs, savings outputs, and the impact on energy efficiency outcomes. However, the need remains for further data and methodological improvements. At the same time, increased focus on the issues of energy security, economic growth, sustainable development and climate change mitigation, which can each be enhanced through improved energy efficiency, is likely to support a continued growing emphasis on this “first” fuel.

PART 1
**THE MARKET FOR
ENERGY EFFICIENCY**

1. TOWARDS A BETTER ESTIMATION OF THE GLOBAL ENERGY EFFICIENCY MARKET

Summary

- The energy efficiency market generates substantial outputs: in 11 IEA member countries evaluated, energy efficiency investments saved 56 exajoules (EJ) or 1 337 million tonnes of oil-equivalent (Mtoe) in 2011. Savings from energy efficiency increased by 260 petajoules (PJ) (6.2 Mtoe) between 2010 and 2011. Energy efficiency improvements in these countries are “powering” more energy service demand than any other single conventional energy resource.
- Energy efficiency gains of 56 EJ in 2011 were larger than the combined total final consumption (TFC) of energy in the European Union or in Asia excluding China. These savings were 80% of TFC in China and 87% of TFC in the United States for that same year.
- New to this year’s report are six different methods to estimate the size of the global energy efficiency market. Although there is no single accepted methodology for estimating the size of energy efficiency investment at a global level, a number of methods are being developed and refined. They include both top-down methods and bottom-up approaches. Applying these approaches, the estimated value of energy efficiency investment in 2012 is between USD 310 billion and USD 360 billion. This range of values confirms the magnitude of the estimate of USD 300 billion made in the *Energy Efficiency Market Report 2013 (EEMR 2013)*.

Energy Efficiency Market Report 2014: Approach to evaluating the energy efficiency market

The International Energy Agency (IEA) published its inaugural *Energy Efficiency Market Report (EEMR)* in 2013, highlighting the importance of the market for this fuel – one that is no longer a hidden fuel but in fact the “first fuel” for IEA member countries. This year’s report continues the theme by assessing the market activity and potential of this large, but largely unnoticed, energy resource. The thrust of this year’s report is to refine our understanding of the energy efficiency market; to discuss and define the market in better terms; and to track more closely actual market developments both globally and in key sectors.

Several methodological improvements have been implemented since last year’s report, including an improved decomposition analysis to better isolate efficiency impacts, and the expansion of the analysis of energy efficiency impacts from 11 to 18 countries, in many cases given stronger data availability. This year’s report presents six methodologies to estimate the size of the market, in addition to the leveraged lending method. These methods confirm that the energy efficiency market is in the order of USD 300 billion, as estimated last year.

As highlighted in the *EEMR 2013*, energy efficiency can be described as the first fuel of national energy systems – meaning that energy efficiency satisfies more energy service demand than any other fuel. Energy efficiency is also typically the cheapest and most available “source” of energy supply to power economies. While other energy sources have dedicated industrial sectors focused on investment, extraction and production, which operate in defined markets that facilitate the trade of these fuels, energy efficiency is realised by the uptake of efficient technologies and practices throughout the economy.

A market is traditionally defined as an exchange of goods or services between buyers and sellers. However, in the context of the energy efficiency market, buyers and sellers are often not exchanging specific units of energy efficiency. Rather, energy efficiency improvements are an embedded feature of equipment, buildings and other energy-using stock that provide other services for users.

The challenge in defining, tracking and evaluating this market is that energy efficiency market activity and data are disaggregated among millions of ordinary transactions made every day, involving many energy-consuming technologies across all sectors of the economy. At the same time, it is also subject to interpretation. For example, is a purchase of a new car that happens to be more efficient an energy efficiency market activity? This makes it difficult to estimate the magnitude of investment necessary to power our economy with “energy efficiency” rather than energy supply.

Without a market price for a joule of avoided energy, or the data to evaluate investments undertaken to avoid a set number of joules, the task of defining the market and quantifying annual energy efficiency investment continues to be a challenge (see Box 1.1). Despite this difficulty, energy efficiency is a real market in terms of the magnitude of invested capital and its influence in shaping the global energy system.

Box 1.1 The data challenge for energy efficiency

The energy efficiency market does not resemble traditional energy commodity markets. For example, electricity markets include highly sophisticated segments, with generators and electricity wholesalers trading in large volumes of electrons along one-minute intervals. The unit of trade (megawatt hours) is clearly understood by all parties and the price is a reasonably transparent figure that has been reached by competitive and regulatory processes. Oil is traded in both global and regional markets with many financial products, such as futures contracts, catering to the needs of thousands of market participants. These energy markets react to changes in the supply and demand for fuels, with prices adjusting for individual energy commodities. Data on prices, trading volumes, supply and consumption of fuels and energy resources are dispersed through multiple information channels, facilitating changes in behaviour, prices and corporate investment.

There is no equivalent medium of exchange or unit of trade in an avoided joule of energy from energy efficiency adoption. Nevertheless, we know that firms and consumers routinely make investment decisions with minimising energy consumption as one consideration. Even if firms or consumers do not value energy savings from efficiency, replacing old technology with new often brings with it an embedded energy efficiency improvement, and this replacement represents invested capital. This highlights one of the many issues in precisely defining an energy efficiency investment.

Savings generated by energy efficiency: The market's output

To estimate the size and value of the energy efficiency market, data are required that estimate the energy savings generated by investment in energy efficiency goods and services. However, these data are lacking, both at a country and global level. In light of data challenges, a decomposition analysis is used to isolate the impact of activity, structure and efficiency factors on TFC to derive an estimate of the energy savings generated through improved energy efficiency (Box 1.2).¹ Even this type of analysis requires a robust set of data that is sufficiently comparable to provide a basis for

¹ This method attempts to isolate energy efficiency improvements from structural change and changes in activity that have an impact on energy consumption and energy intensity. Decomposition allows for a more precise estimate of energy-using activities. For detailed explanation of the method and outcomes of the decomposition analysis, see Chapter 2.

comparison and aggregation. A set of 11 IEA member countries provides sufficient data up to 2011 to allow such analysis, with suitable historical and comparable energy use and efficiency data. These countries collectively represent over 69% of TFC in OECD member countries, and accordingly provide a strong indicator of the size of the energy efficiency market across OECD countries.

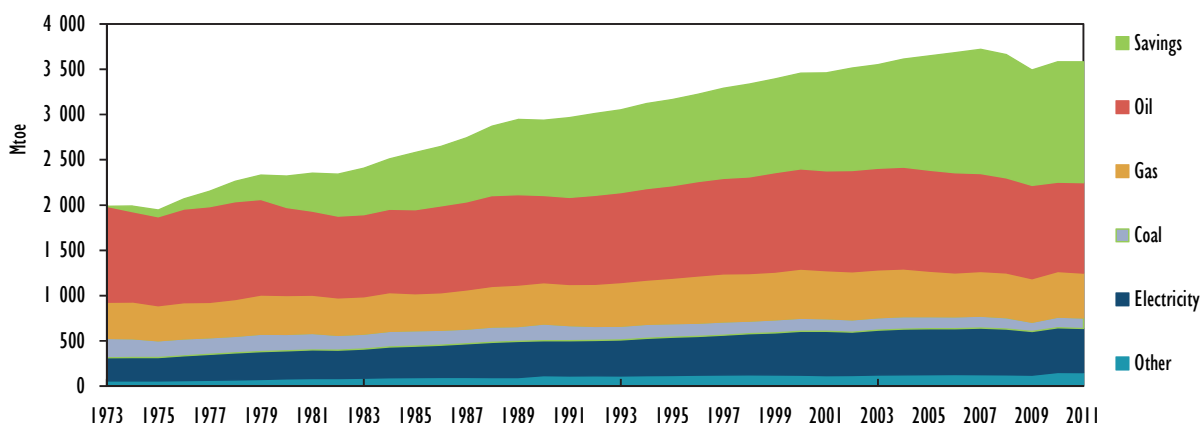
Box 1.2 Identifying energy efficiency improvements: The decomposition analysis

The IEA estimates how much energy is saved from energy efficiency by tracking relative efficiency improvements since 1973. This is achieved using decomposition analysis that better isolates efficiency improvements from other factors that affect total energy consumption, such as the structure and growth of the economy. In essence, this method accounts for improvements in the energy efficiency of energy-consuming stock (buildings, lights, machines, vehicles, etc.) over the past 40 years. It estimates how much hypothetical energy consumption there would have been if our economy and population had still grown at the same rate but there had been no energy efficiency improvements in end-use sectors (residential and commercial buildings, transport and industry) since 1973. Decomposition analysis requires collecting detailed energy efficiency indicators, as described in Chapter 2. Most countries do not yet track energy efficiency indicators, which limits the scope of analysis of the impact of energy efficiency and the size of the market.

Energy efficiency: Still the first fuel

Generating energy efficiency savings, like producing oil, gas and other fuels, is the result of investments made over a period of time. Figure 1.1 shows the impact of energy efficiency improvements made since 1973 for 11 IEA member countries. The aggregate energy intensity improvements since 1973 amount to over 56 EJ or 1 337 Mtoe, and savings from energy efficiency grew by 260 PJ or 6.2 Mtoe between 2010 and 2011. These 11 countries represent over 69% of TFC in all OECD member countries, and therefore the energy efficiency gains of numerous other countries would, if included, further increase this figure.

Figure 1.1 Energy savings from energy efficiency and energy consumption by energy source in 11 IEA member countries, 1973-2011

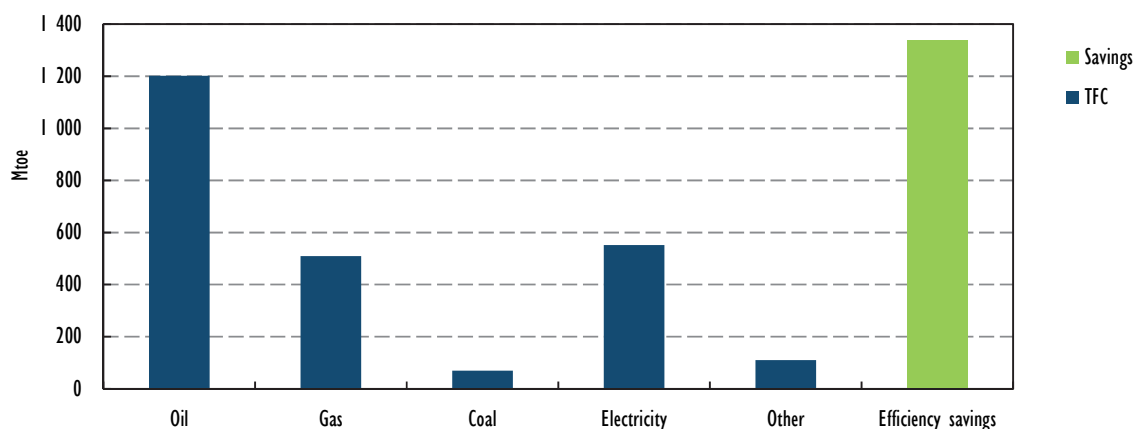


Notes: The 11 countries evaluated are Australia, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Sweden, the United Kingdom and the United States.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

The savings from energy efficiency in 2011 of 56 EJ were equal to 59% of TFC in those 11 IEA member countries in that year. Savings from energy efficiency provided more avoided energy to “power” the economies of these 11 countries than the amount of TFC met by any other single energy supply source. As in 2011, energy efficiency maintained its position as the first fuel (Figure 1.2).

Figure 1.2 Energy savings relative to other fuel and electricity consumption in 11 IEA member countries, 2011



In addition to energy savings, the energy efficiency market also produces a variety of other benefits, including health, economic and energy security benefits (Box 1.3). All of these benefits can serve to increase the attractiveness and cost-effectiveness of the energy efficiency market.

Box 1.3 Counting multiple benefits

Energy efficiency investments generate a variety of benefits. The principal benefit identified in this publication is energy savings, which strongly relate to the role of energy efficiency as an energy fuel. A variety of other benefits are addressed in greater detail in the IEA publication *Capturing the Multiple Benefits of Energy Efficiency* (2014a). The multiple benefits approach extends the reach of energy efficiency beyond the well-established impacts of energy demand reduction and reduced greenhouse gas emissions, revealing its potential to deliver a host of other benefits to the economy and society. Benefit areas fall into several categories: energy security, economic development, social development, environmental sustainability and building wealth. The value of these benefits is subject to considerable variability across countries and sectors. The evaluation of energy efficiency in this market report does not quantify these multiple benefits, even though they can often be monetised.

The rebound effect

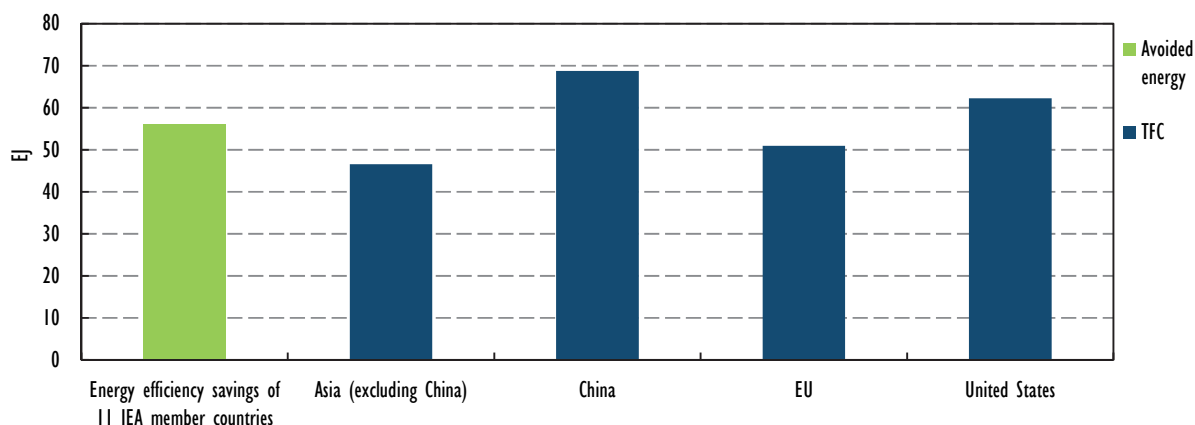
It is important to note that while energy efficiency investments generate direct energy savings, they can also lead to effects that result in additional energy consumption, thereby indirectly reducing the overall savings impact (IEA, 2013). The rebound effect results in lower-than-anticipated energy savings from a given action, as a result of financial savings from reduced energy consumption being spent on additional energy-consuming activities or products. A wide range of estimates has been made regarding the magnitude of the rebound effect, which highlights the need for further analysis of this issue.²

² The estimates vary greatly, from 9% in the IEA *World Energy Outlook 2012* to 10% to 30% in studies documented by the IEA report *Capturing the Multiple Benefits of Energy Efficiency* (IEA, 2014a).

IEA energy efficiency exceeds TFC of other regions

The magnitude of avoided energy consumption in 11 IEA member countries in 2011 was nearly the size of TFC in the world's two largest economies, the United States and China. For example, the 56 EJ of savings was larger than the 2011 TFC in Asia excluding China or in the European Union; it represents 80% of TFC in China, and 87% of TFC in the United States (Figure 1.3). Considering the important role that China has had in the last two decades in shaping global energy and commodity markets, energy efficiency has also played a critical role in the energy supply/demand equilibrium and resulting energy market outcomes.

Figure 1.3 Energy efficiency savings compared to TFC in selected regions and countries, 2011



Estimating investment in the energy efficiency market

While energy efficiency is a sizeable resource, the question remains: how large is global annual investment in energy efficiency? Efficiency investment is hard to define (Box 1.4), to observe or to count. Within these constraints, two principal methods are used to estimate the size of investment in the efficiency market: bottom-up and top-down.

- **Bottom-up** approaches involve counting the individual exchanges of goods and services that increase energy efficiency. This method can provide a robust estimate of the size of the market, as long as the appropriate data are available and aggregation systems are in place. A bottom-up approach tracks the many individual activities that take place within homes and businesses. This would examine, for example, the different ways consumers might heat and light their dwellings. It might also track the array of consumer appliances, such as computers, cook stoves and refrigerators, and assess their typical usage patterns. Bottom-up calculation requires relatively detailed data over time to compute stock adoption, the energy performance of each different stock type and behaviour changes down to the individual or business level. Typically, these data are not currently available, at least at an economy-wide or other broad level.
- In the absence of available granular data, a **top-down** method evaluates trends in energy consumption and economic growth to estimate the scale of investment required to improve efficiency. In light of data challenges, this can be a more practical approach. Top-down methods sacrifice accuracy but still provide insight on the size of the market and changes over time. A top-down approach uses a combination of historical levels of economic activity and proxy indicators for energy efficiency, such as the energy intensity of economic activity (energy per USD of gross domestic product [GDP]).

Box 1.4 Autonomous versus motivated energy efficiency adoption

Energy efficiency investments are driven by several factors, in particular price signals and policy. Some investments are explicitly designed to achieve energy efficiency objectives, while other actors may make investments that improve efficiency without the knowledge or purpose of doing so. The former type of investment can be characterised as “motivated” and the latter as “autonomous”. In the context of evaluating an energy programme, the proportion of investments motivated by government policies and programmes is often of particular interest to policy makers. However, for the purposes of calculating the size and scope of energy efficiency markets, both autonomous and motivated investments are pertinent to determining the full scale of energy efficiency investments and resulting energy savings.

Although data limitations prevent a definitive estimate of the market, sufficient information is available to help shape a “probable magnitude” of investment in energy efficiency. Six different methods to estimate the size of the energy efficiency market are presented.

1. Estimate the market, based on an assumed energy efficiency component of gross capital formation.
2. Estimate the investment in efficiency to achieve observed global energy intensity savings.
3. Use an established forecasting model to estimate the investment cost of energy intensity improvements.
4. Use those model findings in a Monte Carlo simulation to produce a weighted range of possible market estimates.
5. Estimate energy efficiency investment by using reported financing dedicated to energy efficiency.
6. Scenario analysis of *World Energy Investment Outlook*, which uses bottom-up data on stock adoption and estimates of the energy efficiency component of unit costs to model an estimated investment in energy efficiency.³

Method 1: Estimate using gross capital formation

One approach to making initial estimates of the total size of the energy efficiency market is to understand the size of the gross capital formation market and then estimate the energy efficiency component.

Gross capital formation comprises the investments made in additions or improvements to, or the replacement of, existing fixed assets. These assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.

Energy efficiency adoption is the investment of capital into energy-using stock. Market activity that achieves greater energy efficiency falls within three aggregate sub-sectors: consumer goods and appliances; transport vehicles;⁴ and an array of construction activities, including buildings, industrial processes and equipment, and infrastructure improvements.⁵ Table 1.1 highlights recent worldwide market spending on these three categories. Although the information is provided for different years, total spending is about USD 6.8 trillion worldwide.

³ Other top-down estimates exist. For example, a study by the American Council for an Energy-Efficient Economy (ACEEE) estimated that energy efficiency investments in the United States alone were worth USD 90 billion in 2010. The findings were based on an assessment of existing energy efficiency programme data and stock sales, extrapolated to the wider economy. This was a top-down assessment using sector-specific data from different sources as a guide to efficient stock turnover and efficiency programme spending. That was then extended to a wider definition of the energy efficiency market outside of sector and programme-specific scopes, to develop an estimate of the economy-wide energy efficiency investment (Laitner, 2013).

⁴ See Chapter 3 for a detailed description and analysis of the energy efficiency market in transport.

⁵ The construction industry comprises those sectors of a national economy engaged in the preparation of land and the construction, alteration and repair of residential and commercial buildings, as well as structures ranging from roads and bridges to power plants, incinerators, chemical plants, and other real property.

Table 1.1 Total market size of selected energy-using stock

Sector	Value (USD billion)	Region	Year	Source
Appliances	900	World	2005	World appliance companies
Vehicles	1 300	World	2011	IEA
Construction	4 600	World	2015	Global Industry Analysts

Sources: Appliance Magazine (2005), "Portrait of the Global Appliance Industry", www.appliancemagazine.com/editorial.php?article=1762; Global Industry Analysts (2012), "Global Construction Spending to Reach \$4.6 Trillion by 2015", *Construction Business Owner Magazine*, www.constructionbusinessowner.com/topics/global-construction-spending-reach-46-trillion-2015-old.

Table 1.1 provides the basis for a first estimate of energy efficiency investment magnitudes. Of the total investment in the three sectors, how much is invested in energy efficiency? Various studies have estimated the percentage of investment in capital that goes to energy efficiency; these range from 5% to 15% (Ehrhardt-Martinez and Laitner, 2008). Using the lower figure of 5% of total investment, the annual energy efficiency market would have a value in the order of **USD 340 billion**.

Method 2: Estimate based on changes in energy intensity

Energy intensity measures the amount of energy consumption required to produce economic output; as described in Chapter 2, it provides an imperfect measure of energy efficiency at a macro-level.⁶ Data in this regard are relatively widely available, notwithstanding challenges, and as a result can provide a potentially fertile ground to estimate the market. To identify the impacts of energy efficiency within overall changes in energy intensity, it is necessary to factor out activity impacts and structural changes. By using a year-on-year comparison, the impact of structural changes, which typically reflect longer-term changes in the structure of the economy, can be viewed as minimal. As a consequence, under this approach, energy efficiency largely equates to the annual change in energy intensity after factoring out the impact of change in activity.

This approach compares energy intensity across two years (in this case 2011 and 2012), and then factors out the activity change. The figures underlying this calculation for 2011 and 2012 are set out in Table 1.2.

Table 1.2 Key 2012 values: GDP, TPES and energy intensity

Metric	2011	2012	Delta	% change
GDP (2005 billion USD PPP)	70 313	72 314	2001	2.8
TPES (EJ)	549.0	553.1	4.1	0.7
Intensity (MJ/USD GDP)	7.81	7.65	-0.16	-2.0

Note: MJ = megajoule; PPP = purchasing power parity; TPES = total primary energy supply.

Between 2011 and 2012, activity associated with global economic growth led to a pro rata increase in the demand for energy services of 15.6 EJ.⁷ Actual TPES increased by only 4.1 EJ. Subtracting 4.1 EJ of new energy supply from the 15.6 EJ increase in energy service demand indicates that changing energy intensity led to energy savings of 11.5 EJ in 2012 (Figure 1.5).

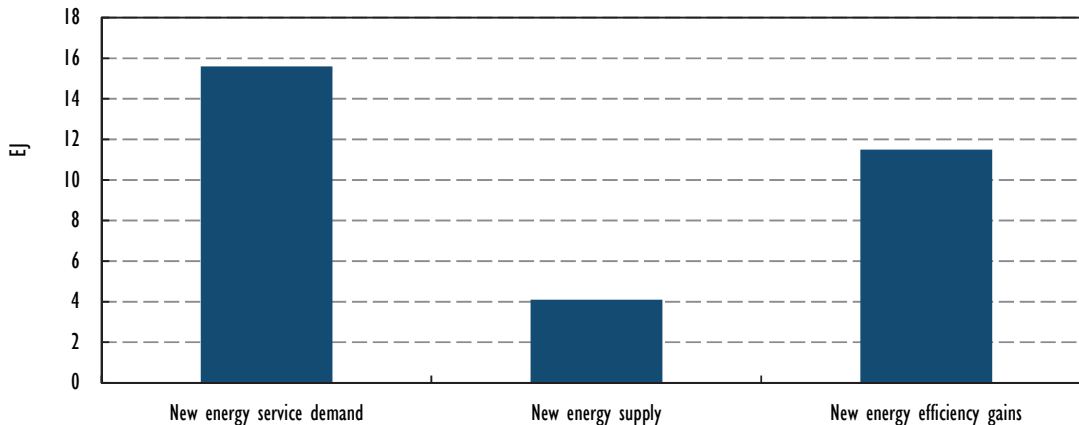
The next step is to transform the estimated energy savings into a monetary value that can provide insights into the underlying value of investments. In 2012, the weighted average price of energy was

⁶ As discussed in detail in Chapter 2, energy intensity collapses into a single metric the impacts of structural changes in the economy and changes in the energy efficiency of products and processes.

⁷ This figure is derived as follows: the change in global GDP from 2011 to 2012 is multiplied by the energy intensity of 2011 to generate a pro rata change in energy demand assuming that energy intensity had not changed since 2011.

USD 13.96 per gigajoule (GJ),⁸ meaning that 11.5 EJ of avoided energy service demand was worth USD 160.5 billion. This savings figure can be translated into underlying investments on the basis of the average payback period that drives business and consumer energy efficiency expenditure. Assuming that businesses and individuals make energy efficiency investments seeking a return of their initial capital investment (the payback period) over a two year period, then the size of the investment made (in year 1) would be USD 321 billion (with the payback effected through the USD 160.5 billion savings made in years 2 and 3).⁹ Under this approach, the size of the energy efficiency market is **USD 321 billion**.

Figure 1.4 Global demand for energy services and energy supply, 2011-12



Method 3: Estimate based on the Long-term Industrial Energy Forecast (LIEF) model

The economic structure of the LIEF model can also be used to generate a top-down estimate. LIEF was developed by Argonne National Laboratory in 1993 to identify future energy use and investment associated with reductions in energy intensity. The model uses assumptions on technological improvement to reduce energy intensity based on sector responses to increasing cost curves for energy efficiency in response to changes in energy prices (Ross et al., 1993). While initially developed for the industrial sector, the modelling framework allows the LIEF model – depending on the availability of data to be used within the model – to be opened up to other sectors and to the economy as a whole. The assumption in the LIEF model is that as a sector or the economy as a whole adopts energy efficiency – either through best practice or technology – the cost of investment per unit of energy saved will increase. The rate of that potential cost increase depends on prevailing energy prices, the elasticity of the efficiency supply curve and the discount rate. It also depends on how innovations and research and development (R&D) policies might shift the best technology or best practice frontier. Based on the array of variables, and maintaining the same 11.54 EJ energy efficiency gains for 2012, the LIEF assessment indicates a market assessment of **USD 313 billion**.

Method 4: Estimate based on a Monte Carlo simulation

A Monte Carlo simulation¹⁰ exercise is used here to generate a range of estimates for the size of investment in energy efficiency (rather than a single point estimate) based on the assumption of

⁸ This assessment draws on a published estimate of 2010 world energy expenditure (Desbrosses, 2011) as USD 6 400 billion (in constant 2005 USD expressed in PPP). Using IEA energy price data, the calculation converts that 2010 value into 2012 price equivalents, and divides by total primary energy consumption. This generates an average 2012 price of USD 13.96 per GJ.

⁹ For simplicity, this calculation does not include a discount factor. In addition, it also assumes that revenues (through savings) will continue to accrue following the payback period, thereby generating positive returns on the underlying investment.

¹⁰ Monte Carlo simulation is a technique used in probability assessment, and has been an essential tool to explore the risks and uncertainties for a wide variety of financial and project management costs.

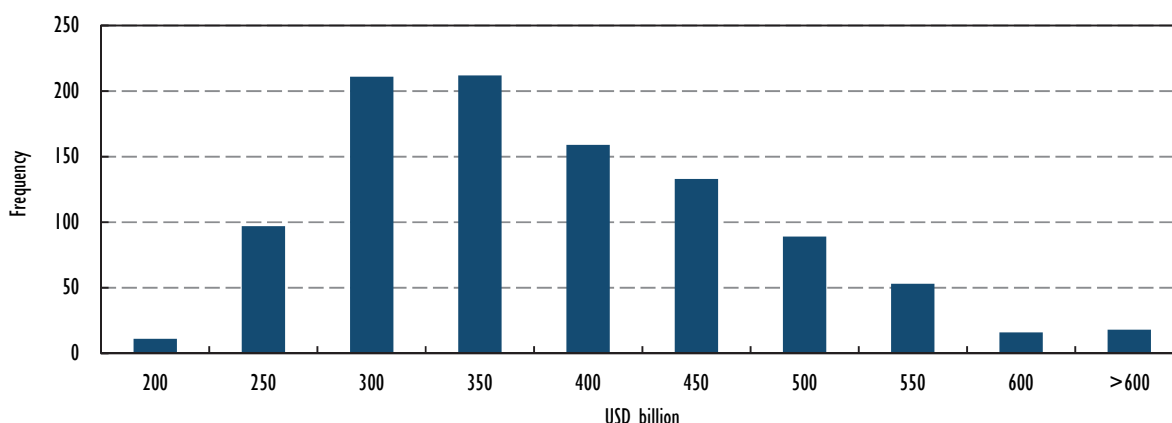
fixed values for each of the variables used within the LIEF model. In effect, this approach expands the range of values for the set of variables, and then randomly assigns them within a Monte Carlo simulation to highlight a range of possible outcomes. By allowing all the key values to vary randomly, but to do so in ways that are consistent with the range of other data (including the assumptions on the efficiency gap, actual energy prices and consumer preferences as reflected in their implicit discount rates), the Monte Carlo simulation yields a range of possible investment magnitudes between USD 173 billion and USD 698 billion (Table 1.3). The average investment value is **USD 356 billion**.

Table 1.3 Range of magnitudes in energy efficiency investment from Monte Carlo simulation

Investment magnitude (2012 USD billion)	
Average	356
Minimum	173
Maximum	698

Figure 1.6 provides two key insights for understanding the prospective scale of the global energy efficiency market. The first insight is that there are more than 400 sets of results that are valued at between USD 300 billion and USD 400 billion. The second insight is that the distribution of results appears asymmetrical – in this case leaning more heavily towards the higher end of the range. This suggests that previous estimates may be too low, especially if this were confirmed by a more complete estimation using detailed bottom-up data.

Figure 1.5 Frequency distribution of Monte Carlo estimates of energy efficiency market



Note: The figure describes the frequency distribution of investment values for 1 000 simulations.

Method 5: Estimate based on leveraging

The *EEMR 2013* evaluated the size of the market, based on extrapolating the amount of public finance that was being put into energy efficiency programmes and outcomes, and the private investment it leveraged. Using the leverage ratios from the AGF report¹¹ with data obtained from countries and multilateral development banks, together with relevant estimates provided in various analyses, the IEA calculated a range between **USD 147 billion and USD 300 billion**. This investment range was considered to be conservative in the report, as it may have under-estimated private sector energy efficiency activity (IEA, 2013).

¹¹ The IEA estimated the amount of energy efficiency finance that international financial institutions (IFIs) are leveraging in developing regions by applying leverage ratios to their energy efficiency finance numbers. IFIs provide different kinds of financial instrument depending on the country context, i.e. the maturity of a country's energy efficiency and capital markets. Leverage ratios were estimated using the United Nations' High-Level Advisory Group on Climate Change Financing report (UN AGF, 2010).

Method 6: Estimate based on the World Energy Investment Outlook

The *World Energy Investment Outlook* estimates worldwide investment in energy efficiency and projected investment under its New Policies Scenario. Energy efficiency investment was defined according to a baseline of the average efficiency of energy-consuming stock in 2012 (IEA, 2014b). This approach uses the “energy efficiency premium” concept (Box 1.5): it estimates the average efficiency of energy-consuming equipment by sub-sector in 2012, and then evaluates how much energy-consuming stock was added in 2013 that was more efficient than the 2012 average. Efficiency uptake in 2013 is estimated based on consumer and business responses to energy prices and policies. Each of the more efficient technologies is associated with a specific investment cost. The sum of incremental investment required to adopt energy efficiency over the average for 2012 provides the estimate for investment in energy efficiency in 2013. Investment in 2013 above the 2012 baseline was estimated to be **USD 130 billion** in 2013. The cumulative amount of incremental investment in efficiency from 2014 to 2035 (using the same 2012 reference level of efficiency) under the New Policies Scenario was estimated at USD 8 trillion.

Box 1.5 The “energy efficiency premium”: Uses and limitations

A basic definitional issue facing any estimate of investment in the energy efficiency market is to decide what proportion of overall investment to include and how to value it. A consumer or business that decides to invest in more energy-efficient equipment must pay the full cost of the equipment, which can be separated into two parts: the cost of a new but very standard and less efficient piece of equipment (the “base cost”), plus the cost of the added increments of energy efficiency. This second cost represents the “energy efficiency premium”. The base plus the premium equals the full technology cost, or the “total investment” in efficiency.

Using a refrigerator as an example, the current stock of installed refrigerators cost on average USD 350 per unit, with an average annual consumption of 840 kilowatt hours (kWh) of electricity. This current stock constitutes the baseline for energy efficiency and determining whether an energy efficiency premium is present. Over time, new more efficient units become available and are sold in the market, but these refrigerators cost more. A consumer who acquires a high-efficiency unit (which consumes 350 kWh per year) might pay USD 600. The associated “energy efficiency premium” in this case equals USD 250, being the difference between the USD 600 price of the new unit and the USD 350 price of the average base cost unit (for simplicity, this calculation assumes that all other aspects of the refrigerator remain unchanged). This report generally includes the energy efficiency premium as part of the evaluation of market investment.

However, only looking at the energy efficiency premium may miss larger market dynamics that are working to improve total system efficiency. The average efficiency of most energy-consuming stock tends to gradually improve over time, because of continued technological improvement and the competitive market driving the adoption of such improvements. The efficiency of the average unit will be better than that of average units in years past, but may cost the same or even be cheaper than earlier units. This means that, while the adoption of this new average equipment serves to improve total average efficiency when it replaces less efficient older equipment, as there is no efficiency-related incremental cost (i.e. no efficiency premium) there would be no monetary contribution to the energy efficiency market if only energy efficiency premiums are counted.

Conclusion: Towards improved market valuations

Energy efficiency improvements have been one of the major influences on the global energy system in the past four decades. Savings from energy efficiency increased by 260 PJ (6.2 Mtoe) between 2010 and 2011. Energy efficiency investment has been estimated at between USD 316 billion and USD 350 billion in 2012, with the resulting energy savings being generated over succeeding years. This investment

was spread out over millions of individual market exchanges and investments occurring daily, each involving the adoption of new, more efficient energy-consuming stock and practices.

The estimations set out in this chapter provide a snapshot of the size of the energy efficiency market. Developing methodologically rigorous estimates of the size of the energy efficiency market, using real data, is a critical first step. Further work is required in this regard. Additional steps are also needed to improve monitoring of how the market develops in size and shape, along with regional analyses. These will help market actors improve their ability to evaluate the financial potential of participating in the energy efficiency market.

Estimates of the energy savings from efficiency and corresponding investment levels are likely to continue to vary according to the methodology used. However, as data on investment in efficiency and its impact improve, more robust methods can be expected to emerge to track developments in this growing and important market.

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2. WHAT THE NUMBERS SAY: TRACKING ENERGY EFFICIENCY PROGRESS

Summary

- Energy intensity continues to decline around the world, including in OECD member countries. Energy intensity improvements between 2002 and 2012 averaged 1.6% annually. The rate of improvement was higher than the long-term global annual average since 1971, being 0.8%.
- Energy intensity improvements over the past four decades have almost doubled the average energy productivity of OECD member countries, from USD 3.9 billion of gross domestic product (GDP) per million tonnes of oil-equivalent (Mtoe) of energy consumption to USD 7.5 billion GDP per Mtoe.
- Based on a decomposition analysis of energy demand in 18 IEA member countries, energy efficiency has been a consistent and important factor in improving energy intensity and in reducing total final energy consumption (TFC) between 2001 and 2011. Energy efficiency improvements since 2001 saved 218 Mtoe in 2011, equivalent to TFC in Germany in 2011. Cumulative savings in energy consumption between 2001 and 2011 from energy efficiency amounted to 1 731 Mtoe, equivalent to the TFC of the United States and Germany in 2011.
- Energy efficiency has had the greatest impact in the residential sector, where TFC among the 18 countries analysed is down by 5% from 2001 levels, driven entirely by efficiency improvements.
- Improved data collection and analysis will help governments and other stakeholders to better track energy efficiency developments, which will in turn support stronger policy design and better identification of market opportunities.

Introduction: The role of indicators in supporting our analysis of the energy efficiency market

Energy efficiency indicators can help to track the impact of the energy efficiency market on energy use. Assessing energy efficiency developments and their underlying causes requires detailed energy efficiency data and standardised statistical metrics that allow meaningful comparisons. Highly aggregated statistics tell only part of the story; efficiency impacts can be masked by variations in economic structure, climate, population, behaviour or affordability of energy services. This is in contrast to other energy source datasets that can reasonably rely on straightforward production, consumption and capacity statistics. The suite of metrics available from the IEA indicators database is an authoritative source of information on the causes of changes in patterns of energy consumption.

Tracking ten years of changes in energy use, and the drivers behind them, allows trends to be revealed. By exploring the detail behind aggregate energy statistics, it is possible to evaluate where energy efficiency markets are reducing energy use and improving efficiency. The indicators approach picks apart the various factors that influence changes in energy consumption, such as changes in economic activity, transport journeys, residential heating demand and dwelling size. This type of analysis complements the description of market and policy developments in this report, by providing a quantitative measure of the progress that has been made. Analysis of progress indicates the areas where past investments have generated change and where future improvements – and corresponding future investment –

might be expected. Understanding the extent to which changes are related to energy efficiency improvements and underlying market activity, as distinct from other macroeconomic, demographic and structural factors, is a key issue from an energy policy perspective.

The analysis in this chapter updates the information provided in the IEA *Energy Efficiency Market Report 2013 (EEMR 2013)* and also reflects refinements in the methodology and approach (Box 2.1). The *EEMR 2013* outlined the detail of indicators that the IEA collects in its energy efficiency indicators database, and used those indicators to describe how changes in indicators affect energy consumption and efficiency. This year's report systematically reports on the efficiency indicators by sector and, where possible, by energy end use to demonstrate changes over the past ten years.

Additionally, the decomposition methodology is updated to the Log Mean Divisia Index (LMDI), which provides more precision on the role of different factors on energy consumption. The baseline for evaluation has been set to 2001, providing better data coverage that allows for the number of countries evaluated in the decomposition to be expanded to 18.

Box 2.1 Chapter structure and differences compared to the *EEMR 2013*

The information presented in this chapter follows the same format used in the chapter in the *EEMR 2013* entitled, "What the numbers say: Energy efficiency and changing energy use". The analysis has been refined in several ways.

One departure from the 2013 presentation of this data is the grouping of the relevant sectors in alignment with the two key types of actor in the market: (a) individual consumers, and (b) businesses and public sector services. Individual consumers are the class of actor who acquire energy-efficient products for their personal use. The motivation is related to consumption for well-being, rather than profit, and the transactions are typically small in size. The second are businesses and public services that acquire energy efficiency goods and services to improve the cost-effectiveness of their operations, which ultimately provide goods and services to customers. These two groups are subject to different sets of drivers and behaviours that affect their energy consumption patterns and their investments in energy efficiency.

In addition, some figures in this chapter differ from last year in their graphical presentation. This follows the update from Laspeyres to LMDI decomposition analysis, described below in Box 2.3. Decompositions are shown as time series indexed to 2001 levels (e.g. evolutions each year from 2001 to 2011) rather than fixed time intervals (e.g. aggregate change over a period, such as 1990 to 2000 or 2000 to 2010 as used in last year's report). A time series approach facilitates a better understanding of the evolution of different factors over time.

Energy use data are available at different levels of analysis, from countries to sectors and sub-sectors. This chapter begins with a presentation of overall high-level trends for IEA member countries and discusses the broad relationships between population, energy use and GDP. These trends include the rising productivity of energy use – in terms of GDP generated per unit of energy. Energy intensity and productivity metrics are imperfect proxies for tracking changes in energy efficiency, so this discussion is followed by presenting more detailed energy efficiency indicators for 18 IEA member countries.¹ These indicators reveal how the efficiency of energy use has changed over the past decade, including decomposition analyses of the drivers of energy consumption for certain sectors. Sectors included are residential, passenger

¹ Countries are selected based on their submission to the IEA Energy Efficiency Indicators database. Only countries with detailed, consistent and comparable energy use and efficiency data are included in this analysis.

transport, manufacturing, commercial and public services, and freight transport. These are grouped by the market actors, i.e. energy users, being individual consumers or businesses and public services.

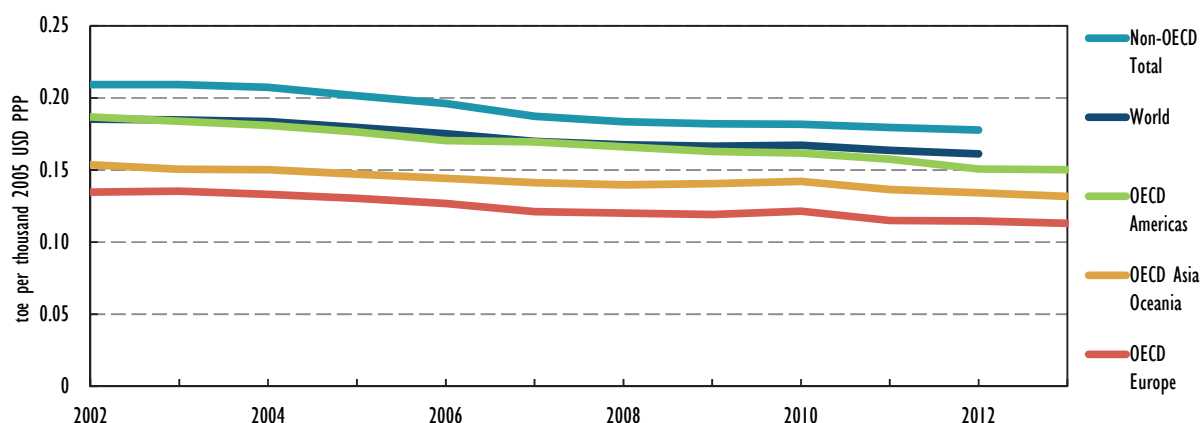
Energy efficiency indicators can be tracked at different levels of detail. The accuracy of aggregated metrics depends to a large extent on the availability and consistency of data at the sub-sectoral level by individual end users. More granular and disaggregated data and indicators can be combined to reveal sectoral, national, regional and even global metrics. The disaggregation and decompositions in this chapter reveal the value of more sophisticated approaches to tracking changes in energy use that account for which sectors use energy and for what purposes they use it. These approaches are well suited to tracking the impacts of energy efficiency policies and evaluating the impacts of the energy efficiency market on total energy consumption.

Global trends: Energy intensity continues to decline

The energy intensity of an economy is a measure of how much energy is required to produce a unit of national economic production. It is a relatively crude measure because comparisons between countries on the basis of energy intensity do not reflect differences in the structure of the economies, the size of the countries, the efficiency of energy use or different climates. On the other hand, at a high level, it can provide useful information about how closely countries' energy needs and economic performance are linked and how their relationship shifts over time. The sections below look at how energy intensity has evolved over the past ten years at a global level, and the benefits of reorienting the discussion towards energy productivity rather than intensity.

Energy intensity, measured in terms of total primary energy supply (TPES) per unit of GDP, has fallen over the past decade at world level (Figure 2.1). The average reduction was 1.6% between 2002 and 2012. OECD member countries have a lower intensity on average than OECD non-member economies, but a range of intensities remains within the OECD. Economies that are structured more towards resource extraction and heavy industry, and which have longer transport distances, tend to be relatively energy intensive.

Figure 2.1 Energy intensity (TPES per GDP) by region, 2002-13



Notes: PPP = purchasing power parity; toe = tonne of oil-equivalent. 2013 data are estimated.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

Another consideration related to energy intensity is that GDP is a highly aggregated expression of national economic activity, encompassing many factors and economic variables. It may not accurately reflect

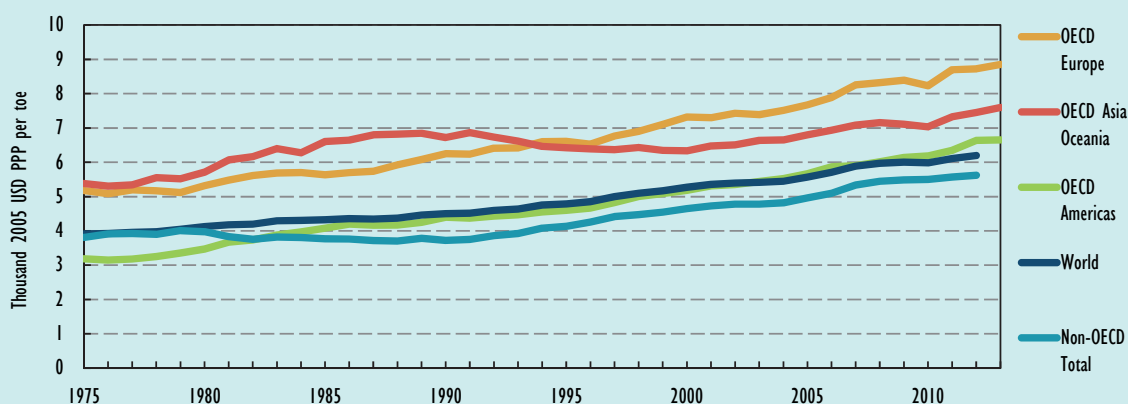
societal well-being, as it poorly reflects “natural capital” and does not include items with a non-market value such as positive and negative externalities.² Notwithstanding these failings, GDP remains the macroeconomic indicator of choice for governments and therefore any change in GDP as a result of energy efficiency activities is important.

The inverse of energy intensity is energy productivity, namely the amount of GDP output produced for each unit of energy input (Box 2.2). This may provide a more meaningful metric than energy intensity for policy makers and other economic actors that are interested in growing their economies as efficiently as possible.

Box 2.2 Regional improvements in energy productivity

Energy productivity provides insights into whether we are producing more economic output per unit of energy consumed. It also corresponds to similar concepts with respect to other inputs, such as labour, which is often evaluated in terms of “labour productivity”. Energy productivity has been increasing at a global level, as well as at regional levels (Figure 2.2). The last decade has seen growth in the energy productivity of OECD member country groups and OECD non-member economies. Energy productivity in OECD Americas grew by 22% between 2003 and 2013.

Figure 2.2 Increase in energy productivity (GDP per TPES) by region, 1975 to 2012



The energy intensity improvements necessary to achieve IEA scenarios

Energy supply needs to respond to the demand for energy. Economic activity and population, together with energy intensity, are key drivers of energy demand. This relationship is expressed by the equation:

$$\text{TPES} = \text{GDP/capita} \times \text{population} \times \text{TPES/GDP}.$$

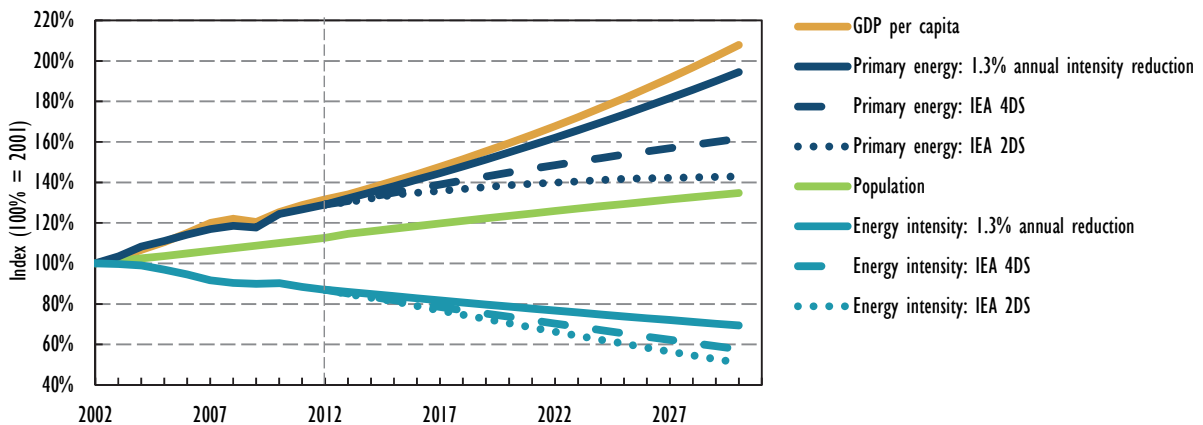
Small changes in intensity can lead to large and divergent changes in TPES under fixed GDP and population conditions. A review of changes in TPES, population, GDP and energy intensity reveals the following trends since between 2002 and 2012 (Figure 2.3):

- At world level, there has been a 13% increase in population and a 48% increase in GDP. TPES has increased by 29% yet TPES/GDP is down by 13%.

² The World Bank and the United Nations Development Programme (UNDP), for example, suggest using the Human Development Index and other indices to reflect broader measures of economic well-being (UNDP, 2014).

- The trend in TPES has thus largely been driven by GDP, which has risen almost four times as fast as population.
- If world GDP were to grow annually by 3.6%, and if the population grew to 8.4 billion by 2030,³ a continuation of the average annual improvement in energy intensity since 1971 would lead to TPES growth of 2.3% per year, a rate that would double TPES after 30 years.
- The IEA 4°C Scenario (4DS)⁴ foresees a rise of TPES of 143 exajoules (EJ) or 3 412 Mtoe, 25% above 2012 levels. This would require an annual decline in energy intensity of 2.3%.
- Keeping the rise in global TPES to the level envisaged for 2030 by the IEA 2°C Scenario (2DS)⁵ (63 EJ or 1 500 Mtoe, 11% above 2012 levels), would require an annual decline in energy intensity of 2.9% to 0.09 Mtoe per billion USD 2005 (PPP). This is 7% below the energy intensity of OECD Europe today.

Figure 2.3 Relationship of TPES to its key drivers (population, energy intensity and per capita GDP) at a global level, and scenarios to 2030



Notes: population projections from UNPD medium fertility projection (UNPD, 2013); GDP growth projection of 3.6% per year (IEA, 2013a). 2001 to 2011 data are from IEA statistics, which show a 1% average annual reduction in TPES/GDP between 2001 and 2011.

Sources: IEA (2013a), *World Energy Outlook 2013*, OECD/IEA, Paris; UNPD (2013), *World Population Prospects, the 2012 Revision*, United Nations Population Division, New York.

Energy efficiency: Metrics to isolate the impact of efficiency indicators

As shown in the above discussion of energy intensity, TPES is generally used to represent energy used in an economy as a whole because it captures the efficiency of conversion of primary energy sources into useful energy for consumers, including sectors such as refining or electricity generation. However, in analysing the impact of energy efficiency in delivering end-use goods and services with lower energy consumption, a more appropriate metric to analyse these improvements is TFC – namely, the sum of direct energy consumption by end-use sectors including residential, transport, services and industry. Accordingly, the analysis of the sectors presented in this chapter below use TFC.

The IEA has been working to improve the quality of its energy efficiency indicators to better capture the impact of energy efficiency on energy use and the economy. A decomposition analysis is used to isolate the impact of changes in energy efficiency – and the impacts of energy efficiency investment – from the other major drivers of energy consumption. The three drivers are structure (the mix of

³ UNDP medium fertility projection (UNDP, 2013).

⁴ The IEA 4DS takes into account recent pledges made by countries to limit emissions and step up efforts to improve energy efficiency. It serves as the primary benchmark of the IEA *Energy Technology Perspectives*.

⁵ The IEA 2DS describes an energy system consistent with an emissions trajectory that recent climate science research indicates would give at least a 50% chance of limiting average global temperature increase to 2°C. The 2DS is the main focus of the IEA *Energy Technology Perspectives*.

activities within a sector or economy), activity levels (the magnitude of activities undertaken)⁶ and energy efficiency (changes in the intensity of energy use that cannot be accounted for by structure or activity) (Box 2.2). The IEA is also working with countries to improve the extent and consistency of the data that enable this analysis, in particular across countries.

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

Sector	Service/sub-sector	Activity	Structure	Intensity (efficiency 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	Appliances ownership/ population	Appliances energy/ appliance stocks
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 ISIC groups are not included in the analysis: 10-14 Mining and quarrying; 23 Fuel processing; and 40-41 Electricity, gas and water supply. Industries in category "Other industries" are analysed only to a very limited extent in this study.

Source: IEA (2014b), *Energy Efficiency Indicators: Fundamentals on Statistics*, OECD/IEA, Paris.

Box 2.3 What is decomposition analysis?

Decomposition analysis quantifies the impact of different driving forces or factors on energy consumption. Understanding how each element affects energy consumption is essential to determining which offers the greatest potential to reduce energy consumption, and the areas that should be prioritised for the development of energy efficiency policies.

⁶ Adjusted for heating and cooling degree days, which can help to normalise energy use in terms of annual changes in weather patterns.

Box 2.3 What is decomposition analysis? (continued)

Decomposition of energy end-use trends often distinguishes between three main components affecting energy consumption: aggregate activity, sectoral structure and energy intensities (commonly ascribed to energy efficiency improvement).

- Activity refers to 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 household sector, by passenger-kilometres for passenger transport, and by tonne-kilometres for freight transport.
- Structure represents the mix of activities within a sector, e.g. share of production between each sub-sector of industry, the changing size of homes in the residential sector, or the modal share of vehicles in passenger and freight transport.
- Energy intensity is the amount of energy used per unit of activity. In the IEA decomposition analysis, changes in energy intensity are calculated at as disaggregated a level as possible, so that changes in energy intensity can be used as a proxy for developments in energy efficiency.

A key issue with decomposition analysis is the choice of activity variable. Ideally the selected activity metrics will utilise easily available data, and fit the stated policy objectives and programme activity objectives as closely as possible. Both physical activity metrics (e.g. tonnes) and activity value metrics (e.g. dollars) are useful for measuring energy efficiency, and both should be tracked on a consistent basis.

The IEA decomposition analysis in this report uses the LMDI methodology to separate out the influence of different factors on overall energy consumption.⁷ The decomposition analysis looks at six separate sectors: residential, passenger transport, freight transport, manufacturing, services and other industries. Table 2.1 shows the specific indicators used in each sector. Values in the Intensity column are the main efficiency indicators, which are presented for each sector in the sections that follow.

The energy efficiency effect in 18 IEA member countries

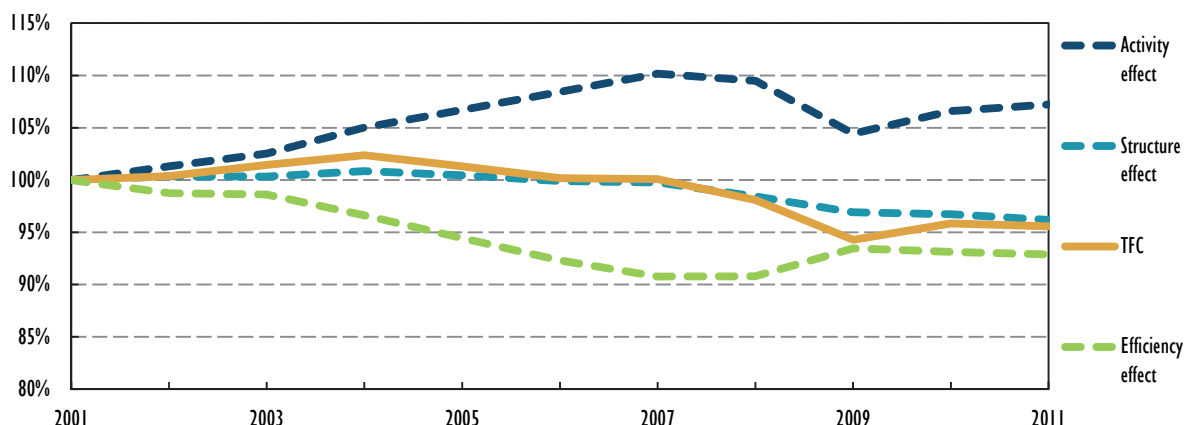
Detailed data are available for 18 IEA member countries, allowing economy-wide analysis on the impacts of activity, structure and intensity on overall energy consumption. This analysis was expanded from 11 countries in the *EEMR 2013*, as a larger sample can now be analysed by using LMDI methodology with the 2001 base year.⁸ The most recent year for which the detailed data are available is 2011. Figure 2.4 describes the impact on TFC – indexed to 2001 – of each driver in isolation for the 18 IEA member countries.⁹ Between 2001 and 2007, the efficiency effect alone would have reduced actual energy use by 10% between 2001 and 2007. However, in reality, the activity effect, as measured by changes in economic output, population and levels of travel, created an equal and opposite (upward) pressure on energy consumption between 2001 and 2007. Thus, efficiency effects counter-balanced the activity effect, leading to no net increase in energy consumption between 2001 and 2007. After 2008, when activity levels grew less strongly, actual energy use fell below 2001 levels as the structure and efficiency effects took over. This highlights the importance of total activity levels to energy consumption.

⁷ This is an updated methodology from the *EEMR 2013*, which used a Laspeyres decomposition methodology.

⁸ The *EEMR 2013* used a 1990 base year. Only 11 countries had comparable data going back to that time.

⁹ Note: the 18 IEA member countries were selected based on the completeness and consistency of their energy efficiency indicator data required to conduct an LMDI decomposition analysis. These countries comprise: Australia, Austria, Canada, Czech Republic, Denmark, France, Finland, Germany, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Spain, Sweden, the United Kingdom and the United States. For purposes of comparison, the sector decompositions presented below keep this sample of countries, although the sample of countries that can be decomposed changes by sector reflecting greater data availability in specific sectors.

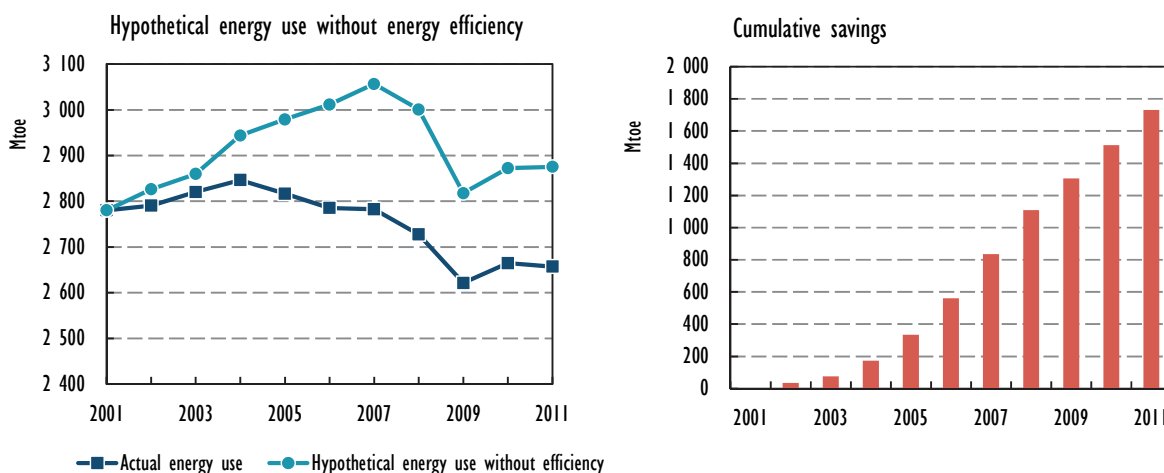
Figure 2.4 Changes in aggregate TFC relative to 2001 levels decomposed by factors for 18 IEA member countries, 2001-11



Notes: Countries comprise Australia, Austria, Canada, Czech Republic, Denmark, France, Finland, Germany, Italy, Japan, the Republic of Korea, the Netherlands, New Zealand, Spain, Sweden, Switzerland, the United Kingdom and the United States. All values are indexed to 2001 levels.

The period between 2007 and 2009 is characterised by a reversal in the long-term trend of improving efficiency on a year-to-year basis. The reason for the drop in efficiency gains is not entirely clear.¹⁰ Some of the activity, structural and intensity impacts appear to be spikes in long-term trends, so a longer data time series will be required to understand the lasting effect on the downturn on energy consumption. After 2009, the efficiency effect reverts back to a downward trend though less pronounced than between 2003 and 2007. The efficiency and activity trends are dominated by developments in the United States, which is the largest country in the group analysed.

Figure 2.5 Hypothetical energy use without efficiency and cumulative energy savings from energy efficiency for 18 IEA member countries



¹⁰ Certain factors can be put forward to explain why efficiency worsened from 2007 to 2009. The efficiency effect is measured by the change in energy intensity to satisfy energy services, and in many sectors service levels declined while energy consumption remained the same. To explain this outcome, we can take a hypothetical case of the freight industry during the recession. Total shipments of goods (the energy services) declined as demand declined, but the total movement of freight vehicles may not have decreased in proportion to the goods being shipped. Trucks would have moved goods at half load to maintain service levels, and a similar number of trucks would have hauled a lower tonnage over the same distance. The equivalent situation in manufacturing and industry is the running of plants at low capacity utilisation, but with continued energy overheads. Or, if production was stockpiled, a proportional increase in economic value-added would not have been recorded for the sector.

For the 18 countries reviewed, structural effects – such as changes in the relative economic importance of industries, shares of transport modes or household size or occupancy – seem to have been less important. While in some developed countries the shift to less energy-intensive production has had important energy implications, structure effects in aggregate have been less important in driving changes in actual energy use over the past ten years than energy efficiency.

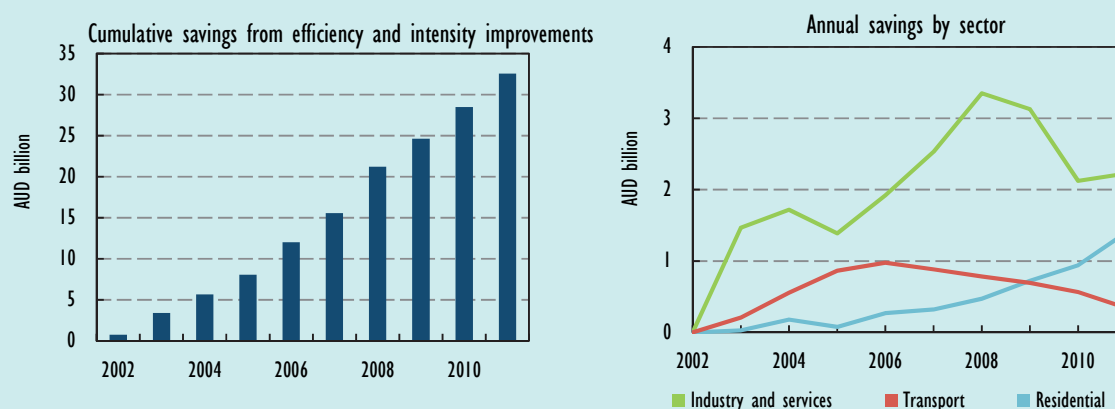
This decomposition allows for an estimation of the energy savings provided by energy efficiency improvements. Figure 2.5 outlines actual energy use and hypothetical energy use had efficiency not improved since 2001. This still accounts for changes in activity and structure across all countries, but removes the efficiency effect. By 2011, hypothetical energy use without efficiency would have been 218 Mtoe (9 EJ), or 8% higher relative to 2001 levels of efficiency. The cumulative savings for the decade from 2001 to 2011 resulting from efficiency improvements for these countries were 1 731 Mtoe.

Decomposition analysis isolating the role of energy efficiency can be used to demonstrate the value of energy savings specifically from energy efficiency. In Box 2.4 Australian energy expenditure is estimated without energy efficiency savings between 2001 and 2011, using energy price and energy consumption data by sector.

Box 2.4 Energy efficiency reducing energy expenditure in Australia

Controlling for structural and activity effects yields a better estimate of the magnitude of energy savings from the adoption of energy efficiency measures and other investments that reduce energy intensity. Using decomposition analysis, the IEA estimates that energy efficiency improvements in Australia saved a cumulative 33 Mtoe of energy between 2001 and 2011. The largest savings were in industry and services. With annual energy price and expenditure data from ClimateWorks Australia, the value of avoided energy expenditure can be estimated based on avoided energy from energy efficiency (Figure 2.6).

Figure 2.6 Energy expenditure savings from efficiency improvements in Australia



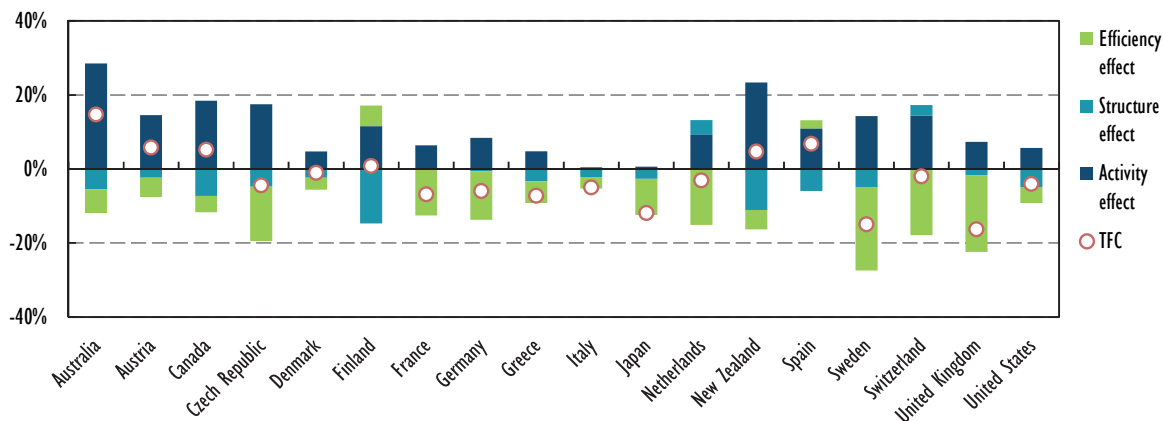
Note: avoided energy cost estimations are derived from weighted real end-use energy prices in each sector; efficiency savings are assumed to have been spread across all energy carriers evenly; this is not a dynamic equilibrium analysis that accounts for price feedback.

Cumulative savings from year-on-year efficiency improvements reached over AUD 30 billion between 2001 and 2011. Avoided energy expenditure in industry and services were in excess of AUD 2 billion annually between 2006 and 2011. Meanwhile, stagnant average vehicle efficiency led to no net energy costs savings in transport from energy efficiency by 2011. Savings from energy efficiency were on average 3% of total annual energy expenditure in Australia.

Energy efficiency indicators at the country level

Decomposition analysis of national energy use is available for each of the 18 IEA member countries analysed (Figure 2.7). This shows that energy efficiency has served to place downward pressure on TFC in 16 countries and is the primary driver of absolute reductions in TFC in 12 countries since 2001. Of the 12 countries that have reduced TFC since 2001, eight have experienced energy efficiency effects larger than total increases in activity.

Figure 2.7 Decomposition of TFC between 2001 and 2011 for 18 IEA member countries relative to 2001 levels



Energy efficiency patterns for individual consumers

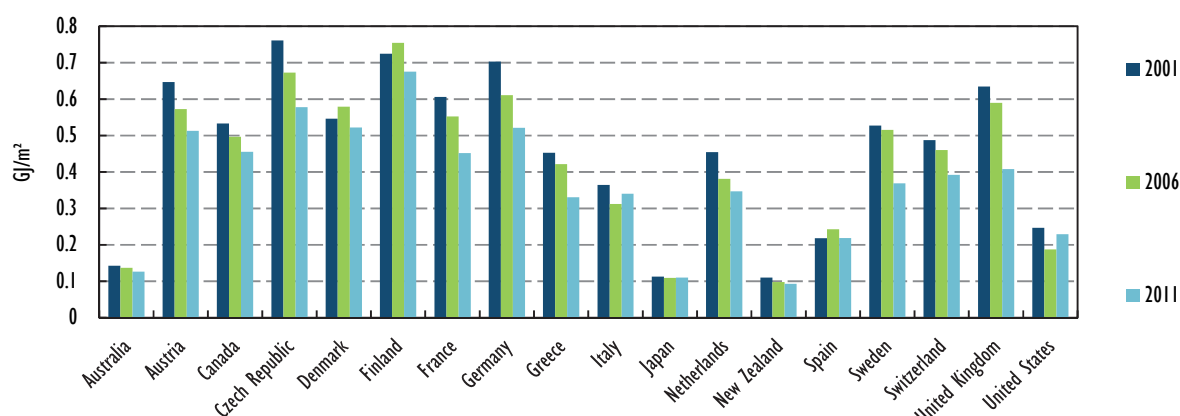
Individual consumers use energy for a variety of purposes, including heating, cooling, appliances, lighting, cooking and personal transport. They acquire energy-efficient products to reduce their consumption of energy in these areas. This section considers changes in energy efficiency indicators used in the residential sector over the past decade, and then looks at passenger transport. It concludes with the overall trends in energy consumption by individuals in the context of household energy prices and costs.

Disaggregating and decomposing residential energy use

Four main end-uses for energy in the residential sector are space heating, water heating, lighting and appliances. This section breaks down residential energy consumption into its major component end uses and outlines the change in how efficiently these energy services are being provided. It also decomposes residential energy use to show how efficiency has contributed to total energy use in the sector.

Space heating

The energy intensity of space heating is a function of the building floor area, climate, building shell efficiency and heating system efficiency. Space heating energy intensity has decreased over the period in almost all countries (Figure 2.8). However, due to a trend across IEA member countries towards larger homes and fewer inhabitants per home, these intensity improvements have not universally led to reduced total energy consumption for these services. TFC for space heating rose in Australia, Canada, Denmark, Finland, Greece, Italy, Japan and Spain between 2001 and 2011. In all of these countries, floor area grew faster than the combination of population, efficiency gains and fuel switching to electricity and gas. The largest percentage improvements in space heating between 2001 and 2011 were in the United Kingdom, the Czech Republic, France and Germany (Box 2.5).

Figure 2.8 Change in energy intensity of residential space heating as a function of floor area, 2001-11

Notes: GJ/m² = gigajoules per square metre. Space heating is adjusted for heating degree days. Values for Denmark also include water heating. Energy is measured as TFC for space heating, and floor area is measured as total residential floor area in the country. Any US energy efficiency indicator data are estimated by the IEA.

Box 2.5 Residential energy efficiency improvements in selected European countries

Residential space heating represents a high share of European TFC. In Germany, for example, this end use exceeds 70% of residential TFC. Thermal energy efficiency improvements, particularly insulation of buildings and boiler upgrades, have decreased the energy intensity of space heating in German homes by 28% from 2001 (0.70 GJ/m²) to 2011 (0.52 GJ/m²).

The first Czech National Energy Efficiency Action Plan (NEEAP-I), published in 2007, drew on national annual averages in final energy consumption between 2002 and 2006 to target a reduction of 19 842 gigawatt hours (GWh) (9%) in final annual consumption. The “2nd National Energy Efficiency Action Plan (NEEAP-II)”, published in 2011, incorporated upward revisions in Czech consumption statistics, and increased its 9% energy savings target to 20 309 GWh. NEEAP-II focused on households and thermal energy consumption reduction, with these projected savings comprising 28% of the overall target in energy savings (Government of the Czech Republic, 2011). Energy intensity in Czech space heating fell by 24% from 2001 (0.76 GJ/m²) to 2011 (0.58 GJ/m²).

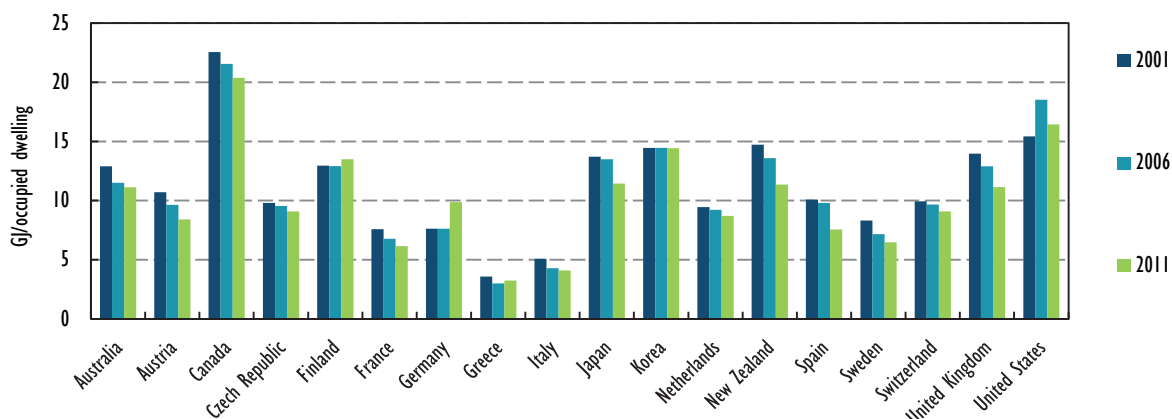
With an estimated 70% of current buildings predicted still to be in use in 2050, UK efforts to improve buildings’ energy efficiency have favoured retrofits (Department of Energy and Climate Change, 2012). From 2002 to 2013, the United Kingdom introduced its Warm Front Scheme to tackle fuel poverty, which offered grants for thermal energy efficiency improvements to over 1.7 million households. As a result, energy intensity of space heating fell by 35% from 0.63 GJ/m² in 2001, to 0.41 GJ/m² in 2011.

Water heating

Steady improvements in water heating energy intensity are also near-universal (Figure 2.9). In many cases, reductions in the energy intensity of heating coincide with policy measures directed at efficiency in the residential sector. This is notably the case in European countries, which have demonstrated some of the largest proportional improvements, especially in northern Europe where winter temperatures are lower and heating requirements higher. While efficiency policies and technologies have had an impact, for instance through boiler standards and labelling, part of the improvement relates to fuel switching. In France, the proportion of water heating provided by oil declined from 25% to 15% between 2001 and 2011, while electricity rose from 36% to 44%. In the Netherlands, on the

other hand, the fuel mix did not alter and intensity improvements can be attributed more directly to efficiency changes. In Korea, the energy intensity of water heating dropped between 2006 and 2011 after increasing by one-third between 1996 and 2006. In Germany, despite efficiency gains, the share of electricity and district heating in residential heating fell between 2006 and 2011 while use of oil, biomass and, in particular, natural gas rose.

Figure 2.9 Change in energy intensity of residential water heating as a function of occupied dwellings, 2001-11

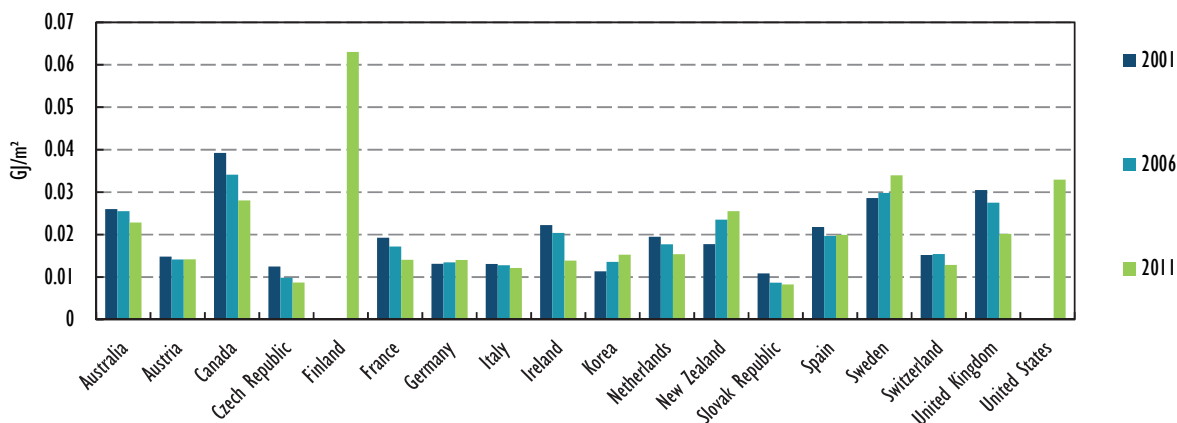


Notes: GJ = gigajoule. Water heating is adjusted for household occupancy. Data for Denmark are unavailable.

Lighting

Despite the introduction of regulations to phase out incandescent lamps in many countries during the period 2001 to 2011, improvements in the energy intensity of lighting have not been universal (Figure 2.10).

Figure 2.10 Change in energy intensity of residential lighting as a function of residential floor area, 2001-11



Note: Data for Finland and the United States are unavailable for 2001 and 2006; data for Denmark, Greece and Japan are unavailable.

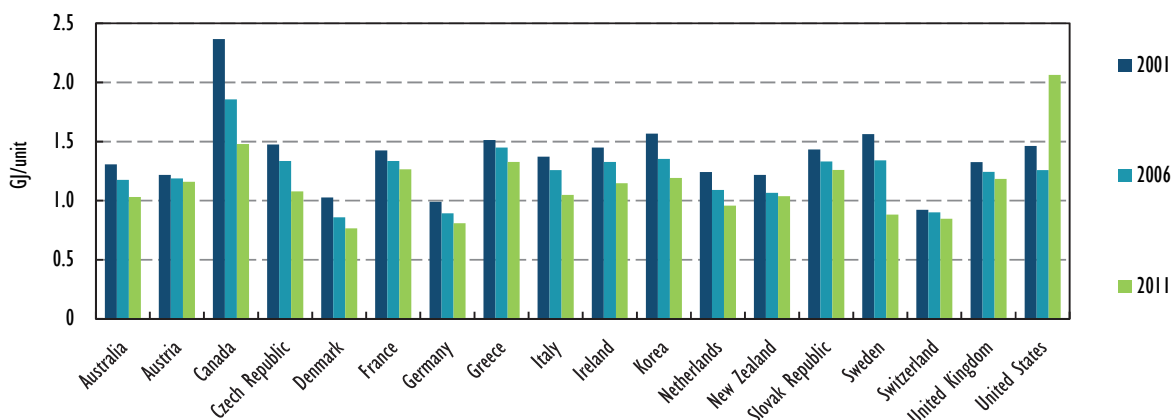
The European Union (EU) Ecodesign Requirements on Household Lamps, which came into force in 2009, aimed to phase out the sale of incandescent lamps by 2012 (European Commission, 2009). The pace of stock turnover inevitably leads to delayed improvements in the efficiency of lighting at a national level; however, intensity increases in Germany and Sweden are the result of more lighting per unit of residential floor area. The United Kingdom has seen large improvements in its lighting

efficiency in the last ten years thanks to efficiency standards. Between 2001 and 2010, the average efficiency of new lamps sold has more than doubled from 13.2 lumens to 27.4 lumens per watt (IEA 4E, 2011). This was achieved with voluntary agreements with lighting retailers and eventual regulatory measures to reduce the amount of incandescent lamps sold by 85% between 2000 and 2010; replacing them were more efficient bulbs, notably compact fluorescent lamps (CFLs). The number of CFLs sold increased 11-fold during this period.

Appliances and consumer electronics

Appliances and consumer electronics are a growing source of energy consumption for households, fuelled by new appliances placed on the market to provide end uses such as recreation and communication. In most of the 18 countries evaluated, the demand for white goods (e.g. refrigerators and washing machines) is no longer growing significantly, while the efficiency of these appliances is increasing, which reduces their total energy consumption (Figure 2.11). This stands in contrast to appliances such as televisions, personal computers and other personal devices that are increasing in size or in other energy consumption requirements. For example, the energy intensity of televisions (in GJ per unit) rose by more than 50% in Australia, Canada, Denmark, France and the Netherlands between 2001 and 2011.

Figure 2.11 Change in energy intensity of large household appliances as a function of appliance stocks, 2001-11

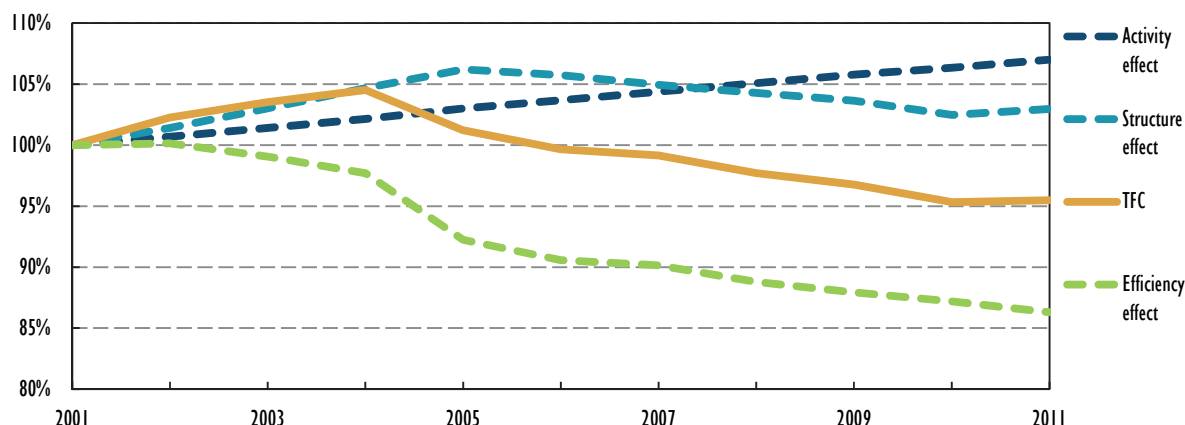


Notes: Large household appliances comprise refrigerators, freezers, dishwashers, clothes washers and clothes dryers. Data for Finland, Japan and Spain are unavailable; data for the Slovak Republic do not include dishwashers, clothes washers or clothes dryers; data for the United States do not include dishwashers, clothes washers or clothes dryers until 2011, explaining why intensity increased.

Decomposing residential energy consumption

Residential energy consumption reduced in absolute terms between 2001 and 2011 among the 18 countries evaluated, owing specifically to the concerted efficiency improvements in the sector (Figure 2.12 and Figure 2.13). As outlined in Part 2 of this report and in the *EEMR 2013*, the residential sector has been the focus of many countries' efficiency policies and programmes. It is also a sector with relatively inexpensive but important efficiency improvements that can be regulated or incentivised. The move from incandescent bulbs to CFLs is one example. The efficiency effect is estimated to have reduced TFC in this sector between 2001 and 2011 by 463 Mtoe cumulatively. This has helped to overcome activity and structure effects that would otherwise have pushed energy consumption higher. Key structural drivers are the move to larger homes and the subsequent need for more lighting and opportunities for more appliances.

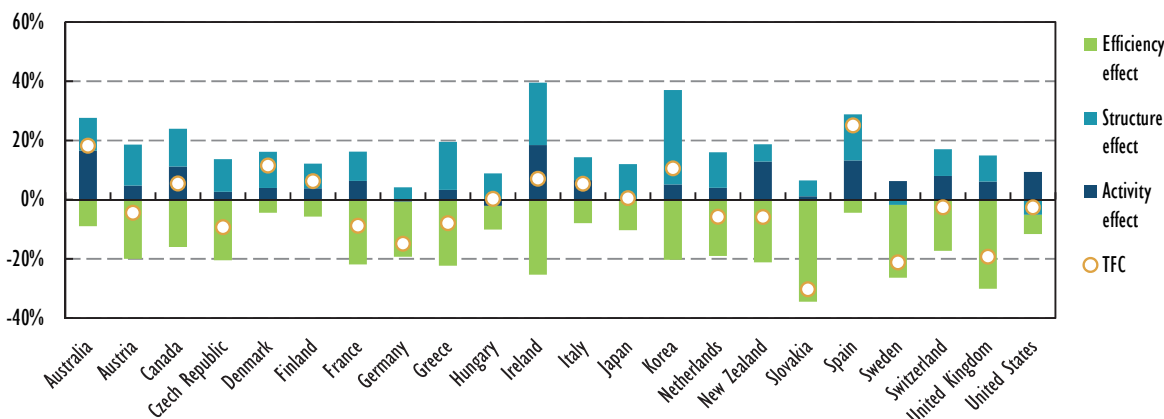
Figure 2.12 Changes in aggregate residential energy consumption relative to 2001 decomposed by factors for 18 IEA member countries, 2001-11



Note: Countries comprise 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.

The sample of countries that can be decomposed for residential energy consumption is expanded from 18 to 22 countries thanks to greater availability of end-use data. All countries analysed have made energy efficiency improvements in the sector, and TFC has been reduced below 2001 levels in 12 countries with efficiency being the primary factor.

Figure 2.13 Changes in national residential energy consumption relative to 2001 decomposed by factors for selected IEA member countries, 2001-11

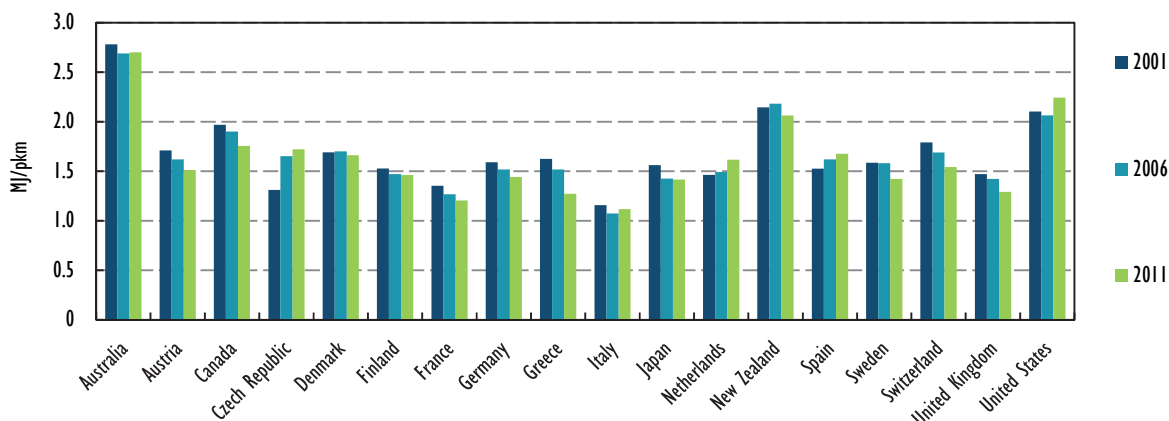


Energy efficiency indicators for passenger transport energy use

The efficiency of passenger transport can be measured by the energy used to move one passenger 1 kilometre. This intensity metric (energy per passenger kilometre [pkm]) has decreased in most countries over the decade considered (Figure 2.14). In the United Kingdom there was a strong improvement, as passenger-kilometres travelled by train – which is among the least energy intense modes of passenger transport – rose by 42% over the period, while pkms by other forms of transport were largely unchanged. Trains were also the fastest-growing mode in absolute terms in France, Japan and the Netherlands. In Australia and the United States, passenger air transport – the most energy-intensive mode of passenger transport – was the fastest-growing mode of transport in absolute terms. In Italy buses grew the most, adding 7 billion pkm per year over the decade. In all other countries, cars and light-duty vehicles

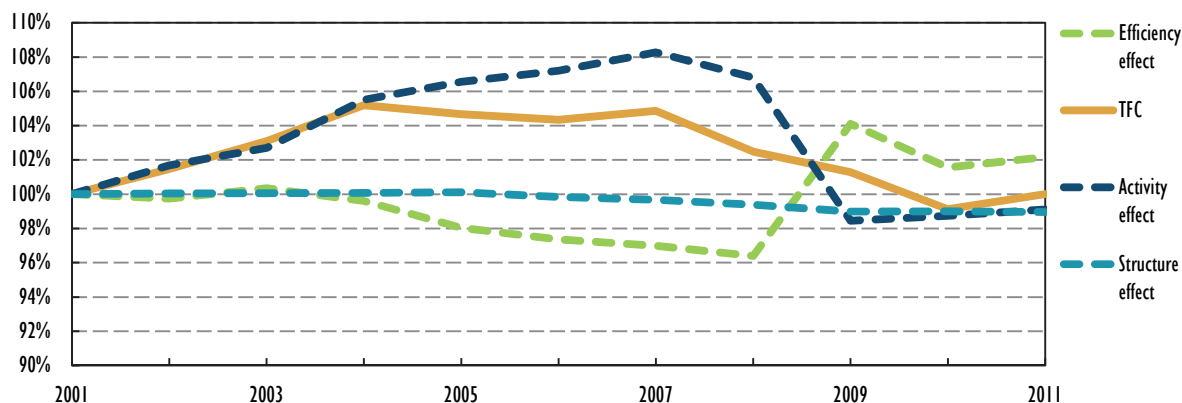
added the most passenger-kilometres, and only in the Czech Republic, Italy, Japan, the Netherlands and the United States did the number of passenger-kilometres decline. For a detailed assessment of efficiency trends in the transport sector please see Chapter 3.

Figure 2.14 Change in energy intensity of passenger transport, 2001-11



Notes: MJ/pkm = megajoule per passenger-kilometre. Passenger cars, buses, passenger trains and passenger aircraft are included; however, the Netherlands and Switzerland do not include passenger aircraft; for air transport, only domestic flights are included (except for Canada which includes international flights), leading to some bias in relation to the different treatment of flights within, for example, the United States compared to flights within the European Union. Energy intensity in the United States reversed in 2011 in part because of a methodological change classifying passenger vehicles between 2008 and 2009.

Figure 2.15 Changes in aggregate passenger transport energy consumption relative to 2001 decomposed by factors for 18 IEA member countries, 2001-11



Note: Countries comprise 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.

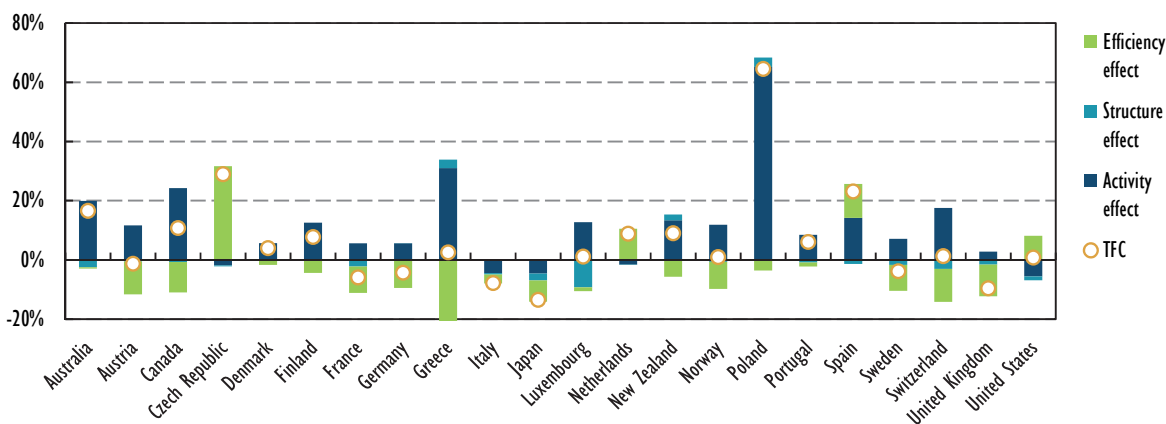
These changes led to total reductions in energy consumption in passenger transport in Austria, France, Germany, Sweden and the United Kingdom despite increases in total passenger-kilometres. In Italy and Japan, total energy consumption for passenger transport declined as a result of efficiency gains, mode switching and fewer passenger-kilometres overall. In the remaining countries, total energy consumption for passenger transport rose, as increased passenger-kilometres outweighed intensity improvements.

Decomposing passenger transport energy use across the 18 countries reveals how important these efficiency effects can be in influencing TFC in the sector. The improvements in efficiency served to mitigate the rise in energy consumption due to increased passenger-kilometres between 2001 and 2007, but TFC

still increased by over 4% (Figure 2.15). This decomposition confirms that efficiency worsened in the post-recession era, as reflected in the increase in TFC tied to the efficiency factor between 2007 and 2009.

Decomposition by individual country reveals a number of trends including an increase in efficiency in a majority of the countries (Figure 2.16). Several countries – Austria, France, Germany, Italy, Japan, Sweden and the United Kingdom – have had success in reducing total transport energy use thanks largely to efficiency improvements driven by fuel efficiency standards.¹¹ In Japan, the 2010 target for passenger cars was a 23% increase in kilometres per litre of fuel compared to 1995 levels. Various European countries have also had success in limiting the growth of energy use in transport through improved vehicle efficiency, more so than from structural shifts to different transport modes. Several countries (such as the Czech Republic, the Netherlands, Spain and the United States) experienced a reduction in efficiency in passenger transport. Moreover, total activity levels were higher in 2011 than in 2001 in most countries, driving up TFC for this sector in many countries.

Figure 2.16 Changes in national passenger transport energy consumption relative to 2001 for selected IEA member countries, 2001-11



Energy efficiency's impact on affordability of energy services for individual consumers

The affordability of energy services is in large part a function of two factors: energy prices and the amount of energy needed to deliver the desired services. If less energy has to be purchased to meet the service needs of consumers, these services each become more affordable than they would otherwise have been, unless counter-balanced by increases in prices. The last decade has seen a continuing trend towards increasing prices for most fuels (Figure 2.17).¹²

The data presented in the previous sections show that energy efficiency measures have had a strong downward influence on energy use in the residential sector and to a lesser extent in passenger transport. These two sectors form the basis of energy expenditure for individual consumers.

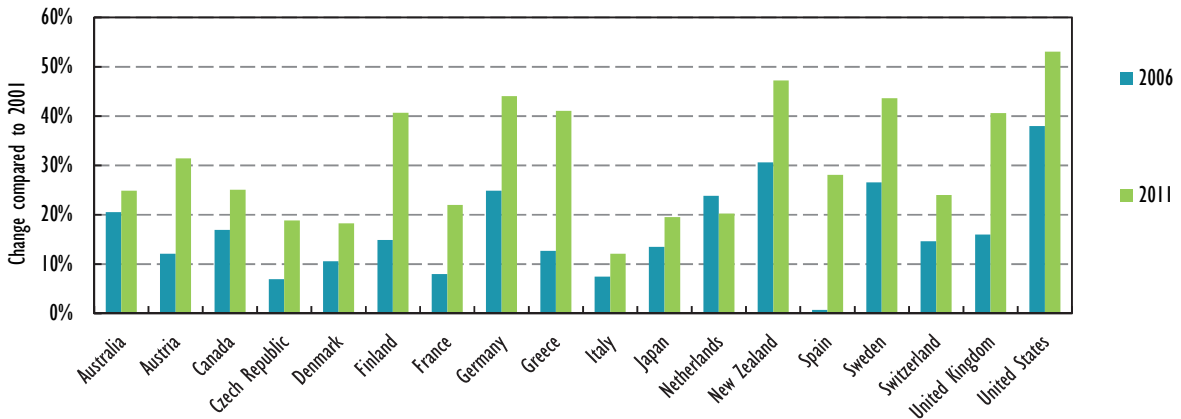
In general, the proportion of disposable household income that is spent on energy has risen in many IEA member countries (Figure 2.18). Of the 13 countries analysed, 11 saw an increased share of

¹¹ See Chapter 3 on transport for more detail on the effects of technology and policy on passenger transport intensity.

¹² 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. Electricity is more expensive per unit of energy to provide to households, but is capable of satisfying a wider array of energy service demands than other energy carriers. In 15 of the 18 countries shown in Figure 2.17 (all but Canada, Denmark and Sweden), the share of electricity in residential energy consumption increased between 2001 and 2011, sometimes by as much as 22% (up to 21% in Germany, 28% in Switzerland and 25% in the United Kingdom) or even 40% (up to 35% in France).

disposable income being spent on energy since 2001. A higher share of income is being spent on energy even in countries that reduced individual consumption of energy for both residential uses and passenger transport.

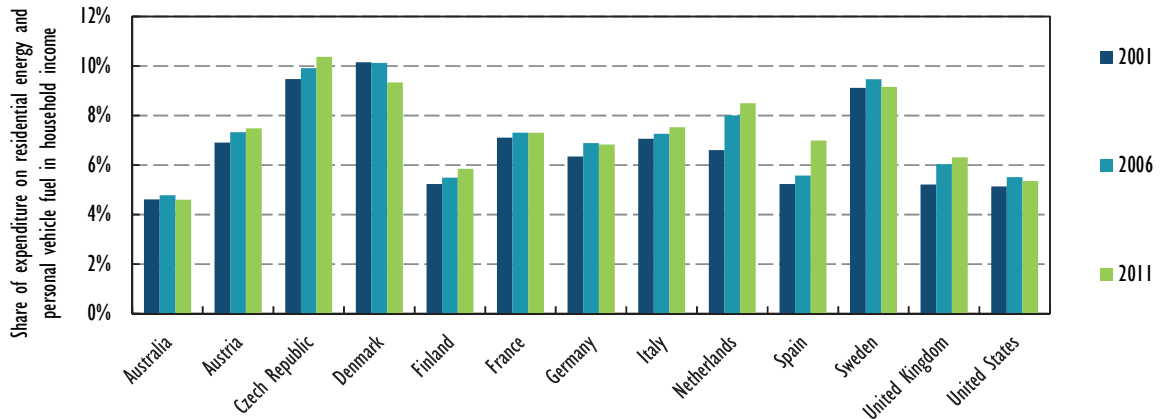
Figure 2.17 Increase in the weighted price of one unit of energy for individual consumers in 18 IEA member countries, 2001-11



Notes: based on IEA indices of real energy prices for households (total energy); these indices are an estimation of weighted average prices per unit of energy after tax across a range of fuels used by residential consumers and for passenger transport. Gasoline for personal transport is included in the household index, but automotive diesel is not (IEA, 2014c).

Source: IEA (2014c), *Energy Prices and Taxes, Quarterly Statistics, First Quarter 2014*, OECD/IEA, Paris.

Figure 2.18 Share of disposable income that is spent on energy, 2001-11



Notes: Household energy expenditure and income data are from OECD statistics; household energy expenditure is calculated as the sum of household expenditure on electricity, gas and other residential fuels and household expenditure on personal vehicle operational costs, adjusted to eliminate vehicle maintenance costs. A constant multiplier of 0.6 is used to calculate vehicle fuel expenditure from total vehicle operational expenditure, i.e. assuming that maintenance and equipment costs are 40% of the total. Data for Canada, Greece, Japan, New Zealand and Switzerland are not available.

In this context, energy efficiency can operate as a counterweight that reduces the impact of higher fuel prices on energy bills and therefore household budgets by dampening the demand for energy consumption in residences and for passenger travel. This can represent an opportunity for government action. Depending on the initial capital and transaction costs, it can also provide an important motivator for energy efficiency investments by individuals.

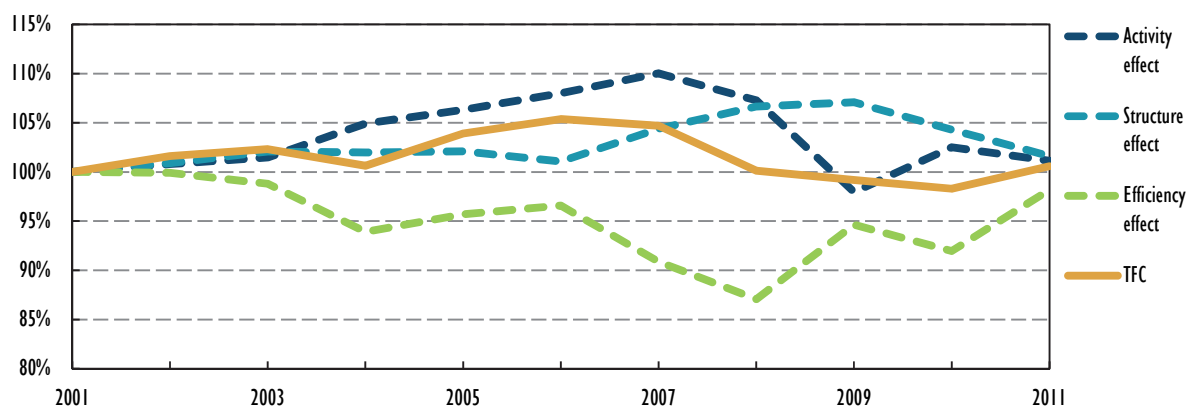
Energy efficiency patterns of business and public services

Businesses and public services use energy for a variety of purposes, ranging from powering industrial processes to lighting buildings and transporting goods. This section looks at energy efficiency indicators for freight transport, and then looks at the industrial and service sectors. It concludes with the overall trends in energy consumption by businesses and public services.

Disaggregating and decomposing energy use in freight transport

The decomposition of the freight industry highlights the relatively limited overall impact of energy efficiency on TFC since 2001 (Figure 2.19). This is largely due to the economic crisis, which has had a deleterious impact on energy efficiency since 2007; this is likely to be the result of freight vehicles operating at lower capacity factors. The share of more energy-intensive freight transport modes (structure effect) also rose, offsetting the reduction in energy use that would have resulted from fewer tonne-kilometres being transported after the crisis. At the country level, the energy intensity of freight transport increased in nine of the selected countries between 2001 and 2011 (Figure 2.20).

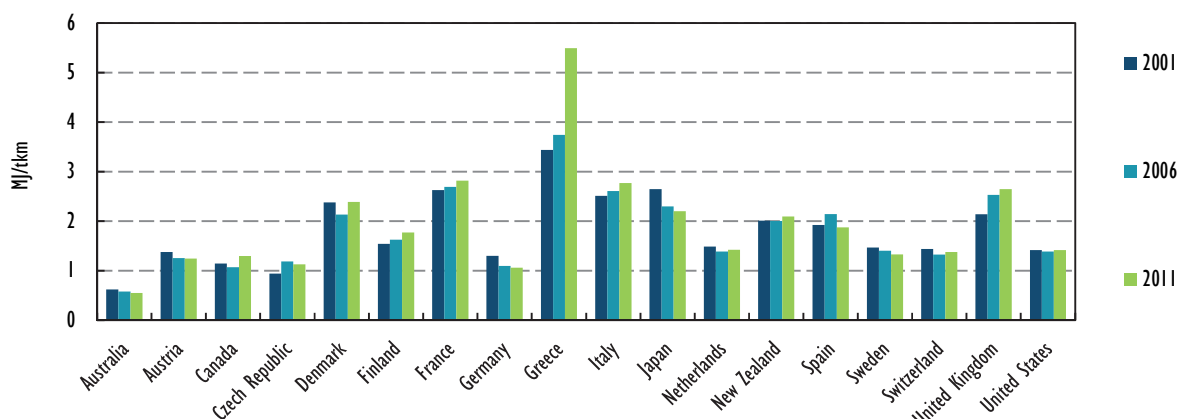
Figure 2.19 Changes in aggregate freight energy consumption relative to 2001 decomposed by factors for 18 IEA member countries, 2001-11



Note: Countries comprise 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.

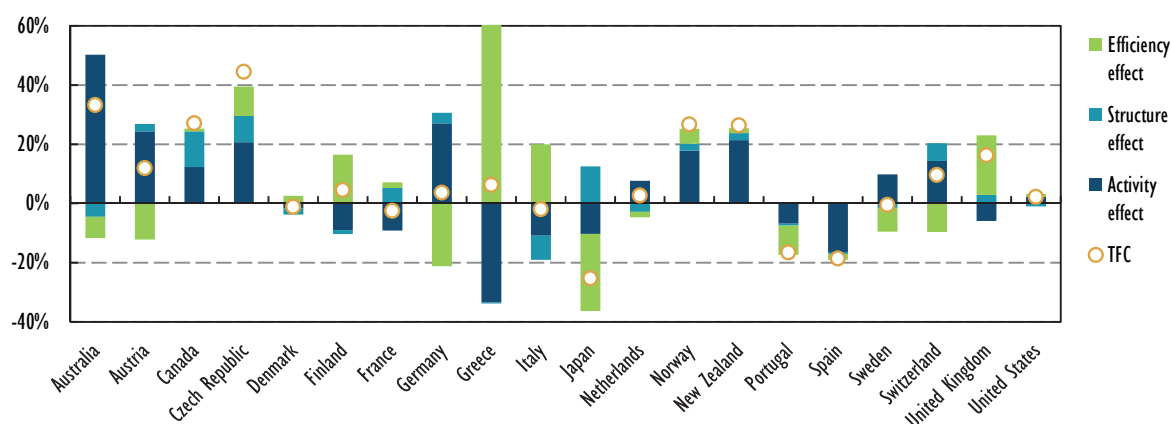
A decomposition analysis of this increase in intensity at country level points to a varying set of drivers across countries. Of note, eight countries saw a positive efficiency effect, while ten others saw deterioration over this same decade (Figure 2.21). Of the seven with improved efficiency, five saw an increase in TFC, as activity effects outweighed any efficiency gains. In fact, activity has been the largest driver of energy consumption in 10 of the 12 countries that experienced higher total energy consumption in the freight sector. Structure effects have been important in only four countries. Japan's improvement in the energy intensity of freight transport is noteworthy because road transport increased its share of tonne-kilometres from 54% to 62% over the decade to 2011, while less energy-intensive ship freight fell from 42% to 34% (helping to drive an upward structural effect). Greece, hit acutely by the recession, is likely to have seen a significant reduction in the amount of freight transported, with a consequential increase in the number of freight vehicles operating below capacity; the combination of fewer tonne kilometres at higher energy intensity resulted in a small increase in total energy use in the Greek sector.

Figure 2.20 Change in energy intensity of freight transport as a function of tonne-kilometres, 2001-11



Notes: MJ/tkm = megajoule per tonne kilometre. Freight transport includes road, rail and water transport; Denmark, Finland, and Greece exclude marine transport from total freight transport; this would serve to increase freight transport energy intensity relative to other countries that include marine transport if there are significant volumes of freight travelling by marine modes.

Figure 2.21 Decomposition of change in national freight transport energy consumption relative to 2001 of selected IEA member countries, 2001-11



Industry and services

As a general trend across the countries analysed, energy used in industry¹³ decreased between 2001 and 2011, while it increased in commercial and public services (Figure 2.22). The following sections consider the national trends in manufacturing and service sector energy intensity. It then looks at the issue of structural change, which appears to be a key driver for these sectors.

¹³ 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.

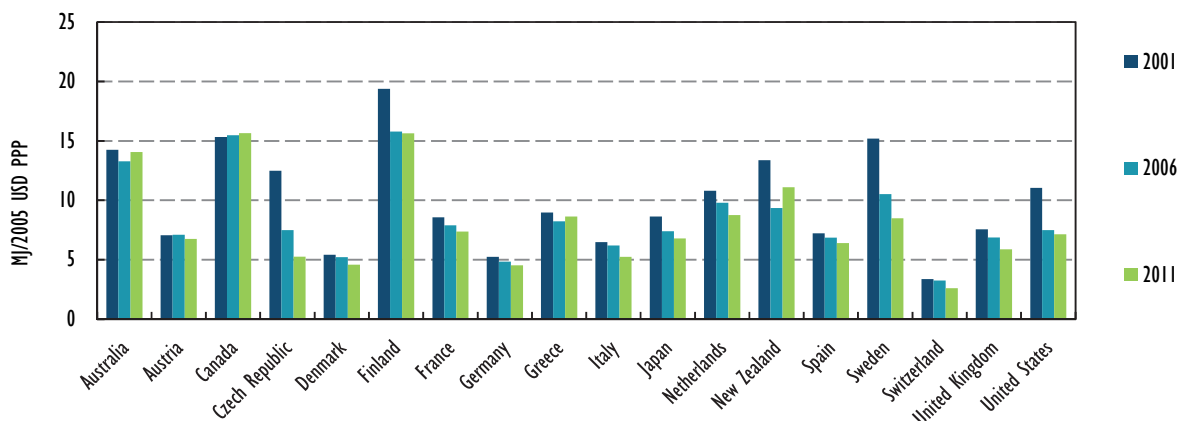
Figure 2.22 Change in national manufacturing, commercial and public services energy consumption among selected IEA member countries, 2001-11



Industry

The evolution of manufacturing¹⁴ energy intensity between 2001 and 2011 shows a trend towards lower intensity in all countries except Canada (Figure 2.23). There was also an absolute reduction in final energy used in industrial sectors in 13 of the 18 countries, the exceptions being Australia, Austria, Germany, Korea and Switzerland. Due to a lack of data, a rigorous decomposition analysis is not practicable. Given the important weight of industry in TFC, together with services, better data collection and analysis of energy use and efficiency would provide benefits for policy makers and market actors to identify opportunities and to achieve greater efficiency improvements.

Figure 2.23 Change in energy intensity of manufacturing as a function of value added among selected IEA member countries, 2001-11



Note: MJ = megajoule.

Finland and Sweden experienced large reductions in the energy intensity of manufacturing. They help to illustrate the impact of energy efficiency policy drivers (Sweden) and structural effects (Finland).

- While modulated by the impacts of recession in 2008 and 2009, the reduction in Sweden's energy intensity has been driven primarily by the country's commitments to its 2020 energy savings targets.

¹⁴ Manufacturing comprises 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, for which manufacture of coke and refined petroleum products is included, and Canada for which bitumen extraction from the oil sands is accounted in the mining sector.

Sweden's export-oriented economy is highly energy intensive. The implementation of the Swedish programme for improving energy efficiency in energy-intensive industries (PFE) in 2005 has played a key role in Sweden's attempts to realise (and even exceed) this target. A total of 180 energy-intensive industries entered the five-year PFE voluntary agreement, which rewards the implementation of profitable energy savings measures with an exemption from the EU minimum tax on electricity. By the programme's end in 2009, PFE participants had achieved cumulative energy savings of approximately 1.45 terawatt hours per year, or roughly USD 77 million in economic value. Industrial energy efficiency must remain an economic priority of the Swedish government as it attempts to meet its 2020 energy intensity reduction target.

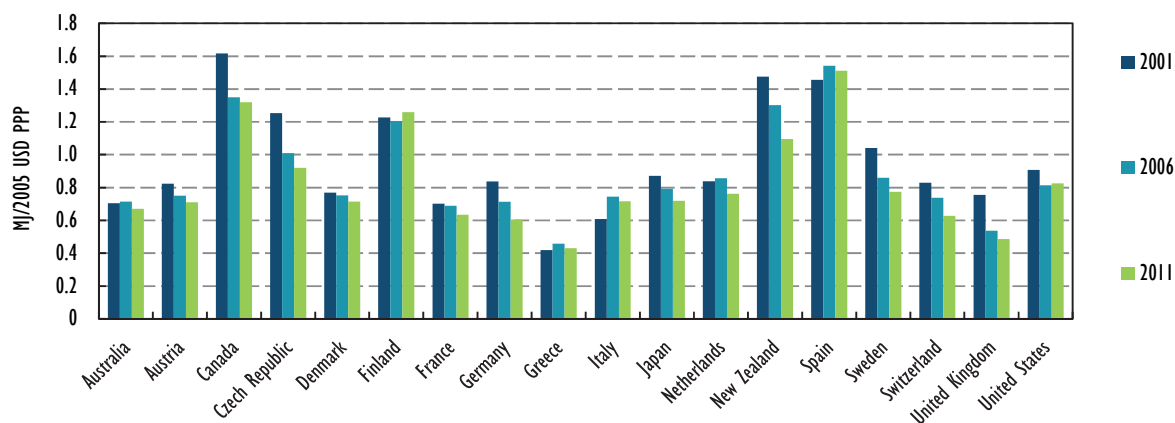
- The energy intensity of Finland's manufacturing sector has declined more than the EU average in the last 10 years (a 28% reduction on 2001 levels in 2011, compared to the EU average of a 23% reduction), and this reflects the significant impacts of recession and consequent structural changes in its manufacturing economy. From 2000, strong growth and innovation had elevated Finland to one of the OECD's most competitive economies; but Finland suffered under the 2008 recession. Forestry and electronics, the dominant industries in Finland's manufacturing sector, were hit particularly hard by the crisis, reducing industry's share of real value-added GDP from 26% in 2007 to 19% in 2012 (OECD, 2013). The electronics industry in particular has declined from 6% of total value-added production in 2007 to just over 1% in 2013 (OECD, 2014). Energy intensity in industry has declined correspondingly (down by 4% in 2011, and by 5% in 2012) (Statistics Finland, 2013), from a 2007 peak that had pushed Finland's energy consumption per capita to the highest levels in the IEA (IEA, 2013b).

Services

In the service sector, energy intensity declined between 2001 and 2011 in 14 of the 18 countries (Figure 2.24). Energy demand from services increased in Australia, Austria, Denmark, Finland, France, Greece, the Netherlands, New Zealand, Spain and the United States over the same period. In Australia and Spain, this increase was by more than one-third.

It is not practicable to conduct a decomposition analysis for services to isolate the efficiency effect given limitations in data. However, shifts in the relative shares of manufacturing and services provide interesting insight into how structure is affecting TFC.

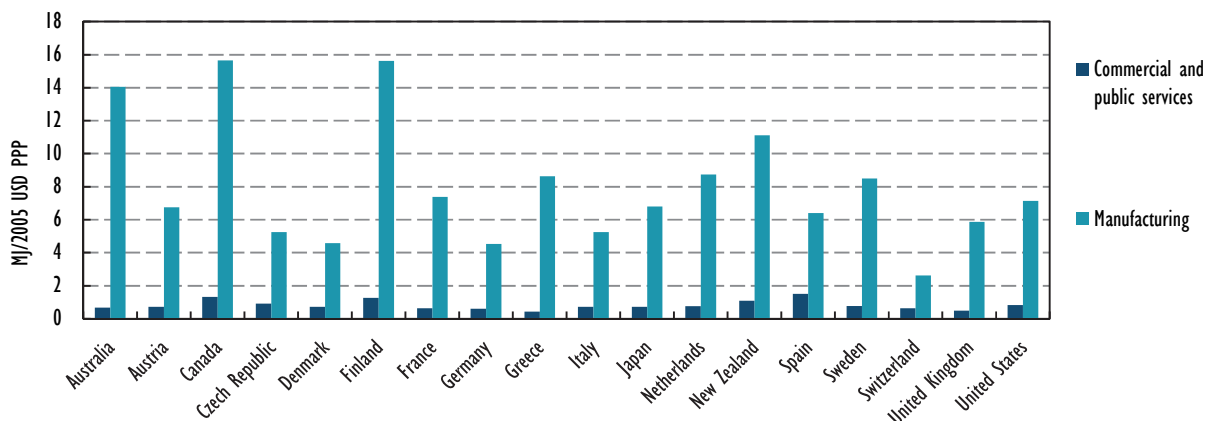
Figure 2.24 Change in energy intensity of services as a function of value added, 2001-11



Changing energy intensity: The impact of structural changes between industry and services

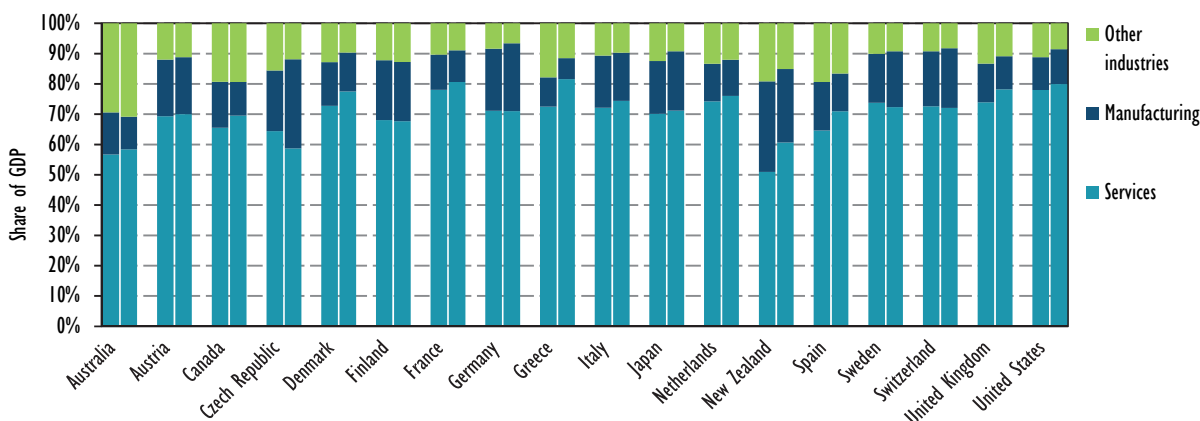
The creation of one unit of value added in the manufacturing sector requires on average around ten times as much final energy input compared to the commercial and public service sectors; this is true across a variety of IEA member countries (Figure 2.25). Accordingly, changes in the energy used in the economy are related to changes in economic structure between manufacturing and services.

Figure 2.25 Relative energy intensities of the manufacturing and services sectors in relation to value added



Therefore, changes in economic structure can have a large impact on the overall balance of energy used per unit of GDP, and each increase in the share of GDP generated by services instead of manufacturing has a corresponding impact on energy intensity. The share of GDP generated by the services sector rose in almost all countries (Figure 2.26).

Figure 2.26 Change in the relative shares of manufacturing and services contributions to value added, 2001-11



Conclusion

IEA data show that energy productivity has been increasing at a global level, meaning that we are generating more GDP output for every unit of energy put into the economy. The last decade has seen growth in the energy productivity in OECD member countries and OECD non-member economies.

At the same time, the 18 IEA member countries analysed in this chapter have seen cumulative savings from efficiency improvements between 2001 and 2011 amounting to 1 731 Mtoe. TFC is decreasing in many IEA member countries for individual consumers, businesses and public services – the key actors in the energy efficiency market. In the case of individuals, this can largely be attributed to efficiency improvements in the residential sector and to lower levels of travel in the post-recessionary period. The story for businesses and public services is similar, with a reduction in absolute energy consumed for manufacturing, services and freight transport in 10 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 as a whole.

This chapter has provided indications of the apparent positive impact of investments in the energy efficiency market. In addition, it points to the potential for policy makers to stimulate further the energy efficiency market to generate further energy 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 outcomes. It has been shown that the necessary collection of data is feasible, and that economy-wide and sectoral indicators can be standardised to provide useful insights for policy makers and market actors. Greater efforts are needed to improve data collection in order to support policy makers, company decision makers and others to develop stronger policies and programmes and to identify and better exploit market opportunities.

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3. THE MARKET FOR ENERGY EFFICIENCY IN TRANSPORT: A FOCUS ON THE LAND-BASED SUB-SECTOR

Summary

- The total transport market is enormous, in particular for land-based transport: expenditure on vehicle and fuel purchases and investment in infrastructure (such as roads and urban transport systems) was USD 6.9 trillion in 2010. Investment in energy efficiency is estimated to represent only a portion of this expenditure (e.g. for efficiency improvements in vehicles), but the amount in absolute terms represents an important part of the overall energy efficiency market, which is valued at between USD 310 billion and USD 360 billion.
- In the next ten years, passenger light-duty vehicle (LDV) purchases are expected to represent the transport category seeing the largest growth in spending, and therefore present the largest market opportunity for energy efficiency deployment. The *World Energy Investment Outlook* (IEA, 2014c) estimates that the efficiency market for vehicles will be USD 80 billion annually by 2020. Investment in efficient vehicles is expected to represent over 60% of all incremental investment in energy-efficient technologies globally during this period.
- Fuel expenditure is a key driver of efficiency, with current global expenditure of USD 2.2 trillion. The market for efficiency in transport is global, with the most potential resting in large emerging economies. Efficiency improvements in the transport system could reduce fuel expenditure by between USD 40 billion and USD 189 billion annually by 2020, depending on the adoption of new policies and the scale of market activity they achieve.
- Fuel economy standards are the critical lever for achieving efficiency gains in the transport sector, given rising passenger LDV adoption and increasing mobility demand; they covered more than 50 million vehicles sold in 2011, or 70% of the global vehicle market. These standards are expected to deliver the largest efficiency outcomes in the transport market, and provide a strong signal for markets to deploy efficient technologies and services in the coming decades.
- There is a growing focus on achieving efficiency improvements in heavy-duty vehicles (HDVs), with the United States, Japan and Korea implementing efficiency-based standards. HDVs are driving higher energy use in the transport sector, while efficiency gains have been comparatively small compared to passenger vehicles. Energy efficiency market activity in the HDV sector is likely to intensify in response to new standards and oil prices, should they continue to increase.
- Transport demand in OECD non-member economies is increasing, but is levelling off in OECD member countries, with a corresponding geographical shift in the potential energy efficiency market. Passenger vehicle ownership is levelling off or even declining in OECD member countries, which still have the highest rates of vehicle use and distance travelled per vehicle, but show limited change from one year to the next. Passenger travel demand in OECD non-members is projected to continue increasing – by a further 90% between 2011 and 2020.

- Investment in transport infrastructure, such as mass transit, including high-speed rail (HSR), bus rapid transit (BRT) and urban rail, can have important efficiency outcomes. Modal shift, achieved in part by investment in alternative transport infrastructure, could deliver net system efficiency benefits of over USD 70 trillion by 2050.

Introduction

This chapter explores developments in the market for energy efficiency in the transport sector. The diversity, size and scale of the transport system mean that evaluating the effect of market activity on energy efficiency is complex. As in other sectors, hard data on investments specifically in transport efficiency are incomplete. Further questions relate to definition and scope: what is considered part of the transport system and what is considered an action to improve energy efficiency?

Notwithstanding these challenges, it is clear that a range of investments are being made to improve the efficiency of transport, notably in vehicles, but also in rail and other forms. Much of the activity in the transport sector is in the land transport sub-sector, which is the focus of this chapter (Box 3.1).

Box 3.1 Land-based transport: The largest component of the transport system

Energy use for transport accounts for 27% of world total final energy consumption (TFC) (2 445 million tonnes of oil-equivalent [Mtoe]). Within the sector, land-based transport is responsible for 76% of total energy use, with air and marine transport making up the remainder. Road vehicles, such as passenger LDVs, two- and three-wheelers, buses, and freight trucks, make up 94% of land-based energy use (with the remainder used by passenger and freight rail). Of passenger road vehicles, passenger LDVs made up 95% of total energy use in OECD member countries (660 Mtoe) in 2010, with buses and two- and three-wheelers accounting for 4% and 1% respectively. In OECD non-member economies, passenger LDVs had a lower share of road vehicle energy use at 67% (281 Mtoe) in 2010. Buses used 21% (86 Mtoe) of road vehicle energy use, and two- and three-wheelers had a 12% share (50 Mtoe).

The transport sector is subject to large-scale trends and drivers that affect total travel levels and mode of travel (e.g. cars versus urban rail systems), which in turn affect energy consumption. The market for energy efficiency in transport is also subject to these dynamics.

This chapter is organised into the following sections: (a) methods to improve the efficiency of the transport sector, notably under the “avoid, shift and improve” paradigm; (b) description of how investments in goods and services that improve energy efficiency drive this change; (c) description of general trends in the transport sector, which set the framework in which transport energy efficiency investments take place, particularly in the land-based passenger area; (d) discussion of the energy efficiency market for passenger vehicles; (e) discussion of the energy efficiency market in the freight sector; and (f) description of investments in transport infrastructure that affect transport system efficiency, such as roads and urban rail.

Improving energy efficiency in transport: The “avoid, shift and improve” paradigm

Efforts to improve the efficiency of transport systems can be effected through three distinct dynamics: “avoid, shift and improve” (GIZ, 2004). This approach includes the application of technologies and practices that (a) enable people and goods to avoid motorised travel, (b) shift travel to more efficient modes, and (c) lead to improved vehicle and fuel technologies (Box 3.2).

Box 3.2 Examples of avoid, shift and improve

- **Avoid:** Avoiding travel is achieved with measures that reduce the need for travel without sacrificing the afforded benefits of travel. For example, different urban forms can promote more or less personal vehicle travel. Denser urban communities that provide access to amenities without need for vehicles see less personal vehicle use. Other examples include virtual mobility technologies (teleworking) and freight delivery co-ordination and logistics technologies that decrease travel volume by finding shorter, more efficient routes.
- **Shift:** Shifting moves travel from more energy-intensive modes to less intensive modes. Mass transit systems can move a person with less than half the energy consumption of a personal vehicle. Measures that help people choose less energy-intensive modes would reduce total energy consumption in the system. Examples include investment in public transport, cycle paths, bike sharing, freight rail, etc.
- **Improve:** Improving travel focuses on increasing the efficiency of vehicles and then ensuring that such vehicles are adopted. This encompasses energy-efficient vehicles and advanced vehicle technologies (e.g. hybrid electric cars).

Efforts are being made in the transport sector to improve its efficiency along these three dynamics. The desired outcome is improved efficiency of the transport sector, namely the delivery of energy services with less energy use (Box 3.3). This discussion complements that relating to passenger and freight transport energy efficiency indicators in Chapter 2.

Box 3.3 Energy efficiency of the transport system

Efficiency in transport can be assessed under narrow and broad scopes. Under the narrow scope, energy efficiency is commonly referred to as increasing the technical efficiency of each mode of transport. Within this perspective, energy efficiency is measured as the efficiency by which fuel is converted to motive power. Energy efficiency, as discussed later in this chapter, is often measured by the amount of fuel it takes to move a passenger or a tonne of freight 1 kilometre (km). This approach provides straightforward improvement benchmarks for regulators and vehicle manufacturers seeking to achieve energy efficiency.

Under a broader lens, transport efficiency can be looked at as the average energy required to move a person or tonne of goods 1 km in a jurisdiction. This scope accounts for the fact that different vehicles or modes of transport have different technical efficiencies, and that shifting travel to different modes can reduce total energy consumption while maintaining the benefits and utility of that travel. The shift in travel by mode is considered a structural change in the transport system, but structural effects have potentially large energy consumption impacts. In one hypothetical scenario, the efficiency of light-duty trucks (a large passenger LDV model) could increase more than smaller cars over a ten-year period, but smaller cars would have a better efficiency rating as their starting point. If a significant amount of travel shifted from small cars to light-duty trucks, total energy consumption would increase faster even if the efficiency improvements for light-duty trucks were greater.

The more traditional assessment of efficiency in transport focuses on actions that *improve*. In particular, actions to improve vehicle efficiency are (as described below) a critical and large portion of the total efficiency market in transport, but there is also a growing focus on actions that *shift* modes, recognising the important system efficiency improvements they can achieve. *Avoid* can also produce efficiency gains (for example improved truck deployment software reducing the miles that delivery trucks need to travel).

How energy efficiency investments relate to avoid, shift and improve outcomes

The land-based transport sector is a huge market comprising millions of individual vehicle owners, as well as fleet operators, vehicle manufacturers, supporting manufacturing industries, infrastructure engineering and construction services, and fuel suppliers. Investment in the goods and services of these various actors will drive energy efficiency improvements in the sector. This section provides examples of investments that produce energy efficiency improvements in the transport sector according to the “avoid, shift and improve” framework.

Market actions that improve vehicle efficiency

Two principal areas of activity in the vehicle energy efficiency area support *improve* outcomes.

- **Capital investment to produce more efficient vehicles:** At the producer level, development and deployment of more efficient vehicles requires vehicle manufacturers to spend on research and development (R&D), testing, production, supply chain optimisation and marketing of new vehicles. Industries that provide inputs for vehicle manufacturers, such as vehicle parts, raw materials and computing systems, are also affected by the adoption of efficiency measures (Box 3.4). This chapter does not attempt to quantify the investment by vehicle producers in R&D or in production capacity of more efficient vehicles.
- **Consumer expenditure to purchase more efficient vehicles:** At the consumer level, money is “invested” (i.e. spent) in the purchase of more efficient vehicles. As explained later in this chapter, greater efficiency can bring about higher costs in the short term, known as the energy efficiency premium (this concept is discussed in Chapter 1). For example, improving a vehicle’s efficiency by 20% could add USD 500 to the vehicle’s cost. This is the energy efficiency premium of more efficient vehicles and is a key component of the transport efficiency market.

Box 3.4 Industrial capacity investment for energy-efficient vehicles

Fuel efficiency can be improved along many different technological streams, including (among others) improvements to engines, lower drag tyres and lighter weight materials. This can create additional investment as manufacturing industries (manufacturers of tyres, vehicle parts and materials) respond to vehicle efficiency requirements. This can have large knock-on impacts. For example, new efficiency standards (discussed later in this chapter) to double the fuel efficiency of vehicles in the United States have spurred large investments in new automobile sector-specific aluminium production. In 2013, over USD 1 billion was invested in new aluminium factories tailored to the automobile industry in response to the demand for lighter, more efficient vehicles (Das, 2014).

Market actions to promote a shift for efficiency improvements

Shifting to more efficient modes improves the efficiency of the transport system. For example, while HSR investments are capital-intensive, they are necessary to facilitate the shift of inter-city travellers from less efficient vehicles. China is spending USD 140 billion building the largest HSR network in the world (Peng, 2012). This money supports engineering and design services, construction, and land development industries. High-speed rail is helping to improve system efficiency because it moves passengers with less energy than other motorised modes; its impacts on efficiency will be felt over a long horizon as travel behaviour and patterns adapt to incorporate the capacity provided by these investments. While this chapter describes some of the investments to support *shift*, because of their relevance to overall transport system efficiency, the focus of the chapter is on actions that *improve*.

Market actions to avoid passenger travel

Actions that serve to *avoid* travel are a potentially significant lever to reduce energy consumption in the transport system. These are achieved using information and computing to efficiently manage freight fleets, to promote virtual travel through network technologies, and by building less vehicle-dependent communities. Avoiding transport requires the development and use of new technologies and systems as well as investments in, for example, new urban designs that promote less vehicle travel and more walking and cycling. To include *avoid* investments as part of the efficiency market would involve a broader scope of efficiency: instead of the efficiency by which we move people and goods around, it would be the efficiency by which we satisfy the benefits of travel. This broader approach is not used in this report, and accordingly, avoid-related investments are not targeted in the discussion below.

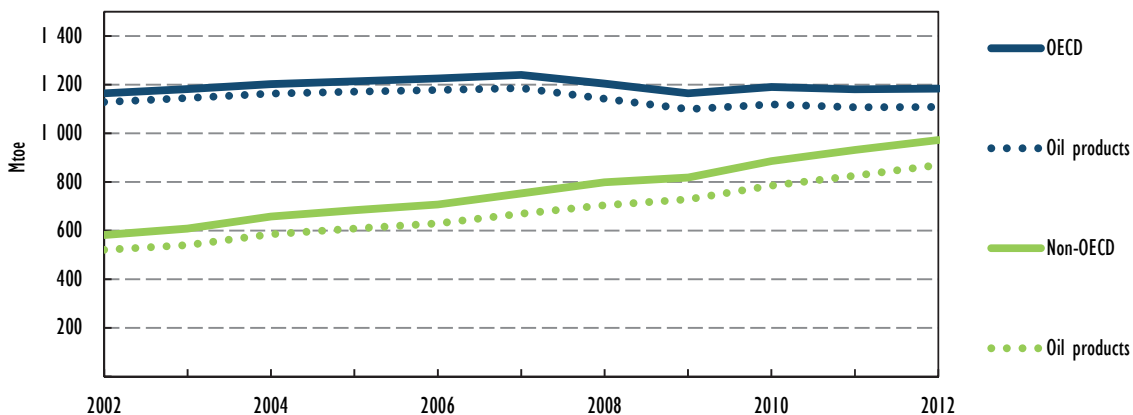
The transport market: Overall context and drivers for efficiency

TFC in the transport sector stood at 2 445 Mtoe in 2011, an increase of 24% over the preceding decade. Land-based transport is responsible for 76% of total sector energy use, with air and marine transport making up the remaining 24%. In 2011, global land-based transport energy consumption amounted to 1 869 Mtoe, which is equivalent to half the TFC of all OECD member countries. Energy consumption for passenger transport accounts for 60% of all land-based transport energy use; the remainder is consumed by freight transport.

Demand for transport

Since 2000, the growth in transport energy use has been driven by increasing demand for mobility in emerging and developing countries, which have nearly doubled their energy demand for transport. While transport energy use across OECD member countries has increased by just 4% since 2000, it increased by 67% (437 Mtoe) across OECD non-member economies. The increase in transport energy use in OECD non-members is primarily the result of continued economic development and rising incomes. Total transport energy consumption over the past decade in OECD member countries and OECD non-member economies is illustrated in Figure 3.1.

Figure 3.1 Transport energy use in OECD member countries and OECD non-member economies, 2002-12

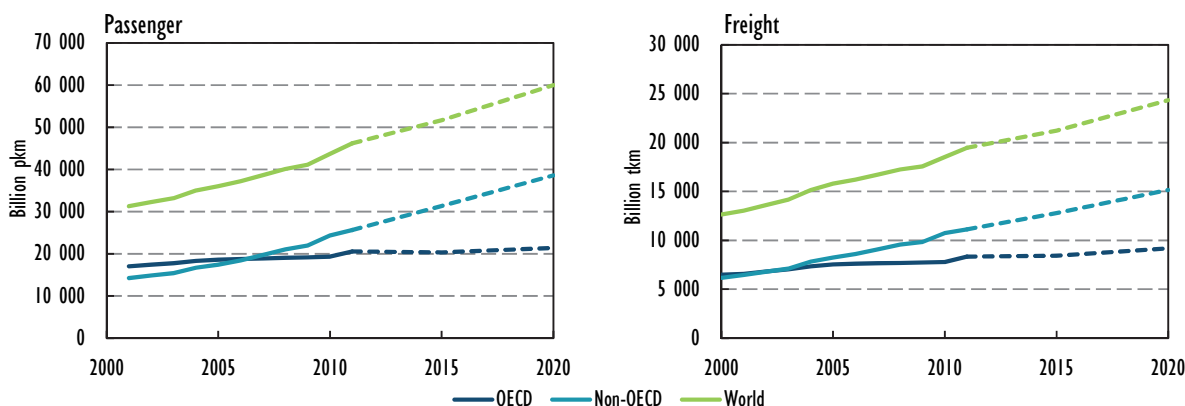


Source: Unless otherwise indicated, data for figures in this chapter are from the IEA *Energy Technology Perspectives* transport sector model and database.

Total travel demand (mostly road, but also maritime and air) is estimated to continue to increase at a similar pace to that seen in the period 2000 to 2010. However, as illustrated in Figure 3.2, the growing importance of transport demand in OECD non-member economies is changing the evolution of the global

transport system. Demand for passenger road transport in OECD member countries is likely to see only small changes to 2020. This is consistent with what some have called saturation levels for passenger road transport in personal vehicles (van Dender and Clever, 2013). Vehicle ownership is levelling off or even declining in OECD member countries, where the highest rates of vehicle use and distance travelled per vehicle show limited change from one year to the next. Meanwhile, passenger travel demand in OECD non-members is projected to continue increasing – by a further 90% between 2011 and 2020.

Figure 3.2 Current and estimated passenger and freight transport in OECD member countries and OECD non-member economies



Note: pkm = passenger kilometre; tkm = tonne kilometre.

While economic growth and transport demand are highly correlated, important country-specific variations exist, as the geography, economic structure, policy and preferences of each country can affect the nature and size of the transport sector, notably the rate of personal vehicle adoption. The United States, for instance, is characterised by high average incomes, low-density development in urban areas, significant investment in road and parking infrastructure, and low overall population density. This is coupled with the highest average national levels of personal vehicle ownership per unit of income. In contrast, Japan has personal income levels that are comparable with those of the United States, but possesses much higher urban and overall population densities. High quality public transport, both in urban areas and across the country, in conjunction with other policies such as parking restrictions – affecting the appeal of personal vehicles, especially in cities – has resulted in personal vehicle ownership per unit of comparative income that is half that of the United States.

Important increases in freight transport activity have also taken place (Figure 3.2), driven largely by global merchandise trade, which increased by 50% from 2000 to 2012 (UNCTAD, 2013). Global freight intensity, measured by tonne-kilometres (tkm) per unit of gross domestic product (GDP), increased by 16% from 2000 to 2011. While total freight transport has increased significantly in OECD member countries, freight intensity is generally declining as these countries move to more service-oriented economies. In contrast, in OECD non-member economies, not only is total freight transport increasing, freight is also gradually increasing in intensity per unit of economic output, reflecting greater industrialisation and growing incomes among consumer classes.

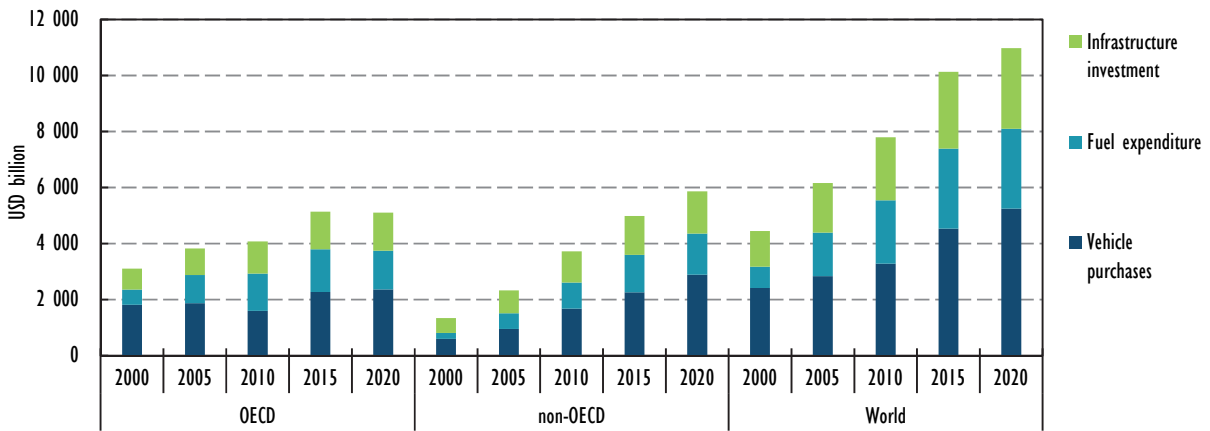
Transport sector expenditure

The total transport market is enormous and expenditure in the sector (including vehicle purchases, transport infrastructure investment and fuel expenditure) has been growing rapidly. Expenditure on

vehicle and fuel purchases and investment in infrastructure totalled USD 7.8 trillion in 2010. Between 2000 and 2010, transport system expenditure grew by 75%, from USD 4.5 trillion to USD 7.8 trillion. Growth in expenditure is led by fuel costs, which tripled from USD 756 billion to USD 2.3 trillion.

Expenditure on vehicles, fuel and infrastructure in OECD non-member economies grew by 176% between 2000 and 2010, from USD 1.3 trillion to USD 3.7 trillion, while OECD member country expenditure grew by 31%, from USD 3.1 trillion to USD 4.1 trillion. The International Energy Agency (IEA) estimates that the rate of growth of transport expenditure in OECD non-member economies will be more than double that in OECD member countries between now and 2020. Total transport expenditure is projected to increase by 41% between 2010 and 2020, to USD 11 trillion (Figure 3.3). The greatest increase in expenditure is on vehicles, in particular in OECD non-member economies where it is projected to increase by 89% to USD 2.2 trillion in the period to 2020, while fuel purchases are expected to increase by USD 586 billion.

Figure 3.3 Estimated global expenditure on the transport system, 2000-20



Drivers for improving energy efficiency in transport

Several drivers affect the level of interest in energy efficiency actions in the transport sector and the rate of efficiency adoption. The four principal drivers are: curtailing fuel expenditure, reducing local air pollution, greenhouse gas emissions abatement, and alleviating congestion.

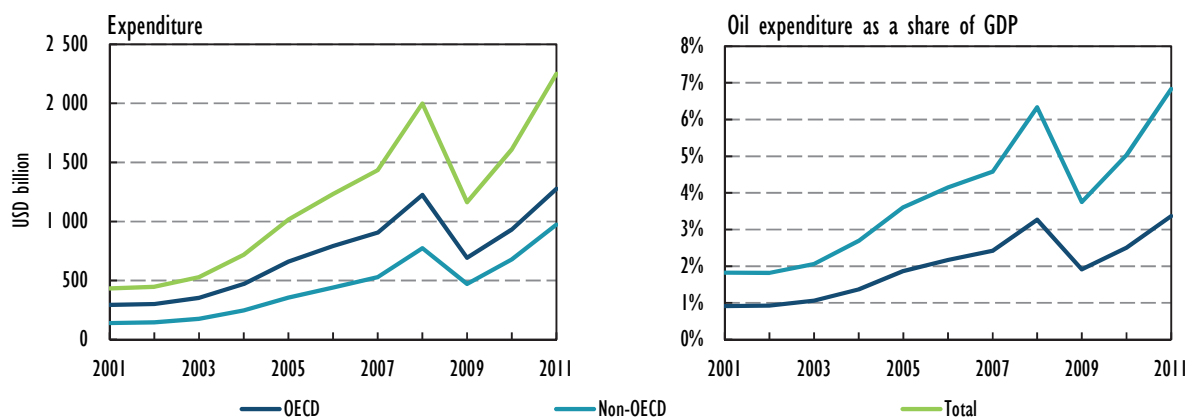
- **Fuel expenditure (and prices):** Fuel expenditure and related costs/prices drive interest in energy efficiency both for consumers and at the policy level.
 - For consumers, high fuel prices are often a strong driver for investing in more efficient transport. When consumers purchase new vehicles, fuel prices have a strong impact on the efficiency rating of new vehicles selected. For example, in an analysis looking at consumer purchasing decisions in the United States, a USD 1 per gallon (USD 0.26 per litre) increase in fuel price correlated to a 20% increase in the share of new vehicle purchases from the most efficient quartile. Conversely, the least energy-efficient quartile of new vehicles lost 24% of its share (Busse, Knittel and Zettelmeyer, 2012).¹ Many consumers who are not able or otherwise choose not to purchase a new vehicle simply absorb high fuel costs (Small and van Dender, 2007). In the short term, consumers often

¹ This describes outcomes in the new vehicle market. For used vehicles, market shares were less affected by rising fuel prices. A 1 USD per gallon increase in fuel prices saw the most efficient quartile of used vehicles increase their share by only 3%, while the least fuel-efficient quartile lost a 7% share. The lower impact of fuel price increases on efficient used vehicle adoption can be explained by examining the change in used vehicle prices. For every 1 USD per gallon increase in fuel prices, prices for the most fuel-efficient quartile of vehicles fell by USD 236, while for the least efficient the prices decreased by USD 1 073. Much lower prices for less efficient vehicles in the wake of high fuel prices modulated their declining appeal.

do not have the means to replace their current vehicle before the end of its useful life, and relocating residence to reduce distance travelled and thus fuel expenditure is difficult and costly.

- Increasing fuel costs due to high oil prices are a key driver for the adoption of vehicle efficiency policies in the transport sector. The transport sector is the largest consumer of oil – since 2001 the sector’s share of total oil consumption has increased by two percentage points to 63%, and total consumption of oil reached 2 265 Mtoe in 2011. Oil made up 93% of total transport energy use in 2011, while global expenditure on oil increased by 366% between 2000 and 2010, to over USD 2.2 trillion. Expenditure on oil for transport purposes has outpaced economic growth in many countries, causing it to consume a larger share of national income. This can be an important driver in the adoption of policies to improve the fuel economy of vehicle fleets (Figure 3.4).

Figure 3.4 Oil expenditure on transport



- Air pollution:** It is estimated that outdoor air pollution causes 3.3 million premature deaths every year (Lim et al., 2012). Energy efficiency in the transport sector, through a combination of active travel like walking and cycling, public transport planning and lower-emission motor vehicles, plays a major role in reducing local pollution (Matthews et al., 2006; Macmillan et al., 2014; Rabl and Nazelle, 2011). The number of years of life saved by energy efficiency measures implemented in London transport systems has been estimated at 7 300 disability-adjusted life-years (DALYs) per million people. The corresponding result for Delhi was almost 13 000 DALYs (Woodcock et al., 2009) (IEA, 2014b).
- Greenhouse gas emissions:** Since 2000, annual world transport emissions have grown by nearly 2 billion tonnes of carbon dioxide (CO₂) equivalent. Transport is the fastest-growing source of fossil fuel CO₂ emissions and accounts for more than a quarter of all energy-related CO₂ emissions, making it the third-largest emitter after the power generation and industrial sectors. Those modes with the highest carbon emission intensity, i.e. road and air travel, are predicted to show the highest growth rates in the future. Transport CO₂ emissions might increase by 80% between now and 2050 if no action is taken. Improving fuel efficiency and promoting shift and avoid actions work to reduce these emissions.
- Congestion:** The trend towards greater vehicle ownership worldwide has led to significant shifts away from non-motorised transport and public transport modes towards individual motorised transport, and corresponding increases in congestion around the world. The annual cost of congestion in wasted fuel and time in the United States has been estimated at USD 121 billion, or an extra USD 838 per commuter in 2011 (Schrank, Eisele and Lomax, 2012). Shifting travel to more efficient modes, such as rail and bus, can help to alleviate congestion by reducing the number of vehicles on the road.

Improving energy efficiency of passenger vehicles: Trends and market developments

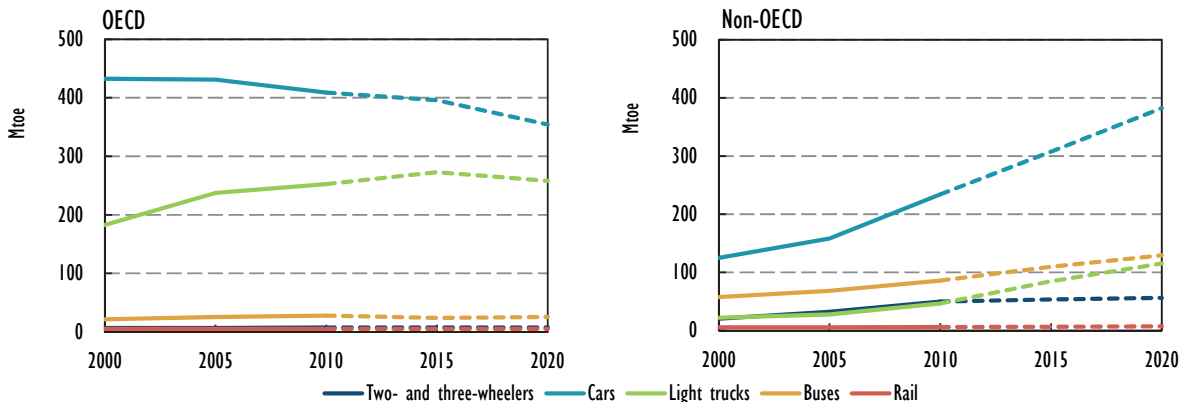
This section reviews trends, drivers and market developments to improve the energy efficiency of passenger LDVs. It describes trends since 2000 in passenger vehicle use and efficiency in OECD member countries and OECD non-member economies, and the major driver for efficiency adoption in vehicle efficiency standards. It also discusses market developments for more efficient vehicles, including total market size, vehicle adoption rates and unit costs for efficiency.

Trends in passenger transport

Energy use in the passenger transport sector is mostly land-based, with land transport responsible for 81% (697 Mtoe) of total passenger transport energy use in OECD member countries and 80% (417 Mtoe) in OECD non-member economies in 2010. Land-based passenger transport includes all passenger LDVs, two- and three-wheelers, buses and rail. LDV sales totalled approximately 70 million units in 2011, with 60% of those in OECD member countries and 40% in other countries. In 2011, China was the world’s largest vehicle market with 13 million sales (representing 57% of all vehicle sales in OECD non-member economies), as against 12.6 million in the United States.

Energy consumption across OECD member countries for land-based travel has increased by only 5% since 2000. The economic recession has had important impacts by reducing energy demand; however, countries such as the United States had already seen initial reductions in travel demand before the recession, as personal vehicle travel appeared to have reached saturation by the mid-2000s.

Figure 3.5 Actual and estimated energy use for land-based passenger transport by mode in OECD member countries and OECD non-member economies



As outlined in Figure 3.5 growth in energy consumption for transport in OECD non-member economies has been much stronger than in OECD member countries since 2000. Energy consumption for land travel increased by 70% between 2000 and 2011 and is projected to continue at a similar pace over the next decade. This underlines the shift in the global transport system to one propelled by growing mobility demand in OECD non-member economies. With strong growth prospects, the total efficiency of the transport sector will increasingly rely on developments in these regions.

Trends in passenger transport efficiency

At the global level, the amount of energy required to move a passenger one kilometre (pkm) declined by 12% between 2000 and 2011. In OECD member countries, the average efficiency of passenger transport across all modes improved by 5%, with LDV efficiency improving only marginally (2% from 2000 to 2011)

(GFEI, 2014). Between 2005 and 2011, average LDV efficiency globally improved at an average annual rate of 1.8% (Table 3.1), representing both technological efficiency improvements across all vehicle types and a move towards smaller vehicles (which travel at lower energy use per pkm) driven by OECD member countries.

Average efficiency of personal vehicles has steadily improved at world level, driven by improvements in OECD member countries (Table 3.1), which experienced an annual rate of improvement of 2.4% between 2005 and 2011. This was facilitated by the adoption of higher efficiency vehicles in the marketplace, spurred both by fuel efficiency standards and preference among some consumers for higher efficiency vehicles. By comparison, the annual rate of improvements in OECD non-member economies was 0.1%.

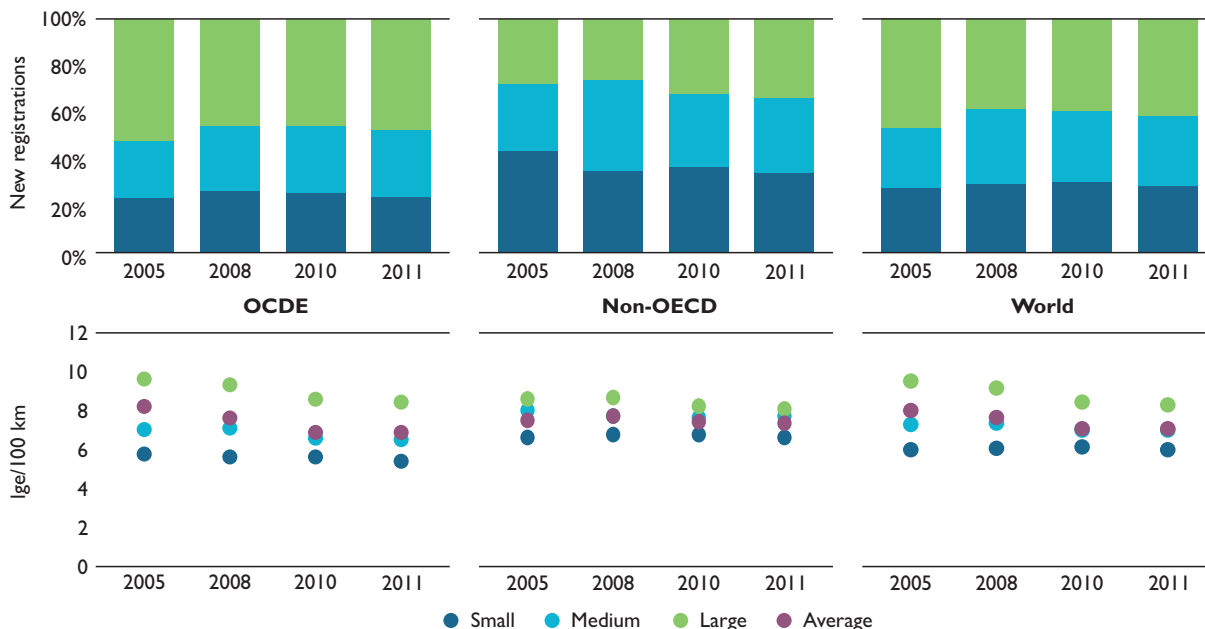
Table 3.1 Average fuel economy and improvement rates of personal vehicles, 2005-11

		2005	2008	2011
OECD average	Fuel economy	8.1	7.6	7.0
	Annual improvement		2.4%	
Non-OECD average	Fuel economy	7.5	7.6	7.5
	Annual improvement		0.1%	
Global average	Fuel economy	8.0	7.6	7.2
	Annual improvement		1.8%	

Notes: Fuel economy is measured as litres of gasoline equivalent per 100 km (lge/100 km). Annual improvement is the annual average over the period 2005 to 2011.

Source: GFEI (2011), *International Comparison of Light-Duty Vehicle Fuel Economy: An Update Using 2010 and 2011 New Registration Data*, Global Fuel Economy Initiative, London.

Figure 3.6 New vehicle registrations and vehicle efficiencies by vehicle size



Source: GFEI (2014), *Fuel Economy State of the World 2014*, Global Fuel Economy Initiative, London.

The evolution of average passenger vehicle fuel economy (VFE) is a function of several factors, including not only fuel economy standards, but also consumer preferences between different-sized vehicles, as well as the penetration of newer more efficient vehicles as compared to used vehicles. This effect is observed in OECD non-member economies, where the share of new vehicle registrations is gradually increasing for

large vehicles whose average efficiency is lower than for medium-sized and smaller cars (Figure 3.6). By comparison, the share of larger vehicles has remained relatively stable in OECD member countries, diminishing slightly from 2005 to 2011. The global share of large vehicles has fallen since 2005, but the increase in the adoption of large vehicles in OECD non-member economies will affect future efficiency outcomes should it continue given the growing size of this market. For example, annual sales of sports utility vehicles (SUVs – also known as light-duty trucks) has been projected to see growth of over 4 million units from 2011 to 2020 in China, as well as an increase in their share of the vehicle fleet over this period (Wang, Liao and Hein, n.d.).

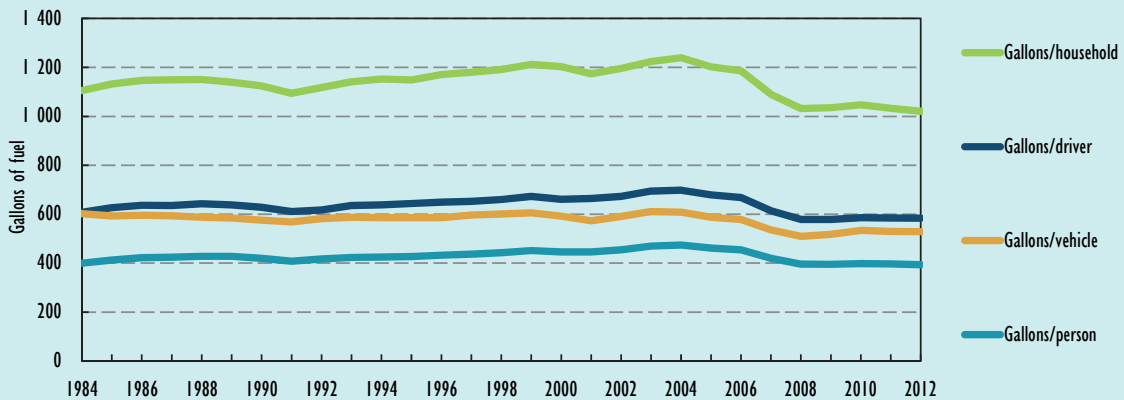
Passenger vehicle travel is also affected by other factors, including living patterns (urban versus suburban), as well as preferences for different configurations of vehicle travel (single versus multi-passenger travel). Countries with mature passenger markets, such as the United States, are seeing downward trends in consumption per household and other factors that potentially point to a less vehicle travel-intensive economy (Box 3.5).

Box 3.5 Lowering fuel intensity trends in the United States, 1984-2011

The United States has been reducing fuel consumption on per capita, vehicle, registered driver and household bases since 2004 (Sivak, 2014). Despite population growth, the absolute amount of fuel consumed by LDVs decreased by 11% from 2004 to 2012. Vehicle kilometres per person, per household and per registered vehicle have fallen since 2004 and are now at mid-1990s levels. Sivak notes that rates of fuel consumption per vehicle, driver, household and person are at the lowest point of the data series. The decline in transport pre-dated the 2008 recession, which probably augmented the downward trend in travel. (Figure 3.7) While the United States returned by 2012 to absolute economic activity above pre-recession levels, rates of vehicle use have not followed. The factors underlying this shift require further evaluation, but the current result is a less vehicle travel-intensive economy.

Passenger transport efficiency covers more than simply vehicles; it also includes other modes of transport. In OECD non-member economies, the average energy required to move passengers (0.9 megajoules [MJ] per pkm) is half that of OECD member countries (1.9 MJ per pkm). This reflects the higher share of more efficient modes, such as buses, rail and small two- or three-wheel personal vehicles; it also reflects higher average vehicle occupancy.

Figure 3.7 LDV fuel consumption intensity for passenger transport in the United States



Note: 1 gallon of fuel is equivalent to 3.785 litres.

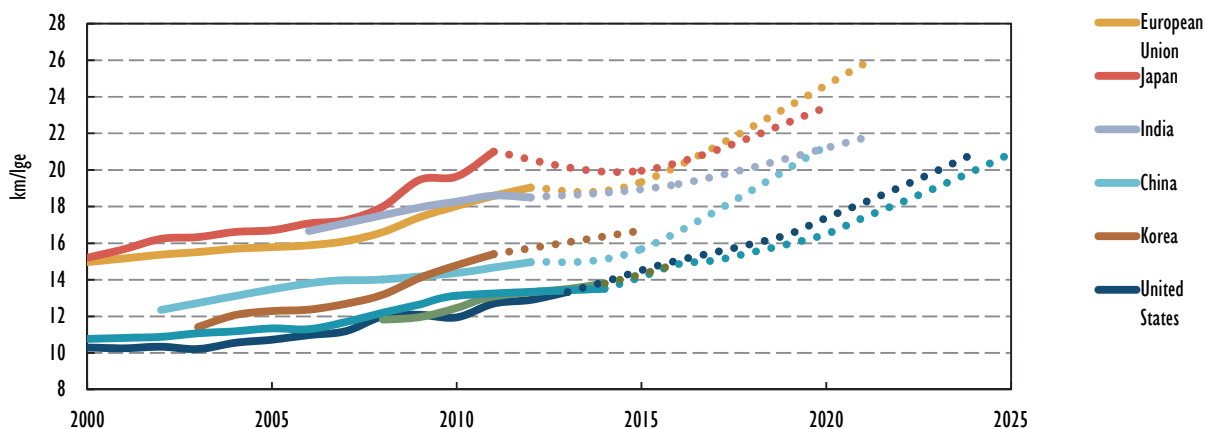
Source: Sivak, M. (2014), *Has Motorization in the U.S. Peaked? Part 5: Update through 2012*, University of Michigan Transportation Research Institute, Ann Arbor, MI.

With the number of personal vehicles in OECD non-member economies growing rapidly, a challenge will be to reconcile the preference for more and larger vehicles with the need to improve efficiency. While significant growth in vehicle demand is anticipated, the trajectory of efficiency is still subject to a wide range of outcomes. Policy and market signals to improve the efficiency of vehicles at a faster pace than business-as-usual will be needed. This points to the need for a holistic approach to transport efficiency that has the ability to influence the activity and structural drivers for total vehicle transport; this includes modal shift as well as greater technical efficiency of vehicles.

Driving energy efficiency for passenger LDVs: The pre-eminent role of fuel economy standards

Increasingly, governments in both OECD member countries and OECD non-member economies are exploring and implementing vehicle economy standards that set a corporate average efficiency target (Figure 3.8). These standards allow vehicle manufacturers to continue to cater to consumer preferences by offering a variety of vehicle types and sizes while still achieving an overall efficiency improvement. Standards are achieved by making targeted efficiency improvements on vehicle types that have high market share, can attain improvements cheaply, or cater to consumers who value more efficient vehicles. Because standards are average values, they allow vehicles with widely different characteristics to be marketed, giving flexibility to manufacturers and incentivising the market to provide efficiency in different vehicle classes. These standards covered more than 50 million vehicles sold in 2011, or 70% of the global vehicle market.

Figure 3.8 Enacted LDV fuel economy standards



Notes: lge = litre of gasoline equivalent. The lines in the chart describe the historical national annual average efficiency performance as measured by number of kilometres travelled per lge; the higher the number the greater the average efficiency of new vehicles sold. Dotted lines represent announced standards.

Source: ICCT (2014), *Global Passenger Vehicle Standards*, International Council on Clean Transportation, Berlin, www.theicct.org/info-tools/global-passenger-vehicle-standards.

In response to efficiency standards, new vehicle fuel efficiency increased by 20% in OECD member countries and by 10% in OECD non-member economies between 2000 and 2010, leading to an average global improvement of 15%. Based on the new tranche of national standards, the average efficiency of LDVs will improve much faster over the next ten years if full compliance is achieved. In the United States, vehicle efficiency standards helped achieve a 17% efficiency improvement in new vehicle models between 2008 and 2013 (Schoettle and Sivak, 2013). Eight countries and the European Union have enacted or are in the process of implementing vehicle efficiency targets that will result in vehicle

efficiencies of between 3.9 lge/100 km and 6.7 lge/100 km. The efficiency improvements made in Japan and the European Union are smaller than those of the United States and Canada, but their fleets already consume one-third less fuel on average.

The use of fuel economy standards has taken hold worldwide. In addition, international co-operative initiatives have also been launched to promote the expanded use of these standards (Box 3.6).

Box 3.6 The Global Fuel Economy Initiative and “50by50” campaign

The FIA Foundation, IEA, the International Transport Forum (ITF) and the United Nations Environment Programme (UNEP) have been working in partnership on the Global Fuel Economy Initiative (GFEI) since 2009, with the objective of promoting further research, discussion and action to improve fuel economy worldwide. The International Council on Clean Transportation (ICCT) became a full partner in the initiative in May 2012.

The overall objective of this initiative is to make all LDVs worldwide 50% more fuel efficient than in 2005 by 2050. This is consistent with IEA findings that technologies for improving the fuel economy of two-wheelers, LDVs and HDVs are already commercially available and cost-effective, and that their potential to reduce the fuel-specific consumption of vehicles within the 2030 time frame ranges from 30% to 50% (IEA, 2012a).

The initiative seeks to achieve its objective by providing guidance and support in the development of policies to promote fuel-efficient vehicles, promoting the adoption of measures including: fuel economy labelling systems; fuel economy standards/regulations requiring manufacturers to make improvements to their new models; and pricing systems to encourage consumers to purchase the most efficient models, such as CO₂-based vehicle taxation or feebate systems. Fuel taxation is also acknowledged as a very important signal in this regard, as many countries still subsidise motor fuel.

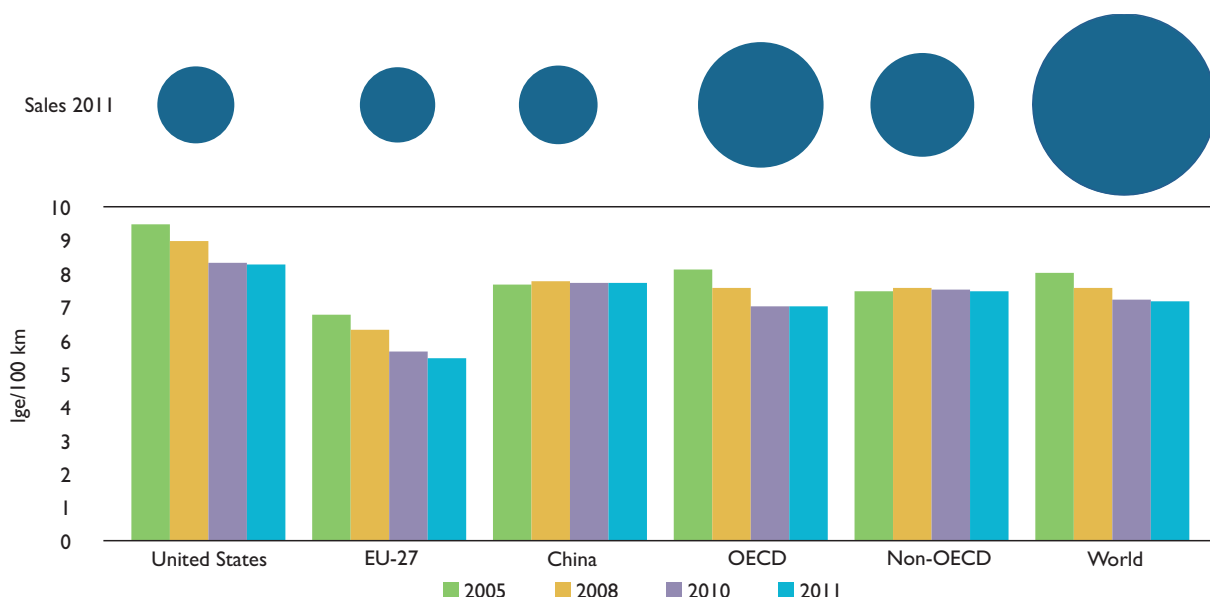
The energy efficiency market for passenger vehicles

Looking back. Figure 3.9 outlines the average efficiency of new vehicles according to region-specific test cycles adopted by model year, with total vehicle sales in 2011 according to region. At the global level, the improvement in average fuel economy from 8.0 lge/100 km in 2005 to 7.2 lge/100 km in 2011 represents an annual reduction of 1.8% over that period (GFEI, 2014). In OECD member countries, the average fuel economy of passenger cars improved by 2.4% between 2005 and 2011, almost reaching the annual 2.7% improvement rate required to achieve the GFEI target of halving specific fuel use per kilometre in new vehicles by 2030.

Looking forward. Achieving new emissions standards as outlined in Figure 3.8 will require new investment. Efficiency improvements achieving upward of 20 km/lge will require a portfolio of actions, which could include:

- higher market penetration of advanced powertrain technologies, including better combustion technologies, more energy recuperation and electrification, as well as other fuel-switching capabilities such as fuel cells
- wider use of technologies that allow reductions in vehicle weight, rolling resistance and aerodynamic drag
- broad deployment of advanced internal combustion engines, including improved starters and alternators, start-and-stop and non-idle technologies, and direct injection
- a shift in the market towards smaller more efficient vehicles with marketing and pricing innovations, along with other market drivers such as high fuel costs.

Figure 3.9 LDV sales in 2011 and average vehicle efficiency of new vehicles by model year

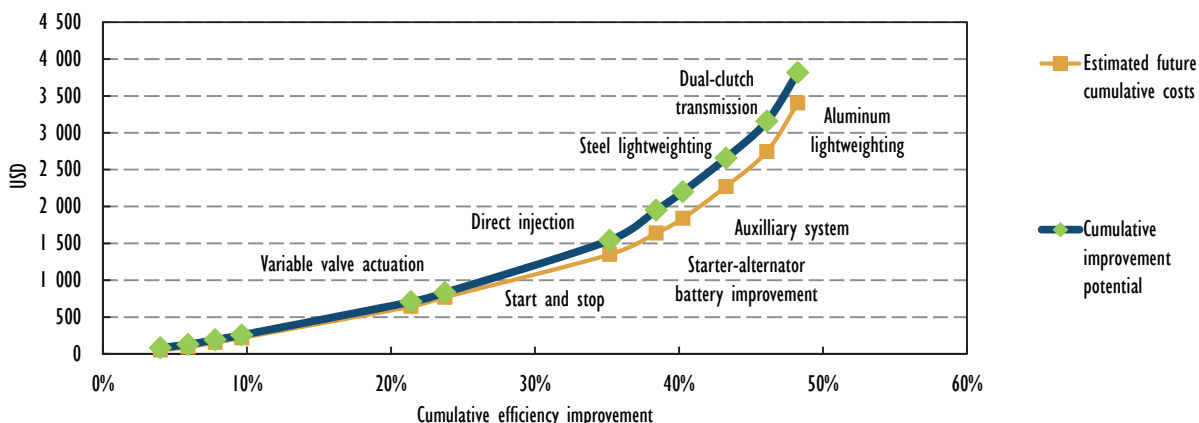


Note: World new vehicle sales were 70 million LDVs in 2011.

Source: GFEI (2011), *International Comparison of Light-Duty Vehicle Fuel Economy: An Update Using 2010 and 2011 New Registration Data*, Global Fuel Economy Initiative, London.

In the short term, more advanced internal combustion engine (ICE) technologies and low resistance aerodynamics and tyres are the most cost-effective efficiency improvements. Figure 3.10 outlines examples of cumulative efficiency improvements from selected technologies and practices from 2005, with an estimate of cumulative current costs. In the short term, the anticipated impacts of standards up to 2020 are to add an extra 6% to vehicle costs, or approximately another USD 1 000. With innovation, scale and production and process improvements, the estimated cost reductions over time for energy-efficient technologies range from 7% to 40% (IEA, 2012b).

Figure 3.10 Example of incremental costs by cumulative energy efficiency improvement for gasoline-powered ICE personal vehicles



Note: Efficiency improvement potentials and incremental cost are understood as relative to a gasoline ICE for 2005 vehicle model years.

The IEA *World Energy Investment Outlook* estimates that the value of the efficiency component of new passenger vehicles adopted between 2014 and 2021 will approach USD 80 billion annually (IEA, 2014c).

Investment in efficient vehicles is expected to represent over 60% of all incremental investment in energy-efficient technologies globally during this period. Efficient vehicle purchases, increasingly in OECD non-member economies, are anticipated to account for the largest share of overall investment in efficiency over the next five years.

Market for electric vehicles: Part of the efficiency story. In addition to continued efficiency improvements to ICE vehicles, a small part of the increase in average vehicle efficiency is electric vehicle (EV) adoption (Box 3.7). Battery electric vehicle (BEV) sales increased by 229% between 2012 and 2013 in the United States to 46 000 vehicles (EVObsession, n.d.). Globally, EV sales doubled between 2011 and 2012 to 113 000 vehicles. Significant challenges still remain to the widespread adoption of EVs; as of 2012, the total stock of EVs represented only 0.02% of passenger cars (EVI, 2013). Key to overcoming these challenges are lowering initial vehicle cost, the development of electricity storage and fuelling technologies, and the co-ordination of infrastructure investment to enable wider deployment and integration with existing transport systems.

Box 3.7 EV adoption and efficiency

Electric vehicles are significantly more efficient than ICE vehicles. For a range of vehicle types, EVs are anywhere from 44% to 92% more efficient than their ICE counterparts (IEA, 2014a). Efficiency gains from moving to electric motors are a primary factor in reducing the fuel cost of personal vehicles. Fuel cost changes from ICE to EV are a result of two factors: the price differential between electricity and gasoline, and the efficiency differential between ICE and EV engines. In some countries there are additional costs in moving from gasoline to electricity, such as in New Zealand, the United States and Germany, where household electricity prices are higher than gasoline on a per-joule basis. Meanwhile in Korea, electricity costs almost half as much as gasoline. Figure 3.11 describes the fuel cost savings per kilometre travelled between typical ICE and typical EV passenger vehicles in six countries. In all cases, EVs are cheaper to power per kilometre and the efficiency improvement is the key determinant of operating cost savings.

The figure demonstrates the effect that efficiency improvements and fuel price differences between gasoline and electricity have on the fuel cost in USD per kilometre travelled. In Germany, with electricity prices higher than gasoline, the fuel switch adds USD 0.04 per kilometre, while the efficiency gain reduces driving costs by USD 0.046. The EV efficiency improvement is still enough to reduce vehicle fuel costs by 33% per kilometre over ICE.

Figure 3.11 Fuel cost comparison of switching from ICE to BEV cars



Projecting fuel savings. Fuel prices and VFE standards are sending strong signals to the transport market and are expected to continue to encourage the adoption of more efficient LDVs over the next ten years in several key economies. The additional efficiency premium of personal vehicles is one metric of the size of the market for efficiency. The other is the avoided cost of fuel for consumers who purchase new efficient vehicles (Box 3.8).

Box 3.8 Net benefits of vehicle efficiency in *Energy Technology Perspectives*

The 2012 edition of *Energy Technology Perspectives (ETP)* compared total transport system costs under two scenarios (IEA, 2012a). Cumulative investment in vehicles and transport infrastructure, as well as all expenditure on total fuel demand and operation and maintenance costs, were compared over the entire scenario period (2010 to 2050). The analysis estimated that by 2020, efficiency policies could reduce global fuel expenditure by between USD 40 billion and USD 189 billion depending on their intensity. Higher expenditure on more costly vehicle technologies would be outweighed by lower fuel expenditure due to more efficient technologies, less overall travel and a shift towards more efficient modes, together with anticipated lower oil prices due to lower oil demand. Furthermore, the reduction in individual motorised transport would result in less total infrastructure investment. Higher expenditure on public transport systems would be compensated by significantly lower investment needs for road and parking infrastructure.

Improving the energy efficiency of freight vehicles: Trends and market developments

Freight transport is another important area with potential for efficiency improvements.² Whereas maritime transport accounts for 80% of the volume of global trade (UNCTAD, 2013), its share of energy demand is only 5% of total transport energy consumption (IEA, 2014a). Road freight energy use is comparatively much larger, representing about one-third of total transport energy consumption. This share is expected to increase by 2020 (IEA, 2014a). This section focuses on improving the energy efficiency of land-based freight, particularly HDVs used for road freight.

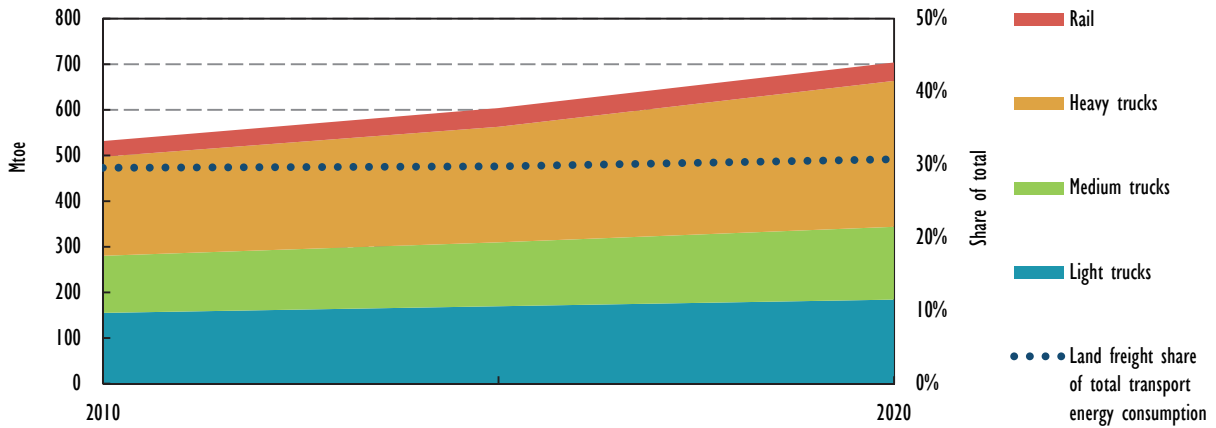
Trends in land-based freight efficiency

Global economic growth is a strong driver of freight activity; this growth has been fuelled in part by increasing global reliance on trade, expanding consumer markets in emerging economies, and rising reliance on on-time delivery and remote shopping facilitated by technological advances such as the internet (although it is unclear how much other transport activity these developments are displacing). Provided that global economic growth continues at the same pace, the outlook for freight activity is robust. The IEA *ETP 4°C Scenario (4DS)* estimates that freight movement, as measured in tkm, will continue to grow rapidly, increasing by another 37% to 24 trillion tkm and energy use in the freight sector increases 32% to 717 Mtoe by 2020, driven mostly by OECD non-member economies (Figure 3.12).

In addition to economic activity, economic structure is also central to determining the outlook for a country's freight sector. For example, the relative size of the service sector in any given country, with its low material intensity per unit value-added, will serve to dampen total freight movement. Conversely, if a country is more trade and resource dependent, with a high share of extraction and trade in bulk goods, then the size and growth of the freight sector is likely to be more important.

² Freight is defined as transport of goods by HDV, rail and ship.

Figure 3.12 Estimated inland freight energy use and share of total transport energy use, 2010-20



Inland freight transport in OECD member countries is more energy intensive than in OECD non-member economies (Figure 3.13), because it is more reliant on HDVs as a share of total goods movement. OECD non-member economies use more rail for inland transport, but rail’s share has been declining over recent decades as trucks take a larger share of total goods hauled. Rail moves 1 tkm with one-tenth of the energy of HDVs. Rail is a preferred mode for bulk commodities but is challenged by the need for point-to-point delivery. Also, in OECD non-member economies load factors of road freight are higher due to overloaded trucks and a lower reliance on just-in-time delivery. The extensiveness of the road network means road freight is a more flexible and effective mode of inland shipping between centres of production. As emerging countries continue to develop and build larger consumer economies, the portfolio of goods moved will change as well. This is another potentially significant driver of increased reliance on road freight.

Modal choice in freight transport depends on a variety of factors. The main drivers are size and weight of the transported good, the transport distance and the value of the good. At a given distance, the dimensions of the good together with its value have a key impact on the acceptable travel time. Higher value goods tend to be transported with higher speed transport modes, offering greater flexibility for timely delivery (in other words, minimising transport cost has less relevance as the value of the goods transported increases). Shifts in industrial structure, such as those leading to the decline in energy-intensive heavy industry sectors in OECD member countries, have impacts on global and regional trade patterns, as the same industries are relocated in developing economies. This, in turn, has repercussions on trade distances, modal choice and energy demand for long-distance travel modes. Together, changes in regional industrial production patterns, growth in income and increased demand for flexible delivery, as well as an emerging service sector, shape the energy intensity of freight travel. Looking ahead, almost all growth in freight energy use is consigned to HDVs, increasing the importance of efficiency improvements for this mode.

The efficiency of HDVs has improved by more than 50% over the past four decades in the United States and the European Union (NAS, 2010). However, efficiency improvements slowed in the last 20 years and appear to have flattened in important markets like the United States (EIA, 2012). Most of the flattening trend can be explained by the introduction of more stringent emission regulations for HDVs over the last 15 years (Figure 3.14). Limiting the emissions of nitrous oxides can affect the compression ratio and engine efficiency, while particulate filters increase the exhaust gas pressure and require additional fuel to clean the filters from time to time. Slowing efficiency gains coincided with increasing reliance on HDVs in OECD member countries, leading to strong growth in road freight energy demand.

Figure 3.13 Average energy use per tkm, 2000-20

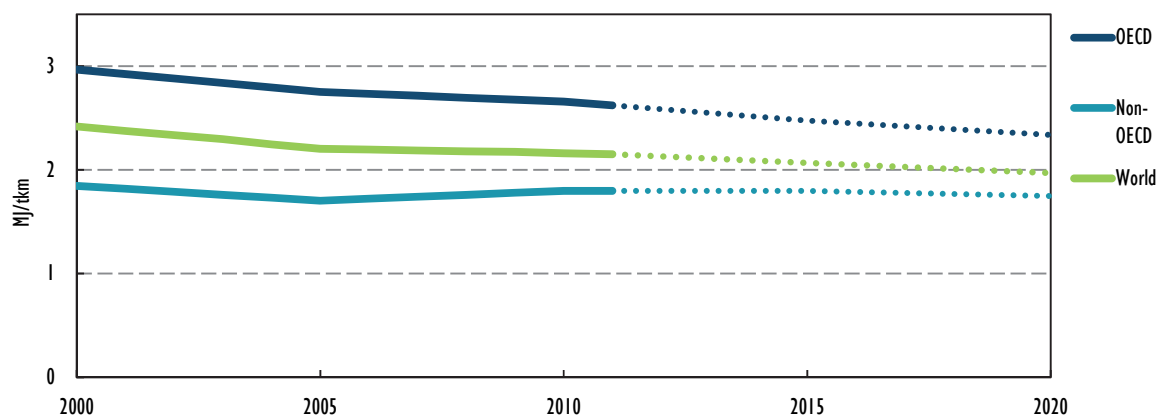
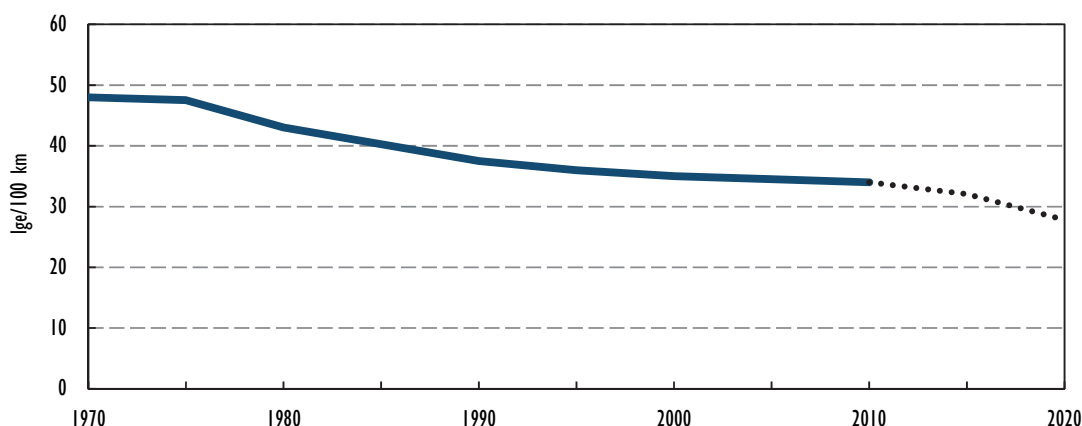


Figure 3.14 Tested fuel efficiency of HDVs in the European Union



Source: adapted from Schuckert, M. and R. Krukenberg (2011), "CO₂/FE regulatory developments around the world", presentation at EC/ICCT workshop on CO₂ emissions from heavy-duty vehicles, Brussels, 10 November 2011; the projected efficiency is based on IEA ETP.

Fuel cost: A key driver for energy efficiency in freight

The freight industry is particularly exposed to fuel prices as a major input cost. Competitive pressures to reduce fuel costs through efficiency are likely to grow in importance. Fuel costs as a share of total costs in the freight industry in the United States are over 35%, and between 2009 and 2011 fuel costs for road freight increased by 45% (ATRI, 2012). Because of the large share of fuel costs, increasing fuel prices can be a strong incentive for HDV efficiency improvements.

The argument for efficiency and the market impacts of improving freight efficiency extend beyond the freight sector. Freight costs are embedded in the cost of almost all goods. One analysis of the United States divided the total fuel expenditure of the freight industry by the number of households, and estimated that these indirect fuel costs amounted to one-half of direct household expenditure on fuel (Cooper and Gillis, 2014). In other words, for every USD 100 spent on transport fuel, a typical US household spends an additional USD 50 indirectly on the fuel costs of the freight industry embedded in the goods and services they consume. Assuming that all fuel costs from freight are passed on to final consumers, the fuel cost of freight amounts to USD 1 116 per household per year, equivalent to USD 132 billion annually in the United States. Economically viable truck efficiency improvements would reduce indirect fuel costs by USD 400 per household, or USD 50 billion per year (Cooper and Gillis, 2014).

Energy efficiency standards for HDVs: An emerging tool

Efficiency standards for freight vehicles are a relatively new field of policy compared to passenger LDVs. By the end of 2013, only Canada and the United States had enacted efficiency standards for HDVs. Japan, the European Union, Korea and China have all indicated that they will enact standards before 2020, and are in the process of studying, developing and implementing policy.

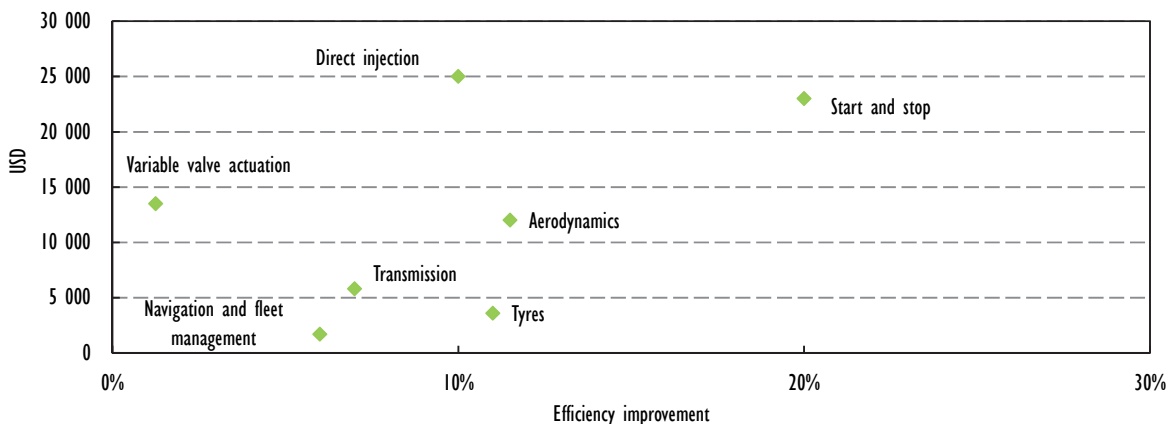
The standards proposed by the United States develop truck class-specific standards for fuel consumption per 1 000 tonne miles, achieving an improvement in fuel efficiency of between 9 and 23 times from 2010 HDV models, leading to USD 50 billion in fuel savings over the life of the vehicles. The estimated additional cost of more efficient vehicles is estimated to be USD 8 billion. Regulations will apply from 2014 to 2018 model years. The regulations apply to different weight classes of freight vehicles, from medium-duty to heavy-duty trucks (EPA, 2011).

Canada’s regulations target reductions in greenhouse emissions and have no direct fuel efficiency standard. In practice, greenhouse gas regulations are drivers for efficiency improvements. Energy efficiency improvements are mentioned as a compliance mechanism to achieve the greenhouse gas target. Analysis indicates that the Canadian target would achieve similar efficiency outcomes to the efficiency standard in the United States (ICCT, 2013).

Ways to improve energy efficiency in freight

Opportunities to improve the efficiency of land-based freight rest both with technological improvement and with fleet management logistics. HDV efficiency can be improved by 45% using a suite of measures, such as aerodynamics and engine improvements. Achieving a 20% efficiency improvement could add an extra USD 25 000 to the cost of a vehicle (Figure 3.15). A 30% efficiency improvement could reduce fuel costs by up to 30% annually (USD 26 400) (IEA, 2012b). Fuel efficiency can be further enhanced with advanced fleet management and logistics techniques that minimise the amount of deadheading (travel with no payload) and unnecessary distances travelled (this represents an *avoid* action). The capacity of information technologies to deliver efficiency gains is latent and the potential is still not clear; estimates suggest that improved navigation, routing and fleet management could reduce total energy use per truck delivery by 20% (IEA, 2012b) (Jeftic, 2009).

Figure 3.15 Example of incremental costs and fuel efficiency improvements to an HDV

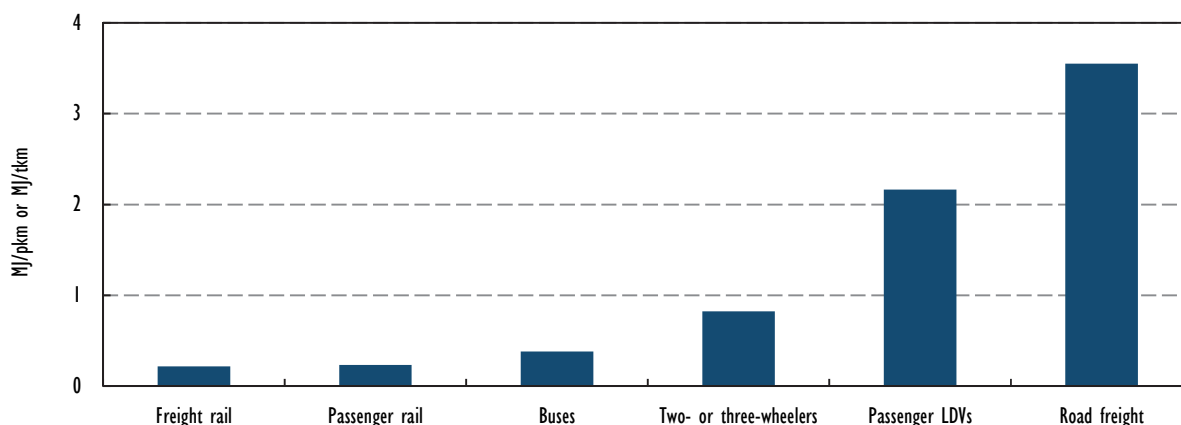


Source: adapted from NAS (2010), *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*, The National Academies Press.

Shift: The impact of modal investments on energy efficiency

The share of different transport modes affects the total energy intensity of the transport system. Vehicle market shares in particular shape total transport system efficiency. Different modes of transport displace their passengers or payloads with different energy requirements. 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 (Figure 3.16).

Figure 3.16 Global average energy use per pkm or tkm by mode, 2010



Investments that help promote modal shift directly affect the efficiency of the transport system. Accordingly, they can be viewed as constituting “energy efficiency investments” if they support a shift to more efficient modes. The inclusion of these investments would represent an expansion of the definition of the energy efficiency market in transport from a more traditional approach focusing on *improve* actions, such as higher fuel economy standards for personal and freight vehicles. This may become more pertinent as there is increasing attention being paid to modal shift in efforts to improve the efficiency of transport systems, and corresponding investment is likely to follow.

Trends in transport infrastructure investment and impact on modal share

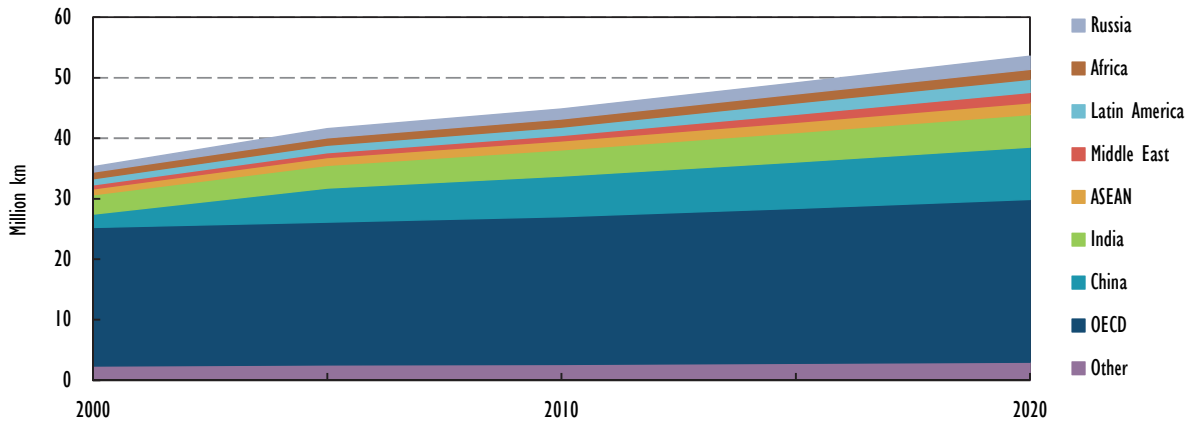
Transport infrastructure can promote or suppress different transport modes, with an impact on the mix of modes and resulting efficiency of the transport system. As a result, the choice of infrastructure investment can be considered a meaningful driver of energy efficiency in the transport system. Investment in road infrastructure illustrates this dynamic.

A historical attraction to investing in roads and the vehicles that use them. Investment in transport systems has been dominated by expenditure on roads, whether for new roads or their refurbishment and maintenance (Figure 3.17). The amount of paved-road kilometres has increased only marginally in OECD member countries since 2000. The total growth in roads is being led by OECD non-member economies, in particular, by China.

This roadway capacity expansion has supported – and arguably encouraged – the expanding market for vehicles discussed previously in this chapter. New transport infrastructure changes the access, time and cost considerations of travellers (van Dender and Clever, 2013). Increased preference for road vehicles has resulted in pressure to build more roads, but the development of new roads also makes vehicle transport more convenient and affordable and supports lower-density housing development

with potentially higher vehicle dependency (De Vos and Witlox, 2013). The pursuit of vehicle-enabling infrastructure in OECD non-member economies has coincided with a general trend towards increased vehicle usage. Current expenditure on road-based infrastructure is USD 1.7 trillion per year, with China and India projected to account for one-third of global roadway expenditure (IEA, 2013).

Figure 3.17 Paved road kilometres by region



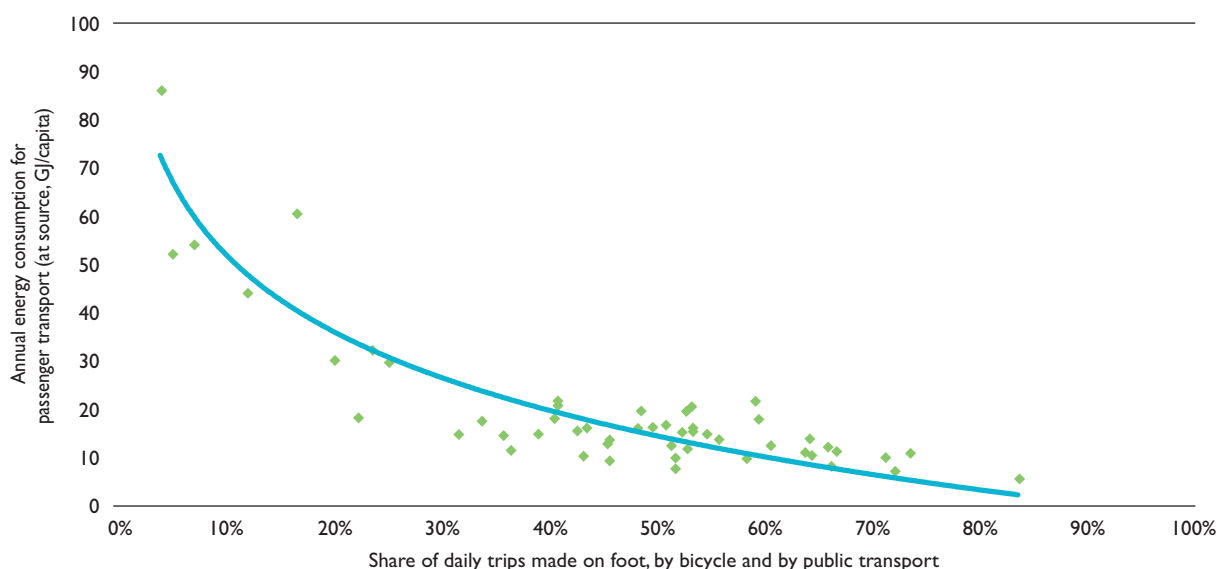
Notwithstanding these investments, congestion is increasing. Growth in road travel is outstripping the completion of new roads. Worldwide, total motorised road travel grew by 42% between 2000 and 2010, while kilometres of paved road grew by 27%. In OECD non-member economies, vehicle kilometres (vkm)³ increased by 108%, while road kilometres increased by 65%. Should congestion, air pollution and other impacts of the rapid deployment of passenger vehicle fleets create negative feedback for additional vehicle use and demand, then more efficient alternative modes (such as public transport modes) may be demanded and infrastructure and spending follow.

Alternative to vehicles: Investment in public transport and other modes. The main alternative to vehicle transport in urban areas is public transport in the form of buses, light rail and metro. HSR and passenger heavy rail are alternatives to inter-urban vehicle transport and longer distance commuting.⁴ On average, passenger rail and buses move passengers with less than 20% of the energy required by passenger vehicles. Shifting modes to these systems would have important efficiency outcomes at scale. Options such as metro can compete with passenger vehicles on time, access and cost to travellers, but they can have high initial capital costs and often require high urban densities to meet cost-effective load factors. BRT systems are less capital-intensive and can work as viable alternatives in lower density and income regions. Alternative transport infrastructure investments often require a long-term approach from a transport planning and system perspective, as their impact is measured over decades, but the expected savings from modal shift made possible by these investments are potentially vast.

Shift investments also extend to non-motorised forms of transport. Increasing the share of cycling and walking in urban transport systems can have significant impacts on the total system efficiency. As outlined in Figure 3.18, the greater the share of cycling, public transport and walking in cities, the lower the per capita energy consumption in the passenger transport system.

³ Vehicle kilometres measure the travel of vehicles, not passenger kilometres or tonne kilometres; it is more relevant when evaluating congestion because actual vehicles on the road dictate congestion, not their payloads or number of passengers.

⁴ In China, for example, some analysis has shown that concurrent modal development is both rapid and running in parallel. Road building and public transport are expanding aggressively at the same time, which is different from the case in the United States and other developed countries, which tended to focus on developing one transport mode at a time leading to a personal vehicle-dominated system (Feng, 2013).

Figure 3.18 Energy consumption of passenger transport by share of foot, bicycle and public transport

Notes: GJ = gigajoule. Points represent cities in the SYSTRA data base, from around the world.

Source: IEA (2008), *Energy Technology Perspectives 2008*, OECD/IEA, Paris. UITP (International Association of Public Transport) (2006), *Mobility in Cities Database*, Courtesy of SYSTRA, <http://uitp.org/publications/Mobility-in-Cities-Database.cfm>.

Developing accessible and safe cycling infrastructure from existing road rights of way provides an opportunity to expand the road network beyond its former functioning capacity (Box 3.9). This in turn can decrease the energy consumption of travel.

Box 3.9 The growing market for cycling infrastructure

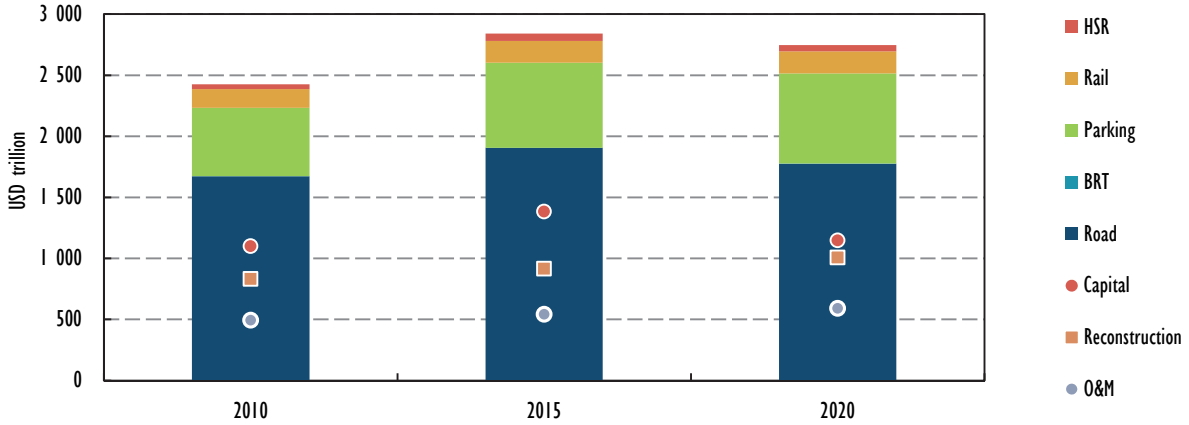
Many cities are in the process of providing cycling infrastructure, and bicycle use is responding. More dedicated cycling infrastructure that prioritises bicycle rights of way and provides additional space for cyclists, key to making cycling functional and accessible, has been adopted in the past ten years in many countries (ITF, 2013). Dedicated cycling infrastructure that improves safety and connectivity has been demonstrated as a key ingredient to the growth of urban cycling across all demographic groups (Buehler and Pucher, 2011). Correspondingly, bicycle use appears to be increasing. The ITF reports that average annual bicycle kilometres per capita have increased by over 9% in Korea, 3.4% in Germany and the United States, and 1.2% in the United Kingdom. American and Canadian cities have increased their rates of cycling noticeably, coinciding with the development of pro-cycling policies, infrastructure and new cycling facilities such as bike-share programmes (Pucher, Buehler and Seinen, 2011). Australia has also been increasing the amount of cycling (Loader, 2012).

While cycling is increasing its share, it is still a small component of most transport systems in OECD member countries – typically less than 5%, outside key cities in northern European countries such as the Netherlands, Denmark and Germany. Bicycle travel costs have been estimated to be significantly lower than vehicle travel from a full cost accounting framework that accounts for capital, maintenance, time, environment and health (Litman, 2014). As cities cope with population growth, congestion and other externalities of personal vehicle-based transport systems, continued interest and deployment of cycling infrastructure, bike-share programmes and other cycle-friendly facilities are likely. New laneway additions for bicycle-specific travel can be an order of magnitude cheaper than new lanes for motorised vehicles (Litman, 2014). This is an area of potentially significant growth over the next ten years.

The shift market: Levels and benefits of investment in efficiency infrastructure

Total infrastructure spending on transport was estimated to be USD 2.4 trillion in 2010, with the bulk of that spent on roads and parking, and relatively little on more efficient public transport and rail systems. Global investment in efficiency-enabling infrastructure such as rail, HSR and BRT, which totalled USD 195 billion in 2010, are predicted to increase by 19% to USD 233 billion in 2020 (Figure 3.19).

Figure 3.19 Annual expenditure on transport infrastructure by mode



Note: O&M = operation and maintenance.

The prospects for efficient infrastructure investment are dependent on preferences and policy support for alternative transport modes. Based on scenario modelling, the IEA estimates that transport infrastructure spending will increase by USD 550 billion in the next ten years, with over 90% of that on road-based modes. The IEA *ETP 2°C Scenario (2DS)* estimates that investment in rail would be USD 38 billion larger than in the 4DS. This would lead to a modal shift that would correspond to avoided fuel purchases of USD 378 billion per year by 2020. Infrastructure investment and additional policy and market support to lessen adoption of vehicles, while maintaining high quality transport services, could leverage ten times the savings in fuel consumption. *Shift*, as well as *avoid* policies, are an important part of policy actions needed to effect this change (see Box 3.10).

Box 3.10 *Shift and avoid policies: An important part of achieving the efficiencies of the 2DS*

As described in the 2DS, nearly 23% fewer vehicle kilometres of travel are possible by 2050; roadway additions decrease by more than 10 million lane kilometres, as road passenger and freight travel are either shifted (e.g. to bus or rail) or eliminated (e.g. due to smarter land-use changes). Global passenger vehicle parking would also be expected to decrease substantially at nearly 27 000 square kilometres less than estimated. In contrast, global rail additions would need to increase to accommodate greater rail travel: nearly 200 000 extra track-kilometres, including nearly 90 000 kilometres of additional HSR above expected additions to 2030. BRT networks grow to more than 25 000 trunk-kilometres by 2050, a ten-fold increase over 4DS projections.

Despite these increases in expenditure on rail, HSR and BRT infrastructure in the IEA 2DS, cumulative global land transport infrastructure spending decreases by nearly USD 20 trillion. The bulk of those savings come from reduced road investment and maintenance costs, which account for nearly USD 15 trillion of total projected savings. Parking reductions also save roughly USD 10 trillion, while rail expenditure (including HSR) increases by nearly USD 3.5 trillion. Modal shift saves USD 70 trillion of net expenditure in the transport system, comprising USD 50 trillion in savings in vehicle and fuel expenditure and USD 20 trillion in infrastructure savings.

Conclusions: Medium-term prospects for efficiency markets in transport

The short-term market for efficiency in transport has principally been driven to date by policy measures that introduce vehicle efficiency standards; these are creating greater demand for energy-saving technologies. Investment in efficiency is likely to be driven by concerns about local air pollution and congestion. Fuel prices will also be a critical driver. Measures to address efficiency have been widely adopted amid concerns about high oil prices, energy security, climate change and pollution.

The market is shifting to rapidly developing OECD non-member economies, where rising incomes and large growth in demand for mobility may lead to net efficiency losses as personal vehicles take up a larger share of total travel. Domestic policies in OECD non-member economies will become increasingly important in this regard, in particular as an increasing number of vehicles are manufactured in these countries. A potentially important role for OECD member countries in this context will be to continue to improve vehicle efficiency not only for domestic markets, but also, given car exports, to support efficiency efforts in OECD non-member economies.

An important area for future energy efficiency transport investment is the freight sector, given the growth it is seeing and its growing reliance on trucks. Although freight efficiency has stagnated in the past 20 years, future action and corresponding investment are likely in the sector, both in response to new policy on freight efficiency and, perhaps more influentially, greater fuel costs. Given that the strong drivers for increasing reliance on HDVs do not appear to be abating, transport markets and policy appear to be converging to support much greater investment in efficiency improvements than in the past 20 years.

The shape of national transport systems, especially in OECD non-member economies, is changing. Significant capacity and air pollution concerns can potentially re-draw the trajectory of vehicle adoption and travel. The ability of appropriate infrastructure to deliver avoided fuel consumption is potent, and could have long-lasting impacts on the trajectory of efficiency improvements in the transport system. This, in turn, is expected to have a major impact on the prospect for the expansion of the energy efficiency market in the transport sector.

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4. ENERGY EFFICIENCY FINANCE

Summary

- Energy efficiency finance is expanding and innovating. Innovation is occurring in contracts, repayment methods, funding approaches and business models.
- The private sector is the key source of finance, but the public sector also plays an important role, not simply as a catalyst for private sector investment, but also for its own account (from such varied activities as efficient lighting in public buildings to more efficient industrial processes in government-owned enterprises).
- Most finance is provided by commercial banks, but other channels and techniques are becoming mainstream, including green investment banks (GIBs), debt capital markets, energy performance contracting and on-bill financing. These different types of finance complement each other because they are designed to overcome different barriers, cater to different sectors, or appeal to particular categories of investor.
- Green bonds with an energy efficiency component are emerging as a promising additional lever. Bond standards will be key to investor confidence.
- Bilateral and multilateral development agencies are very active in promoting energy efficiency investments in developing countries. These programmes totalled over USD 22 billion in 2012.
- Recent trends in finance indicate that the energy efficiency finance market is likely to continue to grow over the coming years. Factors that will support this growth include a wider variety of tailored financial products and increasing attention to related policy issues, such as climate change mitigation. Policy makers can encourage energy efficiency finance by promoting greater transparency and better standards for financial products.

Introduction

Energy efficiency finance can be defined as any external (or third-party) funding to improve energy efficiency. Households, businesses and governments pay for most of their energy efficiency investments using their own capital, cash or savings rather than through financing. The International Energy Agency (IEA) has estimated that under the New Policies Scenario, almost 60% of energy efficiency investment to 2020 could be self-financed, mainly by households and businesses, with the balance financed principally through debt (IEA, 2014a). This would indicate, given our estimate of the total energy efficiency market being upward of USD 310 billion in 2012, that third-party finance for energy efficiency is in the range of USD 120 billion (although further inquiry is warranted to understand its true size). More investment will be needed to meet energy and other goals, notably climate objectives, which in turn will necessitate a larger amount of financing. To achieve this larger magnitude, there is a need for a broader array of financial sources and instruments.

Types of finance. The finance landscape is large and diverse, and represents a critical part of resources needed to support the energy efficiency market. The most basic types of finance are debt, grants, guarantees and equity.

- **Debt** is the traditional financial instrument. It can be provided by private or public actors and in a variety of ways, from simple consumer loans and credit cards to more complex models such as pooled

loans and on-bill financing. Private financial actors provide loans at market rates, whereas public institutions more often – but not always – provide concessional loans, e.g. at preferential rates. Funding from a private bank at a market interest rate can also be combined with public funding at a below-market interest rate. A particular form of debt often used in the energy efficiency context is provided through **dedicated credit lines**. These lines typically involve public sector financing and are often used when private commercial banks are not as a matter of course financing many energy efficiency projects (e.g. due to lack of knowledge and understanding of their characteristics, or limited liquidity). **Bonds** are another specific form of debt; these transactions typically involve a contractually more distant and remote relationship between the lender (e.g. the public or a number of financial institutions) and the borrower. **Green bonds** are becoming increasingly prominent in the climate change area; they have financed a number of renewables investments but can also be used for energy efficiency.

- **Guarantees** and other credit support mechanisms (insurance, derivatives) reduce or spread the risk of project debt. A guarantee is designed to encourage the lender (such as a commercial bank) to provide a loan; often these loans can be provided at a preferential rate as a result of the credit enhancement mechanism. Some guarantees actually backstop other guarantees that provide credit support to the underlying energy efficiency loan. Guarantees for energy efficiency are typically established with public funding to catalyse private investment.
- **Grants** are funds provided without any repayment obligation. In the context of energy efficiency, they are typically used for small-scale transactions to incentivise households or businesses. They may cover all or part of an investment, for example for a specific piece of energy-efficient equipment. Grants are generally public funds, but some grants are provided by private academic, research or philanthropic organisations. Grants can lower the capital requirements of an energy efficiency activity, which would otherwise be met through debt or equity. Grants are often required to cover transaction costs associated with energy efficiency investment (such as energy audits and subsequent monitoring and verification [M&V]), particularly when they are high relative to the size of the underlying transaction. For example, a USD 2 000 rebate for installing an energy-efficient boiler both reduces the upfront capital requirement and improves the risk/return profile of the investment.
- **Equity** is usually sourced from investors who participate in a company; it represents an infusion of cash into the company without a contractual repayment obligation, but with a potential revenue stream from dividends or enhanced stock sale values. A number of energy efficiency projects are financed through project companies, where the contribution of the financier is in the acquisition of shares in such project companies, which may later acquire energy efficiency assets. Equity is expected to be an increasingly important source as markets develop, with one immediate opportunity being equity investment in energy service companies (ESCOs) to allow them to pursue energy performance contracting (EPC) models (see description later in this chapter).

Other financial instruments are available to provide funding for energy efficiency projects. These typically represent variations on the above instruments (such as securitisation transactions) or draw upon them to varying degrees.

Chapter outline. Financing instruments can be categorised in a number of ways, for example, based on whether they are public or private, by type of instrument, by type of actor or by country classification, and there are, correspondingly, a variety of different ways to structure a discussion. This variety often complicates efforts to systematically characterise energy efficiency finance. The private sector remains the critical source of financing; the public sector also has an important role to play, as a catalyst for private sector funding but also for its own account (Box 4.1).

Box 4.1 Diverse roles for the public sector

The private sector is key both in executing projects (businesses, households, etc.) and in financing them (commercial banks, etc.), but the public sector also has important and varied roles to play. One key role is to catalyse private sector, as well as other public sector, investments through policies and support programmes. It also has an important role as a funder, notably through development banks and other public sector financial institutions. Public finance programmes can be particularly important for market segments that are under-served by private markets, such as small businesses. Moreover, the public sector has a role as an implementer of projects itself, for example government agencies and municipalities investing in efficient lighting in public buildings, or the myriad of industrial and energy sector companies that lie within the public sector, including state-owned utilities, cement producers and other industrial enterprises.

This chapter focuses on a selection of areas that are expected to help close the financing gap. Certain aspects have been highlighted (such as the funding provided by multilateral financial institutions) because of their visibility and the availability of data. The chapter uses the following structure:

- public sector finance, including both domestic support and development aid programmes
- selected modes of private sector finance
- selected financing structures (such as ESCOs).

The public finance section includes public finance institutions that support domestic investments; it also includes bilateral and multilateral development finance that supports programmes in developing and other foreign countries, as well as international climate finance and carbon finance programmes. The private finance section discusses energy efficiency finance from commercial banks and institutional investors; it also includes a description of some of the private sector undertakings made in the context of the recent “Rio+20 Voluntary Commitments”. The third section of the chapter focuses on three financing structures: EPC, bonds and on-bill financing.

Public finance

Public finance can be divided into two important categories: programmes that are designed to promote domestic investment, namely within the country (or region), and financing provided to support investment in a third country, typically as part of a development initiative. The discussion is organised along these lines:

- **Financing domestic investments**
 - public finance institution initiatives
- **Development finance: Financing cross-border investments**
 - bilateral development finance
 - multilateral development finance
 - international climate finance
 - carbon finance.

Public finance can leverage several times its value in private funding that would otherwise not have been mobilised, by mitigating risk (Box 4.2), co-financing projects and otherwise building private sector confidence. Much of the public finance for energy efficiency is delivered by governments, including at the national or sub-national level or through specialised agencies. The finance is provided in the form of grants, loans or guarantees via public financial institutions or government agencies. In addition, there have been important efforts to catalyse financing for energy efficiency through multilateral climate change-related financing instruments and carbon finance; this has become a visible part of the financing landscape.

Box 4.2 De-risking private investments through public sector instruments

Public sector instruments can be put in place to target the risks associated with energy efficiency projects. These instruments act in three ways:

- Instruments that **reduce risk**, by addressing the underlying barriers. An example might be a technical standards and certification policy that ensures the quality of materials. By removing the barrier, the risk will be permanently mitigated. UNDP calls this type of instrument “policy de-risking”.
- Instruments that **transfer risk**, from the private sector to the public sector. Not all risk can be removed by policy measures that address the root cause in a permanent manner. In such cases it can be more effective and quicker to transfer the risk to another party that is better able to handle it. An example might be a public loan guarantee for a commercial bank lending for energy efficiency. UNDP calls this type of instrument “financial de-risking”.
- Instruments that **compensate for risk**, providing a direct financial incentive to the actor implementing the energy efficiency activity. Even after addressing most risk through policy and financial de-risking, there is frequently some residual risk that can prevent private investors from investing. An example here may be a public rebate, subsidy or grant.

Source: based on UNDP communication to IEA. For more information, see www.undp.org/DREI.

Public finance institution initiatives: Financing domestic investments

Public finance institutions have played an active role in financing energy efficiency investments in their own countries. They have had energy efficiency on their agendas for a long time (e.g. Germany’s KfW started promotional programmes for energy efficiency in the housing sector in 1996), but interest has grown in recent years. Public finance institutions are typically active in sectors where market failures have substantially limited private sector investment, and often hold a mandate to provide long-term financing independent of market cycles and in line with policy objectives. As such, they are able to leverage capital at below-market rates for targeted investments and develop specific tools for energy efficiency investment. Table 4.1 summarises the available data for four public finance institutions.

Table 4.1 Domestic energy efficiency investment and share of total investment by selected public finance institutions, 2010-13

Institution	2010		2011		2012		2013
	EUR million	%	EUR million	%	EUR million	%	EUR million
CDC	233	1.6	380	2.2	453	2.9	..
KfW	10 315	16.0	9 701	19.0	13 697	27.1	16 000
UKGIB	x	x	x	x	181
EIB	2 200	3.1	1 300	2.1	1 100	2.1	2 100

Notes: EIB = European Investment Bank; .. = data not available; x = not applicable. Figures are self-reported and indicative only, due to data limitations and differences in definition; figures for France’s CDC (Caisse des Dépôts et Consignations) exclude the activities of ExterImmo as well as CDC Climat’s 2013 energy efficiency investments in the industrial sector. UKGIB (the United Kingdom Green Investment Bank) began investing in 2012 and the figure is for non-residential projects.

Sources: Cochran, I. et al. (forthcoming), *Public Finance Institutions and the Low-Carbon Transition: Five Case Studies on Low-Carbon Infrastructure and Project Investment*, OECD and CDC Climat Recherche, Paris; and IEA analysis.

The following four case studies reflect several important market trends, as well as the variety of countries that are undertaking public programmes to finance energy efficiency: (i) promotion of energy-efficient

buildings in Germany; (ii) an energy efficiency fund in Thailand; (iii) the launch of specialised GIBs in several countries; and (iv) a suite of energy efficiency finance-related initiatives at European Union (EU) level. The country-specific chapters in Part 2 of this publication provide further examples and some complementary information.

KfW promotional programme, Germany

KfW is Germany's public investment bank. In 2013, KfW Group committed a total of EUR 16 billion to energy efficiency investments in Germany.

The KfW “Energy Efficient Construction and Refurbishment” programme provides financing by way of concessional loans and grants for energy-efficient construction and refurbishment activities in the German residential sector. To qualify for promotional financing, the efficiency achieved must be greater than the requirements set out in the German Energy Savings Ordinance. For energy efficiency refurbishment activities, KfW offers an incentive in the form of partial debt relief. KfW also offers promotional loans for single measures such as windows, heating systems or insulation for those customers not planning a deep retrofit of their building or housing unit. The promotional loans are refinanced by KfW via the capital market and the interest rate is subsidised further by the Federal Ministry of Building, Transport and Urban Development. For customers who do not want to apply for a loan, there is the option to apply for a grant for investment (Dorendorf, 2013).

In 2013, KfW invested EUR 4.1 billion in residential retrofits, slightly down from EUR 4.3 billion in 2012. Since 2006, it has provided more than EUR 50 billion in loans and grants to 3 million homes to promote energy-related modernisation and energy-efficient new buildings.

Energy Conservation Fund, Thailand

The Energy Conservation Fund (ENCON), established in 1992, finances energy efficiency, as well as renewables investments, from levies on petroleum products. The fund has provided support through various disbursement channels and a range of instruments:

- Energy Efficiency Revolving Fund (EERF), a soft loan programme (maximum interest rate of 4% and seven years maximum loan period).
- Demand-Side Management Bidding, financial support to encourage businesses to invest in higher efficiency equipment, disbursed through a bidding mechanism on the basis of actual units of energy savings achieved per year at lowest cost.
- ESCO Venture Capital Fund to support small and medium-sized project developers and small projects. Disbursement instruments of the ESCO Fund include equity investment, a carbon credit facility, and equipment leasing.
- Tax incentives for operators that invest in energy-efficient equipment and machinery.
- Grants to government agencies, non-governmental organisations (NGOs), businesses and universities.

The EERF stimulated local bank financing (total investment USD 521 million, of which USD 236 million from the EERF and USD 285 million debt financing from local banks). The initial ratio of financial contributions under the programme was 1:1 between the government and banks, but the private sector share steadily increased over time. During Phase 1 (2008 to 2010), 33 projects benefited from the fund, with USD 11 million being deployed, leveraging a total investment of USD 109 million (Lehmann, Uddin and Nylander, 2014). The majority of investments (76%) were equity investments, followed by equipment leasing (24%). The EERF was phased out in 2011, but provides an interesting example of a domestically targeted programme in a developing country.

GIBs

Green investment banks are domestically focused public institutions that use public capital to leverage or “crowd-in” private capital, including from institutional investors, for low-carbon and climate-resilient infrastructure investment. In recent years, at least a dozen of these special-purpose public green infrastructure banks have been established. They are being used in different ways in different country settings, suggesting potential for adaptation and replication (Kaminker et al., forthcoming).

GIBs have been established in the United Kingdom (Green Investment Bank), Malaysia (Malaysia Green Technology Corporation), South Africa (Green Fund), Australia (Clean Energy Finance Corporation), Japan (Green Fund), United Arab Emirates (Masdar) and the United States. In 2011, Connecticut (United States) created the Clean Energy Finance and Investment Authority (CEFIA). Vermont has had a Sustainable Energy Loan Fund since 2013. In February 2014, the New York Green Bank was established to facilitate financing of innovative market participants. It expects to make its first investments in 2014 and eventually to have USD 1 billion available for financing. It will be run by the New York State Energy Research and Development Authority (NYSERDA) and is starting with USD 218 million of state-supplied capital. Hawaii and New Jersey are considering the establishment of their own GIBs, and a United States Federal Green Bank is also under consideration.

Energy efficiency is a major focus area of GIBs. All of the GIBs mentioned above include energy efficiency as a target sector for finance. Australia’s Clean Energy Finance Corporation provides financing for a range of energy efficiency programmes, including corporate finance for large energy efficiency projects and on-bill financing for consumers. CEFIA is also very active in promoting energy efficiency, notably via Connecticut’s Property Assessed Clean Energy (PACE) programme (see below). The United Kingdom Green Investment Bank funds non-residential energy efficiency primarily, but also funds the residential sector indirectly by providing debt finance support for the Green Deal programme. Some GIBs (in Connecticut and New York for instance) also see themselves as playing a key role in standardisation and data collection, potentially making it easier and cheaper for energy efficiency securitisation to occur, enabling private banks to underwrite and credit agencies to rate a securitisation (Kaminker et al., forthcoming).

A suite of energy efficiency finance initiatives at EU level

Several recent initiatives at EU level are aimed at scaling up energy efficiency finance. Taken together, they represent an important aggregate effort to provide finance, although they operate to some extent independently of each other.

The **Energy Efficiency Financial Institutions Group** (EEFIG) brings together in a new way financial institutions, the European Commission and expert stakeholders to facilitate dialogue with, and provide recommendations to, the European Commission on policy and programme development in this area. It was co-convened in late 2013 by the European Commission (DG ENER) and the Finance Initiative of the United Nations Environment Programme (UNEP FI). EEFIG has provided interim recommendations on buildings (EEFIG, 2014), including a call for European Structural and Investment Funds (ESIF) funding through scaled risk-sharing for public-private investments, and the development of standards for the whole investment process. EEFIG is expanding its scope to include industry and small and medium-sized enterprises (SMEs) to produce a final report in early 2015.

The **ESIF** provided funding of about EUR 5.6 billion for energy efficiency, co-generation and energy management over the 2006 to 2013 funding period. Under the new ESIF programming period, 2014

to 2020, the amount of investment in energy efficiency is expected to double or even triple. Along with more money, the ESIF framework brings better opportunities for the creation and scaling-up of tailored financial instruments and other mechanisms to attract new private capital, and also to bring longer-term, secure and affordable financing to the market. In connection with the ESIF, the Commission is expected to publish standard terms and conditions to encourage and guide member states in the establishment of dedicated “off-the-shelf” instruments, e.g. “renovation loans” dedicated to energy efficiency measures in the residential sector to provide individual owners with subsidised loans.

Complementing ESIF, at least EUR 840 million is earmarked for energy efficiency research and innovation under **Horizon 2020** (compared with EUR 285 million over 2006 to 2013). Although this research and development spending does not constitute energy efficiency finance as defined in this chapter, several of the topics enumerated are intended to support or otherwise catalyse financing to this end, including:

- project development assistance for buildings and retail energy market infrastructure
- standardisation and benchmarking of investments, with green valuation techniques
- working with public institutional investors to increase sustainable energy investments
- sustainable energy financing platforms at EU and national levels
- roll-out of business models for innovative energy efficiency services
- replication of successful innovative financing solutions
- large-scale capacity building on innovative financing schemes for sustainable energy.

The **European Energy Efficiency Fund** (EEEF) acts as a risk-sharing facility that works with financial institutions to provide finance to local authorities and ESCOs, in particular to promote the application of EPC. The initial capitalisation provided by the European Commission was EUR 125 million, which was supplemented by contributions from EIB (EUR 75 million), Cassa Depositi e Prestiti (EUR 60 million) and Deutsche Bank (EUR 5 million). In 2013, EEEF committed a total of EUR 101 million to seven partner institutions in France, Germany, Romania and Italy. A further EUR 8.7 million was committed to nine technical assistance projects through a Technical Assistance Facility, mostly public lighting and building retrofits in Spain. The facility was allocated almost entirely to public beneficiaries, for a total project volume of EUR 322 million in 2013. The fund will now actively look for additional senior investors to leverage the EU contribution further to a target level of EUR 600 million to EUR 700 million.

Finally, in 2013 EIB launched the DEEP (Debt for Energy Efficiency Projects) Green Initiative, presenting new products for four key EIB customer classes: financial institutions, the public sector, ESCOs and utilities. The products will generally have two common characteristics: aggregation and risk mitigation or diversification. The first product developed by EIB in the financial institution category is the **Private Finance for Energy Efficiency** (PF4EE) instrument, which was created in co-operation with the European Commission (DG CLIMA). PF4EE is designed to expand the availability and enhance the affordability of commercial debt financing for energy efficiency investments, in particular for SMEs.

Development finance: Cross-border investment financings

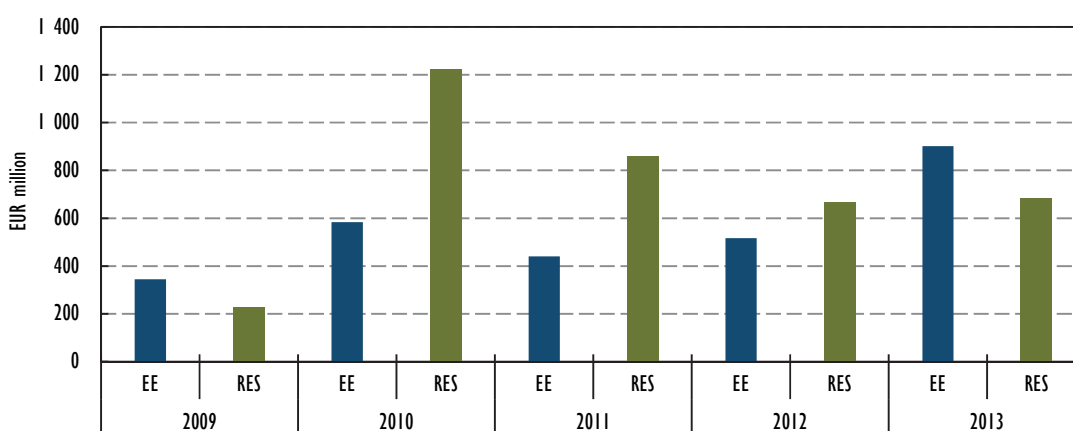
Numerous programmes for energy finance are being developed as part of development assistance goals. These include the international development programmes of numerous governments managed through bilateral assistance agencies, as well as the work of numerous multilateral development banks (MDBs). A number of initiatives finance energy efficiency in the international climate context, including in connection with the United Nations Framework Convention on Climate Change (UNFCCC) process, such as the Kyoto Protocol carbon finance mechanisms and fast-track funding.

Development finance: Bilateral agencies

In total, clean energy and mitigation finance activities of 20 of the largest national, bilateral and regional development banks amounted to about USD 65 billion in 2012 (IDFC, 2013). For the 14 institutions that provided a breakdown, energy efficiency in industry and buildings made up 30% of that (nearly USD 20 billion).

One of the most active of these development banks is KfW Development Bank (part of the KfW Group). Over the last five years, KfW Development Bank's commitment to energy efficiency has shown an upward trend, reaching EUR 900 million in 2013 (including energy efficiency programmes delivered via local financial institutions). The current energy-related portfolio of KfW Development Bank comprises more than 40 credit lines, predominantly in Europe and Asia, but also in Latin America and Sub-Saharan Africa, along with cross-regional funds. The bank now invests more in energy efficiency than in renewable energy (Figure 4.1).

Figure 4.1 KfW Development Bank commitments to energy efficiency and renewable energy, 2009-13



Note: EE = energy efficiency; RES = renewable energy sources.

Source: KfW Development Bank (2014), *German Financial Cooperation in the Energy Sector: Commitments and Project Examples*, presentation, KfW, Frankfurt am Main.

Drawing on the experience of the successful KfW promotional programmes for energy-efficient construction in Germany (described above), KfW Development Bank has implemented a pilot credit line for energy-efficient housing in India that involved a EUR 50 million concessional loan to National Housing Bank (NHB) as a financial intermediary. Also in India, the bank is providing (on behalf of the German Federal Ministry for Economic Co-operation and Development) a concessional loan of EUR 50 million to Energy Efficiency Services Limited (EESL) to promote efficiency in energy-intensive sectors. This loan will be used by EESL to structure, finance and implement energy efficiency measures for its clients (e.g. a municipality that wants to reduce its consumption of energy for street lighting). Finally, KfW established an SME credit line of EUR 50 million in late 2009 that was provided to the Small Industries Development Bank of India (SIDBI). In July 2014, KfW Development Bank announced plans to issue a green bond (see later in this chapter) and has appointed Crédit Agricole, Deutsche Bank and SEB to manage the sale. KfW has been an active member of the UN Principles for Responsible Investment since 2006.

Another prominent bilateral development bank is the Japan Bank for International Cooperation (JBIC), which has increased the priority it places on energy efficiency projects in recent years. JBIC finances energy efficiency under two headings: conventional financing and a dedicated “GREEN” category.¹ It provides loan, guarantee and equity investment, as well as dedicated credit lines to public and private banks in developing countries. The credit lines support small and medium-sized projects in particular. In 2013, JBIC announced that it would provide finance to greenhouse gas emission reduction projects via the Joint Credit Mechanism (JCM). JCM is a bilateral credit mechanism to support emissions reductions in developing countries. It is intended mainly to support energy efficiency projects at first, because the Clean Development Mechanism (CDM) has not been a very successful mechanism for energy efficiency (see below). It also intends to push the adoption of energy efficiency standards as a benchmark for emissions reduction calculations. The combination of conventional finance and a crediting mechanism is an effective approach, particularly when carbon prices are low.

A final example of a bilateral development bank providing support for energy efficiency finance is PROPARCO in France, a subsidiary of the Agence Française de Développement (AFD) that is dedicated to financing the private sector. PROPARCO provides direct support and credit lines for the financing of energy efficiency projects, and works in partnership with other European development finance institutions, including the Netherlands’ FMO and a KfW subsidiary called DEG. In 2013, PROPARCO financed, directly or via intermediaries, energy efficiency projects in Côte d’Ivoire, Turkey and Panama.

Development finance: Multilateral development banks

Multilateral development banks (MDBs) are increasingly active in supporting energy efficiency investment. They use a wide array of financial products in this area, including loans, grants and guarantees. Support is often provided through the use of local commercial banks and other financial intermediaries or through the establishment of dedicated facilities and programmes. These programmes are mostly designed to catalyse private sector funding from project developers (including businesses and households) as well as from private financial institutions. Funding is also provided to public sector entities, including state-owned enterprises, local government authorities and other public sector actors; some programmes also mobilise complementary financing from public banks, including GIBs.

In September 2014, a joint report was produced by the African Development Bank (AfDB), the Asian Development Bank (ADB), EBRD, EIB, the Inter-American Development Bank (IDB), the World Bank and the International Finance Corporation (IFC). It estimated mitigation finance for energy efficiency at USD 4.32 billion in 2013 (AfDB et al., 2013). The estimate covers developing, emerging and transition economies and the data correspond to the mitigation component rather than the entire project cost, for both demand-side and supply-side energy efficiency. An earlier IEA analysis provided figures for individual banks, for 2011 and also over the preceding four years (Table 4.2) (IEA, 2012).

In 2012, EBRD energy efficiency finance totalled USD 2 309 million, and in 2013 it increased again to USD 2 686 million. Asian Development Bank investment also remained strong in 2013, at USD 853 million. This represented a decrease from USD 973 million in 2012 and USD 949 million in 2011, but was still significantly higher than in 2010 when USD 340 million was invested. In 2013, ADB pledged to increase its focus on energy efficiency projects (ADB, 2014).

¹ "Global action for Reconciling Economic growth and ENvironmental preservation (GREEN)"; see www.jbic.go.jp/en/efforts/j-mrv.

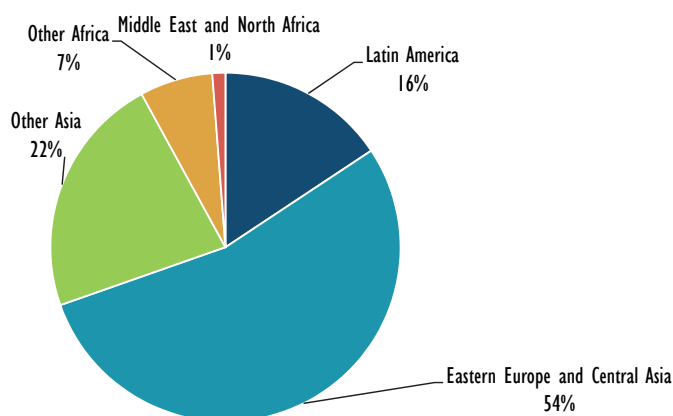
Table 4.2 MDBs' energy efficiency investment, 2011 and annual average 2008-11 (USD million)

	2011	Annual average, 2008-11
ADB	949	564
EBRD	1 726	..
EIB	482	557
IDB	508	419
World Bank Group	1 532	1 636
Total	5 197	..

Note: .. = data not available.

Sources: IEA (2012), *Plugging the energy efficiency gap with climate finance*, Insights Paper, OECD/IEA, Paris; and EBRD communication.

Most MDBs provide funding within a specific region, e.g. ADB in Asia and IDB in Latin America. The World Bank Group is the only one of the five banks examined providing finance worldwide. Eastern Europe and Central Asia receive the majority of lending for energy efficiency, with EIB, ADB and EBRD all providing funding in those regions (Figure 4.2).

Figure 4.2 Share of development finance for energy efficiency by region by value, 2008-11

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

Some banks place greater emphasis on energy efficiency than others. For example, EBRD has been able to identify a large number of energy efficiency investments in Eastern Europe and Central Asia, where there is a high share of heavy industry, ageing infrastructure, high energy and carbon intensity, energy price subsidies and potential for significant energy efficiency improvement.

Recent multilateral development finance activity

There are a number of interesting examples of multilateral development finance for energy efficiency. These programmes operate across a wide variety of countries and country contexts.

The IFC, in partnership with the Global Environmental Facility (GEF), has established a programme called **Commercializing Energy Efficiency Finance** (CEEF) that provides guarantees to energy efficiency investments in Eastern Europe. IFC-GEF guarantees up to 50% of the loss from loan defaults, a risk-sharing arrangement that encourages banks to lend. Local banks select projects and design their credit facilities. No guarantees have been called for under CEEF, and banks have continued to expand lending without the risk guarantees.

IFC programmes in Eastern and Central Europe have been replicated elsewhere, an example being the China Utility-Based Energy Efficiency Program (CHUEE). From December 2006 to September 2009, CHUEE provided USD 512 billion in loans (USD 936 million total project investment) to 78 companies without a default loss. In order to scale up CHUEE for its third financing round of around USD 558 million, IFC changed the design to reach more SMEs by partnering directly with medium-sized financial institutions as opposed to the utilities themselves (Kato et al., 2014).

EBRD has seen an increasing share of its sustainable energy business coming from dedicated credit lines called **Sustainable Energy Financing Facilities (SEFFs)**. EBRD is implementing SEFFs across 20 countries (e.g. TurSEFF in Turkey,² SlovSEFF in Slovak Republic, KyrSEFF in Kyrgyz Republic, or the Ukraine SEFF).³ SEFFs leverage around 80 local financial institutions to lend on funds at their own risk to private sector borrowers for commercial and household projects, thereby reaching a large market of small and medium-sized transactions. Financial incentives – paid upon project completion – are used in some, though not all, markets to target clearly identified barriers and as an interim solution in the absence of market-based instruments. EBRD has a robust M&V regime, which is clearly a key strength in quantifying SEFF impact. Sustainable energy investments worth EUR 1.5 billion have been financed. Technical assistance is supported by grant funding from EBRD donors and focuses on market transformation to higher energy performance technologies and skills transfer for financial product development.

Advised by the EIB, the **Global Energy Efficiency and Renewable Energy Fund (GEEREF)** is a fund-of-funds to mobilise risk capital for investment in energy efficiency and renewables in developing countries and economies in transition. GEEREF was launched in 2008 with funding from the European Union, Germany and Norway of EUR 112 million. It is seeking a similar amount of capital from private sector investors, to bring the total funds under management above EUR 200 million. GEEREF invests in private equity funds that in turn invest in private sector projects and enterprises, thereby enhancing the effect of the investment. It is estimated that with EUR 200 million, up to EUR 9.5 billion could be mobilised.⁴ Some 20% of the investment financed by GEEREF relates to energy efficiency.

The **China Energy Efficiency Financing Programme (CHEEF)** is a dedicated credit line initiated in co-operation with the World Bank and supported by GEF. Its objective is to increase the availability of commercial financing for energy efficiency in medium-sized and large enterprises. The majority of projects are for waste heat recovery (average size around USD 20 million). In the first phase of the programme (2008 to 2010), USD 100 million was provided to each of two participating local financial institutions, which then provided matching funds. Two further USD 100 million loans were provided in 2010. By the end of 2011, a 1:4 leverage ratio had been achieved. The leverage ratio for the third phase is expected to be even higher (IIP, 2012a).

International climate finance

Industrialised nations have promised to boost climate-related aid to USD 100 billion per year by 2020. This represents a significant opportunity to increase energy efficiency finance, because energy efficiency has a key role to play in greenhouse gas reductions under most scenarios.

Established in 2008, the **Climate Investment Funds (CIFs)** are one of the world's largest climate finance mechanisms. As of March 2014, the CIFs had a total pledge of USD 7.5 billion, of which USD 5.2 billion is

² See www.ebrd.com/pages/news/press/2014/140120.shtml.

³ See www.ebrd.com/pages/news/press/2014/140203a.shtml.

⁴ See GEEREF website, <http://geeref.com/about/what-geeref-is>.

in the Clean Technology Fund (CTF). The CTF provides mostly middle-income countries with highly concessional resources to explore options to scale up the demonstration, deployment and transfer of low-carbon technologies. Channelled through the MDBs, CTF concessional financing focuses on large-scale, country-initiated projects in energy efficiency, including industry, buildings, district heating, municipal, lighting and appliances. The share of CTF funding going to energy efficiency in March 2014 was 17%, and the share of mixed energy efficiency and renewable energy projects was a further 7% (CIF, 2014). The private sector is a key player in the CTF, as 37% of all financing is intended for private sector projects to be disbursed directly to companies or through financial intermediaries, to ensure fast scale-up of investments in national markets. The success of CTF public sector projects in attracting private investment centres on the ability to address enabling environments, complementary infrastructure, and investor risk appetite.

A new international climate-financing vehicle is the **Green Climate Fund (GCF)**, which is being established through the UNFCCC. It is hoped that the GCF will be in a position to start financing activities in 2015. The GCF is designed in part to finance energy efficiency activities. One feature of the GCF is its private sector facility, which will enable it to leverage local financial institutions in particular. More clarity is expected on the fund's initial resources, and its capacity to finance energy efficiency activities. Actions such as establishing a dedicated window for energy efficiency, and modalities to aggregate smaller energy efficiency transactions into larger financing packages, might serve to facilitate GCF financing for energy efficiency.

The United Kingdom, the United States and Germany have announced another initiative aimed at raising the promised USD 100 billion for climate change. Launched in partnership with Denmark, France, Japan, the Netherlands and Norway, the **Global Innovation Lab for Climate Finance** will seek private sector input on innovative tools for raising finance to combat climate change. After reviewing climate finance instruments proposed by the private sector, NGOs and think tanks, the Lab will choose the most promising ideas and facilitate their implementation. The Lab will focus on increasing the public sector's ability to leverage private finance. Ideas chosen for implementation should be announced by the beginning of 2015. In addition to the climate finance donor countries, large private financial entities such as Bank of America Merrill Lynch, as well as MDBs such as the World Bank and IDB, are expected to support the initiative.

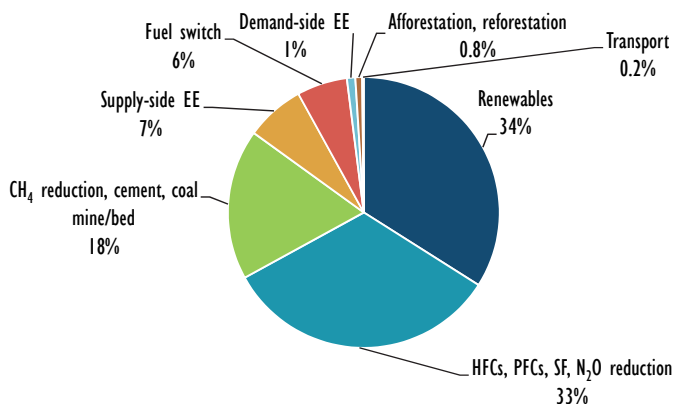
Finally, the **Global Climate Partnership Fund** was initiated by the German government and KfW, with additional investments from IFC, Denmark, Austria and Deutsche Bank. It primarily offers commercial financing to local financial institutions to lend on for sustainable energy projects. It can also provide direct financing. Projects so far include building upgrades and energy-efficient lighting. Committed investments into the fund are around USD 205 million.

Carbon finance

Carbon finance, primarily in the form of the Kyoto CDM offset mechanisms, allows projects in developing countries that can prove they reduce greenhouse gas emissions to earn credits called Certified Emissions Reductions (CERs). Projects then sell the CERs to governments and companies in richer nations to help meet emissions targets. The first CDM projects were registered in late 2004. By 2013 USD 31 billion had been invested in efficiency projects, comprising almost 10% of the total value (IEA, 2014a). The majority of that was in the electricity sector.

Energy efficiency accounts for 8% of CERs (Figure 4.3). The majority of these projects improve supply-side energy efficiency; the demand side only represents 1% of total credits up to 2012. This proportion is not expected to change dramatically in the period to 2020 given the current project pipeline. The relative lack of demand-side energy efficiency initiatives reflects in part the difficulty in developing cost-effective initiatives that focus on end users. Supply-side efficiency projects are more popular because of their relative ease of design and implementation: targeting a defined and limited number of specified facilities, with fewer actors and more certain outcomes.

Figure 4.3 Share of CERs expected from regular CDM projects until 2012 by sector



Note: EE = energy efficiency; CH₄ = methane; HFC = hydrofluorocarbon; N₂O = nitrous oxide; PFC = perfluorocarbon; SF = sulphur hexafluoride.

Source: UNEP DTU (2014), UNEP DTU CDM/JI pipeline analysis and database, 1 August 2014.

The share of energy efficiency is much higher for Joint Implementation (JI) projects under the Kyoto Protocol than for regular CDM. This may reflect the fact that JI covers economies in transition rather than developing countries. Energy efficiency represents 29% of JI projects and 26% of credits.

The use of CDM and JI for energy efficiency has been hindered by complex certification processes, stringent monitoring needs and uncertainty about the post-Kyoto period. Considerable uncertainty now surrounds the medium and long-term prospects for carbon offsetting. Nevertheless, the experience with these mechanisms provides lessons that are applicable to energy efficiency finance more generally, such as the need for quality data, standardisation and M&V.

Programmes of Activities (PoAs) seem to hold much promise for energy efficiency in general, and demand-side efficiency in particular. A PoA is a method of project development under the CDM that enables many small-scale, replicable and geographically dispersed activities to be aggregated under a common framework. Economies of scale are achieved by sharing development and operational costs. As of August 2014, there were a total of 391 PoAs in the pipeline maintained by UNEP DTU. The overall share of energy efficiency has been much higher in the case of PoAs. Also, the share of demand-side energy efficiency has been greater than supply-side energy efficiency. Within the demand-side category, residential energy efficiency projects dominate, which further underlines the applicability of PoAs to such diffuse mitigation activities. The first registered PoA (2009) involved the distribution of compact fluorescent lamps to low-income households in Mexico (CUIDEMOS Mexico).⁵

⁵ See www.environmental-finance.com/content/analysis/carbon-finance-deal-of-the-year-2010.html.

Private finance

The bulk of energy efficiency finance is currently provided by the private sector, much of it traditional commercial bank financing to businesses or households. The public sector can develop policy and regulatory instruments to overcome barriers and facilitate the scaling-up of investment in energy efficiency projects, but private finance will remain the key for the long-term growth and development of the energy efficiency market. Other sources are also emerging, including institutional investors. In time, equity and venture capital may take on a more prominent role. This section also includes a description of some of the private sector undertakings made in the context of the recent “Rio+20 Voluntary Commitments”.

Commercial banks

The role played by commercial banks is central, although diffuse. They help establish the market for energy efficiency finance by supplying finance to meet the growth in demand from their clients. They can do this by anticipating future client needs and adapting existing or developing new products accordingly, and by offering energy efficiency financing in tandem with other credit applications.

The amount of financing provided by commercial banks is large, but small relative to the USD 500 billion that may be required under various low-carbon scenarios.⁶ For example, Citigroup directed a total of USD 1.4 billion to energy efficiency activities between 2007 and 2013 (Environmental Finance, 2014), which represents an annual funding of about USD 200 million per year. This figure, of course, presents some of the methodological and definitional issues discussed elsewhere in this document, namely what portion of an investment in efficient equipment (e.g. more efficient buildings or aircraft) should be counted as an energy efficiency investment.

Two approaches are being taken by commercial banks: demand-driven and strategy-driven (Deutsche Bank, 2012). The demand-driven approach involves re-packaged product extensions, such as lending for commercial retrofits, mortgages extended to cover energy efficiency, or car loans for more energy-efficient cars. The strategy-driven approach assesses whether energy efficiency product types and target markets fit within a bank’s existing strategy or portfolio mix. An example of the strategy-driven approach would be to introduce energy efficiency lending products as part of a multi-tiered programme to grow the SME business segment, with the objective of diversifying revenue and credit risk. The strategy-driven approach is to realise that existing clients’ risk profile and profitability can be improved by improving energy performance, for example by replacing inefficient motors for industrial clients.

Commercial banks finance energy service contracts undertaken by ESCOs (see section on EPC), notably large ones. In recent years, commercial banks have expanded ESCO financing from investments in public buildings to private commercial markets. Commercial banks have also sought to facilitate growth in mechanisms such as PACE (see section on on-bill financing).

Commercial banks are also an important relay in channelling public finance towards energy efficiency. Many of the development banks and GIBs discussed in earlier sections channel funds through local commercial banks, which in turn often provide complementary financing. This, for example, is the case for the various risk-sharing facilities in which commercial banks mobilise the actual liquidity, which then benefits from guarantee coverage.

A number of Chinese banks are particularly active in energy efficiency finance, including the China Export-Import Bank, Shanghai Pudong Development Bank (SPDB), Industrial Bank, Huaxia Bank and

⁶ See for example the IEA New Policies Scenario (IEA, 2014a).

Bank of Beijing. Many of the banks with specialised energy efficiency financing programmes launched them with support from multilateral and bilateral development finance institutions (World Bank, ADB, IFC, AFD, KfW etc.). For example, ADB implemented energy efficiency loan projects in three provinces: Guangdong in 2009, Shandong in 2011, and Hebei in 2012. ADB loans provide USD 100 million to each respective provincial government, and the funds are re-lent through a financial intermediary that manages and reuses the funds (IIP, 2012b).

There remain a variety of important barriers and challenges that are limiting this private finance, including the small size of transactions and the challenges of measuring savings (Box 4.3). Accordingly, there remains an important role for the public sector to play in helping to catalyse this private finance.

Box 4.3 Constraints on the supply of energy efficiency finance

The barriers to investment in energy efficiency are well known, from split incentives to lengthy payback periods to subsidised energy prices. All of these affect the decision to invest and thus the demand for financing. A number of barriers are more specific to the supply of finance, as summarised below.

Small size of projects: Projects are often diffuse and too small to be attractive to lenders. Consequently, project development and implementation costs are higher.

Transaction costs: This is a significant factor affecting access to finance for businesses (particularly SMEs). There are examples of grant or loan programmes to which companies simply do not apply, either because it takes too much time to fill out forms or report on energy savings, or because companies do not have the technical in-house expertise needed to implement energy efficiency projects.

Intangibility: Financial institutions may not consider energy cost savings to be a potential source of cash flow available for debt repayments. This is particularly an issue in industry, where much of the savings potential can be achieved by process change rather than investment in new assets. It is also difficult for ESCO services to qualify for off-balance sheet treatment.

Lack of harmonised M&V protocols: Independent assessment of projects using M&V protocols is needed to win the trust of financiers, as energy savings, particularly in industry, typically change over time depending on production volumes, other process changes, degradation of equipment, etc.

A shortage of objective data and skills to assess transactions and underlying risks: The absence of transparent data and financial research that can act as a signal to investors or means for performance comparison is a significant barrier. Unlike other investments, energy efficiency investment performance data are generally not collected in a systematic manner.

Lack of suitable financial vehicles with attributes sought by institutional investors: There is a lack of financial vehicles that have the necessary attributes of familiarity, investment-grade credit rating, low transaction costs, liquidity, appropriate investment period and availability of related financial research that will make them attractive to institutional investors.

Policies and regulations that favour investment in “brown” infrastructure: Misaligned policy signals, such as continuing support for fossil fuel use and production, low or no carbon prices, and unpredictable changes to energy efficiency policies, can limit attractiveness for investors.

Financial regulations with unintended consequences: Financial regulations agreed at international level to increase banks’ levels of capital and reduce their exposure to long-term debts (Basel III for banks around the globe and Solvency II for insurance companies in Europe) can discourage long-term investments, including in energy efficiency.

Institutional investors

Institutional investors, such as pension funds, insurance companies, investment funds and sovereign wealth funds, look for long-term investments with medium-term returns and low risk. Institutional investors managed USD 83 trillion in assets in Organisation for Economic Co-operation and Development (OECD) member countries in 2012. Yet “direct investment” in infrastructure of all types accounted for only 1% of large pension fund investments on average, and their allocation to green infrastructure investment was much smaller (Kaminker et al., 2013). Given the relative abundance of investment funds available, policy makers are increasingly interested in how best to leverage them. To date only a tiny fraction has gone to energy efficiency, for a variety of reasons (see Box 4.3 on limitations to commercial financing).

Some cases of private funds with an energy efficiency focus do exist, particularly where the investment does not consist solely of energy efficiency measures but is also based on an asset such as the building itself. Sustainable Development Capital Limited (SDCL) manages the GBP 100 million to GBP 150 million UK Energy Efficiency Investments Fund, launched with a GBP 50 million cornerstone investment by the UK Green Investment Bank. It also manages funds in Ireland and Asia. SDCL uses in its projects a combination of shared savings mechanisms and energy service agreements (ESAs, see next section).

In the United States, the Investor Confidence Project (launched by the Environmental Defense Fund) provides ready-made best practice examples of energy efficiency projects based on practical input from industry and existing technical standards. By standardising how projects are developed and savings estimates are calculated, these types of public programme can reduce transaction costs while increasing confidence in performance.⁷ Texas, for example, has developed a PACE programme (see next section) toolkit using the Investor Confidence Project (ICP) Protocols. ICP is also working with Connecticut’s Green Bank and the Los Angeles Better Buildings Challenge. There is interest in expanding the scope of ICP to develop a set of protocols for Europe. A common approach would facilitate a global market. These types of standardisation initiative will help to facilitate financings by institutional investors that look to rely on standardised products rather than project-specific structuring and due diligence.

Institutional investors can also have an important role in driving change in company decision-making, by bringing the issue of energy efficiency to boardrooms.⁸ In 2011, CDP called on the 500 largest companies to achieve annual emission reductions by making investments with “satisfactory positive returns on investment”, as well as to set and publicly report on emissions reduction targets.⁹ Of the emission reduction activities reported by companies for that year, 25% fall into the area of buildings energy efficiency (CDP, 2011).

Rio+20: Private sector Voluntary Commitments on energy efficiency

A key outcome of the United Nations Conference on Sustainable Development, or Rio+20, was a series of Voluntary Commitments to finance development activities. Energy efficiency is at the core of the commitments, leading both in absolute numbers and financing contributions, signifying the recognition of its economic value by states and private firms. Of 1 060 commitments identified, 128, or 13%, focus on energy efficiency,¹⁰ including 88 from private actors (including joint public-private approaches) that

⁷ Source: www.eepformance.org/2/post/2014/03/three-solutions-for-public-programs-to-leverage-icp-protocols.html.

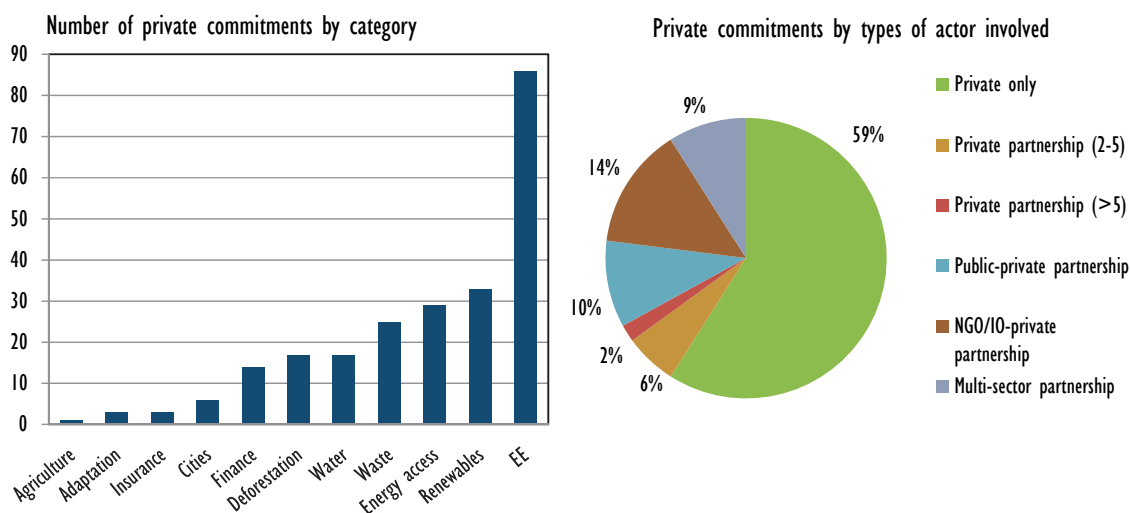
⁸ These aspects are described in Kaminker and Stewart (2012) and Kaminker et al. (2013).

⁹ See: www.cdproject.net/en-US/Programmes/Pages/initiatives-cdp-carbon-action.aspx.

¹⁰ This section draws on research at Sciences Po Paris and the Institute for Sustainable Development & International Relations (IDDRI) assessing the impact of Voluntary Commitments on sustainable development using sources including the UN Sustainable Development Knowledge Platform and the National Resource Defence Council’s Cloud of Commitments.

account for more than half of the total commitments from private actors. Of these, many focus on internal efficiency, with specific and measurable targets, such as Deloitte UK’s “Our Green Journey” and Microsoft’s “Carbon Neutrality” commitments. Other commitments (such as the European PVC industry’s “VinylPlus” initiative) seek to prioritise energy efficiency along the entire value chain.

Figure 4.4 Number of private Rio+20 Voluntary Commitments by category and by type of actors involved



Private actors have committed a total of more than USD 63 billion in financial contributions, notably via Bank of America’s USD 50 billion, ten-year “Environmental Business Initiative”. These energy efficiency commitments span all geographical regions and industries, with an emphasis on rapidly industrialising economies (for example Chinese firms including Sinopec and Quanta Computer) and energy-intensive industries. Significant commitments have also been made by the various MDBs, within the framework of the United Nations’ Sustainable Energy for All (SE4ALL), but also for example the USD 30 billion EBRD Sustainable Energy Initiative Phase 3. Around 20 commitments focus on the creation of financial mechanisms and economic incentives for energy efficiency.

Selected financing structures, techniques and intermediaries

Energy efficiency finance is seeing significant innovation. Financing models have been developed to cater better to the wide diversity of energy efficiency projects and to overcome the range of hurdles they face. Specialised energy efficiency entities, such as ESCOs, could play an increasingly important role in many countries in implementing these models. This section looks at three main categories – EPC models, bonds and securitisation, and on-bill financing.

Many other financing models and techniques exist. These include vendor financing, white certificate schemes, insurance products to remove technical uncertainty, and leasing solutions. Microfinance also has a potentially important role to play, particularly in less developed countries.

EPC and ESCOs

EPC is an arrangement in which a contracting partner (e.g. an ESCO) enters into an integrated contract with an end user, together with a financing institution that provides a loan, to design and implement energy efficiency measures with a guaranteed level of performance. Repayment and profit

is paid out of the financial savings that result. Depending on the accounting rules in place in a given country, EPC may allow the loan to remain on the balance sheet of the ESCO rather than the building owner (a form of off-balance sheet financing).

The EPC model works well in specific market segments, such as services, industry and the public sector; it also works well for project sizes of more than USD 0.5 million given in part the transaction costs. EPCs have relatively high transaction costs due to procurement rules and particularly where they address the building envelope. Projects typically take several months to develop, involving complex contracts and funding from several sources. One way to overcome high transaction costs and mitigate risk is to aggregate contracts; a failure on one building, for example, may be balanced by better results on others.

The EPC model first emerged in the United States in the 1980s, and the market there is now worth more than USD 5 billion a year. It is also emerging in other countries such as China, France, Germany, Italy, Korea, Spain, and the United Kingdom (Table 4.3).

Table 4.3 EPC market size in selected countries, 2013 or latest available

Country	USD billion	Number of ESCOs or projects
China	12.00	..
United States	5.00-8.00	> 500 projects
Germany	0.20 (4.04-5.38 for all ESCO projects)	500-550 ESCOs
France	0.10-0.14 (4.31 for all ESCO projects)	350 ESCOs
Italy	0.67	50-100 ESCOs
United Kingdom	0.54	30-50 ESCOs
Spain	0.40-0.54	20-60 ESCOs
Canada	0.42	..
Korea	0.33	> 1 400 projects
Denmark	0.19-0.20	15-20 ESCOs
Croatia	0.14	10 ESCOs
Russia	0.14	30-100 ESCOs
Ukraine	0.14	30 ESCOs
Japan	0.10	50 projects

Notes: .. = data not available. Differences in definitions and methodology mean that country data are not directly comparable.

Sources: various country sources; for European countries, Bertoldi, P. et al. (2014), *ESCO Market Report 2013*, JRC Science and Policy Reports, European Commission, http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/jrc_89550_the_european_escos_market_report_2013_online.pdf.

In the United States, activity has been concentrated in the municipal, universities, schools, hospitals and federal government markets. In December 2011, US federal agencies were instructed by Presidential Memorandum to enter into USD 2 billion of EPCs by the end of 2013. In many jurisdictions in the United States, EPCs for the public sector have been financed through leasing arrangements that remain off the customer's balance sheet. That model is now in question, with some ESCOs claiming to have a pipeline of projects that are on hold until accounting rules are clarified. Projections of the EPC-ESCO market in the United States in 2020 range from USD 13 billion to USD 20 billion.

The China Energy Conservation Project (implemented with the World Bank) established three pilot ESCOs in China in the mid-1990s. Several phases followed over a number of years – initially capacity building and seed funding, moving on to a guarantee facility in later years. China's EPC market is now

among the largest, if not the largest, in the world. Annual investment topped USD 12 billion in 2013 (EMCA, 2013), and over 4 800 ESCOs have been registered.¹¹ Although most of these are small, they include a wide variety of company types, with strong financing backgrounds or with prominent utility or large industrial holding company shareholders. The EPC sector in China differs from other countries in some respects. For example, industrial projects have always dominated investment in China, whereas investment in publicly owned buildings is relatively small. ESCOs often provide the largest share of project financing, and such off-balance sheet financing is often a key project selling point (see also the chapter on China). A series of support measures have been introduced to further expand the industry, including favourable tax treatment and publicly financed project completion incentives.

ESCO markets in Europe vary widely but are growing in almost all countries. Examples include, in the United Kingdom, Barts Health Care Trust, Peterborough Council, and the RE:FIT programme created by the Greater London Authority, in France, Rhone-Alpes OSER for deep retrofits of public buildings and Energies POSIT'IF in the Ile-de-France region, and the Croatian ESCO HEP (EEFIG, 2014).

Despite challenges, ESCO activities are also under way in Russia (IEA, 2014b). Currently, most ESCO projects in Russia are financed either through ESCOs' own funds and direct loans to customers, or by the customers themselves. There are, however, banks that offer financial leasing contracts. A federal ESCO was created in 2011 to help improve conditions in the market. There is also work in progress on the creation of an energy finance agency.

Other emerging ESCO markets that are becoming established include Brazil and India. In those countries, many ESCOs are present and active but in some of them the market is far from fully developed. In another set of countries, including Chile and Thailand, actions have been taken to support the development of an ESCO market, but activity is limited as yet.

New variations on the traditional EPC model are also emerging:

- An **Energy Service Agreement (ESA)** allows finance to be treated as an operating expense, with the assets kept off the client's balance sheet. An energy service provider finances the entire energy efficiency investment, and uses an ESCO to carry out and guarantee the performance. The client pays only for savings delivered, based on an agreed M&V protocol. The ESA model is growing but still on a small scale. Most of the activity appears to be taking place in the United States. Recent deals include one in Hawaii for an investment of USD 5.8 million.
- The **metered structure** is used to measure efficiency units delivered against a dynamic baseline, taking into account weather and other variables. The utility can then either become the efficiency improvement investor or sign a long-term agreement with an investor. The owner is paid a lease for use of the building, which effectively gives the building owner another tenant and source of income. This aligns the interests of all key parties: the utility, the building owner and the investor.

Bonds: Green and other

Clean energy bonds, green bonds, climate bonds and others have been around for several years and create new capacity for energy efficiency investment by tapping into fixed income markets. In response to investor demand, there are now growing numbers of issuers in North America, Europe and Asia, ranging from development banks to local authorities to businesses. Investors in such bonds range

¹¹ An industry association has been set up (see www.emca.cn).

from pension funds to global asset managers, companies and central banks. By July 2014, green bonds had exceeded USD 20 billion, twice the amount issued in 2013, although that is still a tiny fraction of the USD 80 trillion bond markets.

In total, bonds linked to the buildings and industry sectors total USD 13.5 billion. Of these, the largest segment is energy-efficient appliances at 31%. LG Electronics is included because 93% of its product range is certified with the Energy Star label. ESCOs account for 26%, and bonds from municipal energy efficiency programmes account for 8%. Many energy efficiency solutions are located in internal divisions of large corporations such as Siemens, GE and Schneider Electric (Climate Bonds, 2014).

Public sector agency issuances

Until late 2013, the green bond market was dominated by MDBs. Since 2008, the World Bank has issued USD 6.4 billion in green bonds through 67 transactions and 17 currencies. Separately, IFC has issued over USD 3.5 billion in green bonds, including two USD 1 billion transactions in 2013. Energy efficiency projects are an important component. For example, IFC green bonds are supporting companies like Mexico's Optima Energía, which helps hotels achieve energy savings.

Many other public sector institutions are now issuing green bonds:

- In March 2014, EIB launched a GBP-denominated Climate Awareness Bond (CAB), driven by demand from socially responsible investors based in the United Kingdom. EIB CAB issuance by March 2014 stood at EUR 2.2 billion, compared with EUR 1.4 billion in 2013. Cumulative CAB issuance totals over EUR 5 billion equivalent in nine currencies. The funds raised via CABs are earmarked for EIB lending projects in energy efficiency and renewable energy.
- In the United States, NYSERDA has issued AAA/Aaa-rated bonds guaranteed by the New York State Environmental Facilities Corporation, under the Clean Water State Revolving Fund programme. On the basis that improving energy efficiency would contribute to the state's water quality, NYSERDA was able to offer USD 29 million for low-interest rate loans.
- The city of Johannesburg (South Africa) recently launched a ZAR 1.46 billion (USD 140 million) green bond to improve and expedite its climate change mitigation strategy and move it towards low-carbon infrastructure.

Corporate issuances

Corporate green bond issues (i.e. from companies like EDF and Toyota) are now growing very rapidly – 2013 saw issues totalling USD 10.4 billion, while 2014 is expected to see a total of USD 20 billion (Standard & Poor's, 2014). This is allowing corporations to tap an additional pool of investors committed to principles of socially responsible investing.

Corporate green bonds have mostly been issued in Europe to date. They include the following:

- May 2014 saw the largest green bond issuance yet: GDF Suez's USD 3.4 billion green bond. Orders were three times over-subscribed, evidence of continuing strong demand. The proceeds will be used for energy efficiency and renewable energy projects (Standard & Poor's, 2014).
- Unilever's GBP 250 million bond in March 2014, linked to internal energy and water consumption improvements, took the market beyond development banks and utilities.
- In April 2014, Swedish construction company Skanska issued a SEK 850 million (USD 131 million) green commercial property bond.¹²

¹² See www.climatebonds.net/2014/04/swedens-skanska-sek850m/.

- Swedish company, Vasakronan, has issued just under USD 1.3 billion of unrated corporate green bonds linked to energy-efficient buildings so far in 2014.
- Unibail-Rodamco (France) released a USD 750 million green bond in February 2014, also linked to energy-efficient buildings.¹³

In Canada, Tandem Health Partners issued the first labelled green bond that finances an energy-efficient public-private hospital project: the North Islands Hospital in the Province of British Columbia.

What is in a name: Green bond definitional challenges

Certain bonds are labelled as “green” or “climate bonds”, such as those by MDBs, utilities such as EDF and GDF, and Real Estate Investment Trusts (REITs), while others are for energy efficiency but not labelled as such. While no universal definition of these terms yet exists, some degree of standardisation will be important for market development. The issue of ensuring that the bonds support green development is an emerging challenge. Issuers use different evaluation approaches (Box 4.4). For example, Vasakronan and Unibail-Rodamco used BREEAM (Building Research Establishment Environmental Assessment Method) and LEED standards to evaluate properties, while the Skanska bond was reviewed by the Centre for International Climate and Environmental Research (CICERO). Some bonds include a commitment to use proceeds to make assets achieve BREEAM or LEED certification, rather than being backed by these investments already. These approaches can be expected to vary, given in part the diffuse nature of bond issuers and the different sectoral and country contexts in which they operate, but the question of ensuring such bonds have a sufficiently “green” impact in general is likely to affect this financing instrument.

Box 4.4 Standards and voluntary principles for bonds

The Green Bond Principles (GBPs) were launched in January 2014 by a coalition of banks led by Citi, JP Morgan, Bank of America and Crédit Agricole. The GBPs are a set of voluntary principles that are intended to catalyse the rapidly growing green bond market by (a) providing guidance on the key components involved in launching “credible” green bonds, (b) ensuring investors have adequate information to assess environmental impact, and (c) moving the market towards standard disclosures, which will facilitate transactions.

There have been calls for the GBPs to be strengthened, suggesting that third-party verification should be mandatory, there should be a definition of green, and that the GBPs should address the accountability and transparency of green bond underwriters, not just issuers (BankTrack, 2014).

In the same vein on the investor side, the Climate Bonds Initiative (www.climatebonds.net) is promoting a standard and certification scheme across all types of projects, with one of its working groups seeking to establish a Climate Bonds Standard for Green Buildings. The aim is to mobilise capital by developing a standard that ensures the low-carbon credibility of certified climate bonds issued for green buildings.

Initiatives such as these are particularly important as the issuer base diversifies from institutions, such as EIB and the World Bank, towards corporations. The GBPs, for instance, will promote the verification and auditing of how the proceeds are used, as well as the measuring and reporting of the impacts of projects, for example energy savings. These issues will be key to market development and investor confidence (Environmental Finance, 2014).

¹³ See www.eurotreasurer.com/news/financing-accounting/unibail-rodamco-debuts-with-green-bond-issue/.

On-bill financing: PACE and other programmes

Several countries have introduced financing programmes for household energy efficiency investments in which the debt is repaid by the beneficiary (i.e. the building occupant) through their utility or local tax bill. In many of these schemes, the debt is attached to the property rather than the owner. Such schemes take advantage of the relationships that already exist between utilities or local governments, on the one hand, and occupiers on the other hand.

The Mexico Efficient Lighting and Appliance Project included an appliance replacement programme in which consumers received a credit to purchase new energy-efficient refrigerators and air conditioners, and repaid it in monthly instalments directly through their electricity bill from their power utility. In that way, the project overcame customer credit barriers to generate financing for the energy efficiency investment in new appliances. The project mobilised financing from multiple sources including the government of Mexico, NAFIN (a state-owned bank), the World Bank, the CTF, GEF and consumers themselves.

In the United States, as of January 2014, on-bill financing programmes using utility electricity invoices were operating or preparing to launch in at least 25 states. National Grid has offered an on-bill programme for small-business customers since the 1990s. United Illuminating in Connecticut, San Diego Gas and Electric, SoCalGas, SoCal Edison, Pacific Gas and Electric and others all operate similar programmes for commercial customers. The lifetime loan volume of 30 programmes in one recent review was estimated at over USD 1.8 billion (SEE Action, 2014). Similar schemes are being put in place in Canada, Italy and the United Kingdom.

Box 4.5 Securitisation of PACE loans

In May 2014, CEFIA announced a deal to bundle and sell a sizeable chunk of its commercial PACE loan portfolio to the specialty investor Clean Fund. Clean Fund is a PACE investor that has closed deals in multiple states and hopes to support USD 1 billion in PACE projects, both as a direct lender and through the purchase of existing assets (Lombardi, 2014).

Clean Fund has agreed to purchase USD 24 million of a USD 30 million bond issuance, with CEFIA holding on to the remaining USD 6 million of bonds as a first loss position. The assets represent a diversified portfolio of property owners funded through a USD 40 million CEFIA warehouse programme. CEFIA will use the proceeds to replenish its warehouse facility and fund new commercial PACE transactions in Connecticut.

One missing element is a rating of the bonds by an independent agency, as is customary in most large securitisation deals. Rating agencies require a large scale and a high degree of diversity. However, CEFIA says it plans to work more closely with rating agencies once the portfolio is fully funded. Formalised and consistent ratings can help to support the expansion of the market; this is an area that merits consideration by government and other relevant financial sector stakeholders.

This deal is important in demonstrating the commercial PACE warehouse model and the securitisation concept. The transaction may be the first known securitisation of commercial energy efficiency loans, potentially unlocking institutional capital for energy efficiency finance. It comes shortly after the first securitisation of residential PACE loans in California, valued at USD 104 million. In February 2014, Deutsche Bank launched a similar programme that buys PACE loans from local governments in California, improving their ability to issue bonds for energy efficiency.

The on-bill financing concept is growing rapidly in the commercial property market through PACE schemes,¹⁴ in which repayments are effected through the building's property tax bill (as distinguished from the utility bill). As local tax payments enjoy low default rates, the PACE programme helps to provide security of repayment; this in turn supports the securitisation of these repayment obligations, allowing this funding mechanism to tap into broader sources of financing (Box 4.5).

Local governments in California and Connecticut were frontrunners in introducing PACE. Today, 33 states have enabling legislation in place, with 7 states facilitating 16 different PACE programmes, mainly focusing on commercial buildings. As of January 2014, 208 projects had been funded, totalling over USD 63 million, with about a further USD 215 million in the pipeline. There is increasing momentum, with new initiatives being announced on a regular basis, for example Florida's USD 200 million Evest Program and New York's Energize NY PACE, which secured USD 75 million from Bank of America. Texas aims to target agriculture and industry in addition to commercial property. Maine and Vermont, meanwhile, have introduced legislation that adapts PACE for residential mortgage providers. The market potential for commercial PACE in the United States is estimated at between USD 2.5 billion and USD 7.5 billion by 2015 (Fawkes, 2014).

Melbourne (Australia) is using a variation of PACE in which property owners arrange financing directly with financial institutions, rather than being provided by a local government (which typically must issue bonds to fund such a programme). The financial institution provides the upfront cost and the property owner pays a property tax surcharge equal to the loan's principal and interest payments. The city of Melbourne then forwards the payments to the lender. The surcharge ranks ahead of other debts and obligations, which increases the likelihood that the loans will be repaid and allows for discounted interest rates. If a property is sold, the new owner assumes the payments. This owner-arranged model allows property owners to secure more attractive rates and terms than with a traditional PACE model, because they can seek out commercial lenders independently and obtain loan terms that are specific to each project (CCAP, n.d.).

Conclusions and prospects

Interest in and opportunities for energy efficiency finance are increasing worldwide. The number and variety of energy efficiency financing programmes have expanded dramatically in recent years, as has the diversity of investors, financiers and intermediaries. Commercial banks are still the largest lenders, but in order to reach riskier segments banks look to other types of financial institution, such as public banks and MDBs. On-bill financing and EPCs are among the fastest-growing sectors within energy efficiency finance.

Many OECD member countries in particular are in the process of trying to encourage the private sector to scale up investment in energy efficiency. Governments are accelerating this process with access to finance, but also regulation, incentives, de-risking measures and capacity building. Public funds are being used to kickstart the market and technical assistance is helping familiarise private financial institutions with energy efficiency and appropriate financial products. Public finance programmes are important for consumer market segments that are under-served by private markets, such as small businesses or affordable housing.

¹⁴ PACE was developed in 2008 primarily with residential buildings in mind. In 2010 however, the Federal Housing Finance Agency advised federal mortgage agencies not to underwrite mortgages for properties subject to PACE agreements. Despite various legal challenges, the majority of residential PACE programmes were suspended or abandoned.

Energy performance data and loan performance data are slowly becoming more readily available, which will build confidence and understanding in the market. Financing programmes are being used to deliver more attractive and accessible financial products. Technological advances in data collection (notably in measuring energy savings) present new opportunities for energy efficiency finance. For example, the availability of near real-time measurement enabled by cheaper sensors and information and communications technology is reducing M&V costs.

As markets mature, the menu of financial products expands and access to data increases, energy efficiency finance can be expected to see faster growth. Public policy attention to climate change mitigation, local pollution concerns (notably from power generation) and concerns about security of imports are also factors that may drive up interest in increasing the availability of finance to support energy efficiency investments.

The experience of the last three years in particular hints that the rate of change in energy efficiency finance may be accelerating. Better co-ordination between investor, policy and financial communities could help. Better appreciation of the multiple economic and social benefits (employment, public budget etc.) of energy efficiency could also be a key step in releasing more public and private financing for energy efficiency.

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PART 2
**COUNTRY
ENERGY EFFICIENCY
MARKET PROFILES**

INTRODUCTION

The country case studies presented in this section of the report capture more than USD 30 billion worth of energy efficiency market investments made during 2012, in the following 11 geographically diverse economies:

- Canada
- China
- European Union
- India
- Indonesia
- Ireland
- Italy
- Japan
- Korea
- Netherlands
- Thailand

Compared to the *Energy Efficiency Market Report 2013 (EEMR 2013)*, this year's report contains more case studies from emerging economies and from Asia. Where possible, it also focuses on innovative schemes that harness market dynamics for energy efficiency products. Snapshots of one or two market segments are thus more prevalent in this year's case studies than general descriptions of national energy efficiency markets.

Each case study follows a 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 chapter then takes an in-depth look at **current energy efficiency activity** by describing selected sectors and activities. Rather than provide a comprehensive overview, 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 chapter wraps up with a discussion of key **challenges** for energy efficiency markets in the particular country, and **concludes** 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 the previous chapters of the report, which provide broader assessments, this compendium of case studies conveys the richness and diversity of energy efficiency markets worldwide, and highlights the specific and dynamic contexts within which they operate.

5. CANADA

In Canada, spending on efficiency from provincially owned or regulated utilities was more than USD 800 million in 2013. The bulk of policy and programming for energy efficiency incentives is channelled through provincial governments. There are over 100 efficiency programmes and policies offered through the ten provinces and three territories. Provincial governments are focusing on financing, rebates and other incentive-based efficiency programmes, and on implementation of national codes and standards. These initiatives demonstrate a significant commitment to energy efficiency investment.

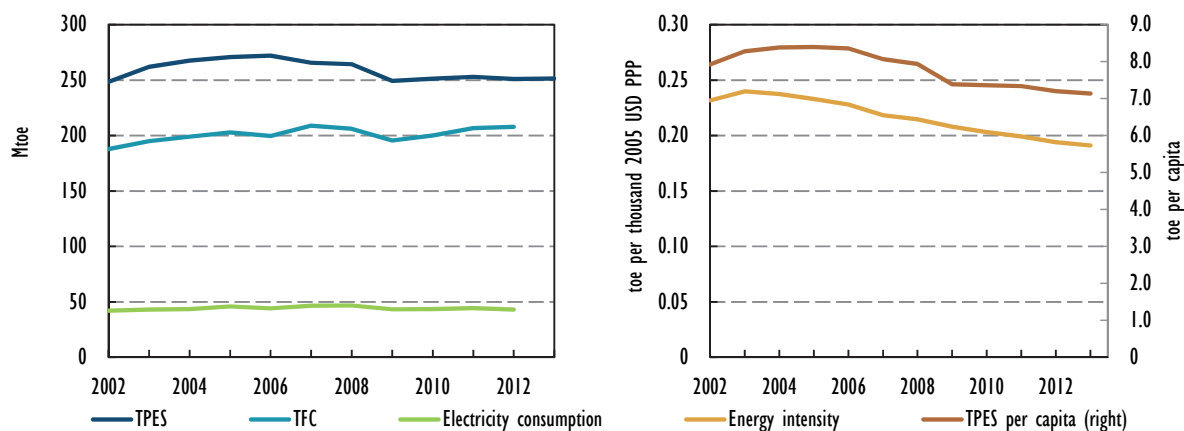
The *Energy Efficiency Market Report 2013 (EEMR 2013)* highlighted national energy efficiency activities in Canada, whereas this year's report focuses on provincial-level initiatives and funding.

Energy profile and context

Between 2002 and 2012, total final energy consumption (TFC) increased by 15 million tonnes of oil-equivalent (Mtoe) (9%). Transport has seen the greatest increase in absolute energy use, reflecting both strong economic and population growth. The transport sector is the largest end user of energy and is growing in share of TFC, driven by a trend towards larger personal vehicles, such as light-duty trucks, and greater reliance on heavy-duty trucks for freight. The largest improvements in energy intensity are in the residential and services sectors. Absolute energy consumption in the services sector is down over the decade, which is noteworthy as economic activity in the sector grew by 33% between 2000 and 2011. Gross domestic product (GDP) per unit of floor area increased by 8% and energy consumption per unit of floor area fell by 21% between 2000 and 2011.

Since 2007, growth in services-producing industries averaged 1.3% per year, while growth of goods-producing industries increased by only 0.2%. Services now make up 70% of GDP, increasing by three percentage points over the last ten years, while goods-producing industries comprise 11%. This has important energy outcomes, as services energy intensity is roughly half that of goods-producing industries.

Figure 5.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12

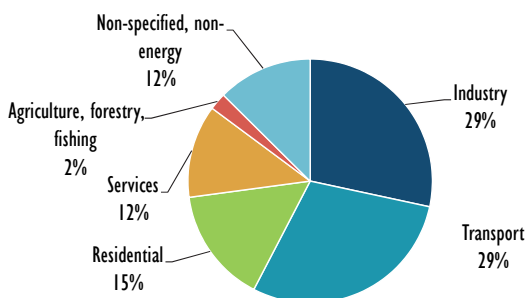


Note: TPES = total primary energy supply.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

Population growth propelled total energy use, with population increasing by 10% from 2002 to 2012. Population growth over that period was five percentage points above the average for member countries of the Organisation for Economic Co-operation and Development (OECD). Over the same period, the Canadian economy grew by 20%, with growth four percentage points higher than the OECD average. Canadian energy intensity improved by 16%, essentially equal to the OECD average. Intensity improvements were driven by energy efficiency adoption and by the relative de-industrialisation of the economy. Energy consumption per capita declined by 9%, which is slightly greater than the OECD average improvement of 7.7%.

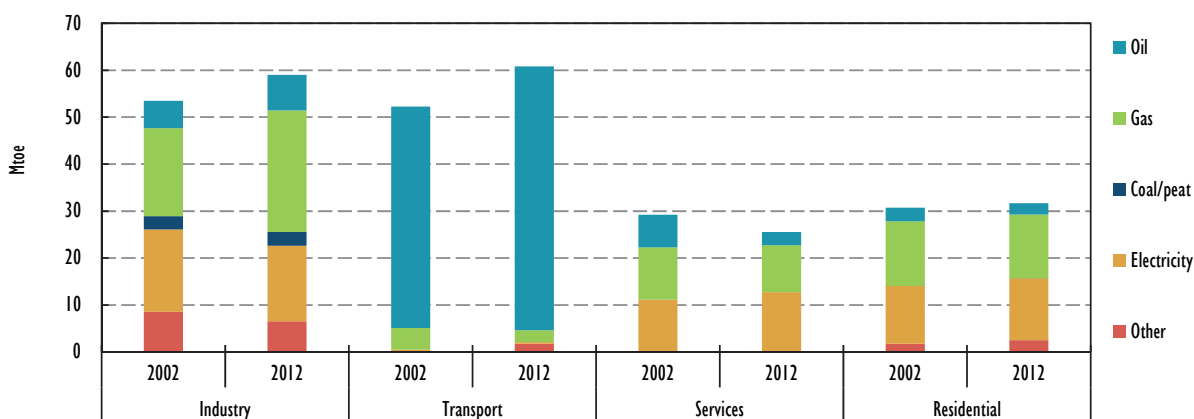
Figure 5.2 TFC by sector, 2012



Canada has the highest energy intensity and one of the highest per-capita emissions levels of all member countries of the International Energy Agency (IEA), though intensity has declined by 20% over the decade (Figure 5.1). Climatic and geographic considerations play a key role in determining Canada’s energy mix and intensity. Canada’s large geographical area and relatively low population drive a large share of its final consumption towards the transport sector (29% of TFC in 2012) (Figure 5.2). Oil thus dominates TFC by fuel source, at 46%. Improving energy efficiency is therefore a key objective in achieving the Canadian government’s economic and energy policy priorities.

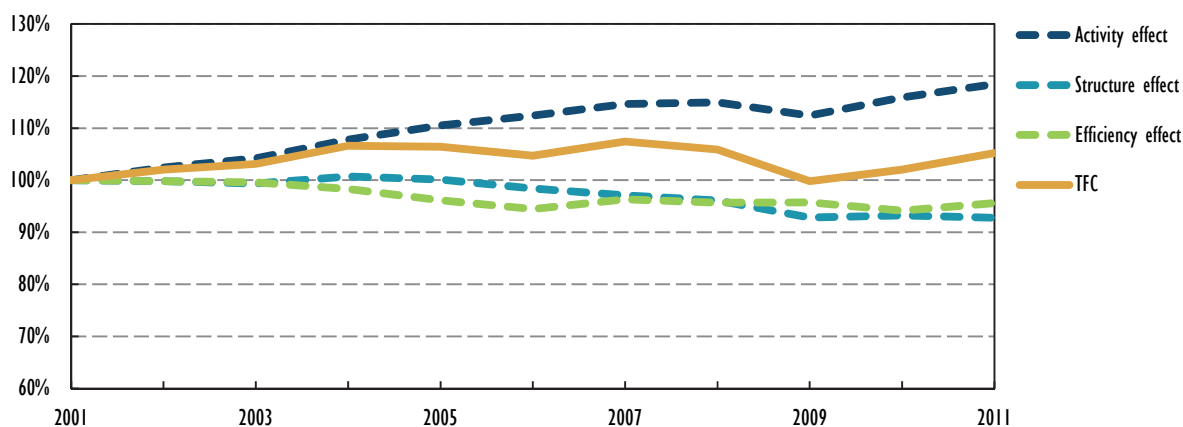
Canadian customers benefit from the high share of hydroelectric power in electricity generation (60% in 2013), with some of the lowest electricity prices in the developed world. Electricity demand has grown at an average annual rate of 1.2% in Canada since 1990. Canada is also a net exporter of electricity to the United States, exporting approximately 25 billion kilowatt hours (kWh) per year.

Figure 5.3 TFC by sector and by energy source, 2002 and 2012



Both efficiency and structural outcomes are helping to lower Canadian energy use. All end-use sectors in Canada have experienced efficiency improvements, but structural factors in the economy have had an important impact as well (Figure 5.4). As described previously, the growth of the service sector in the Canadian economy has been the most important downward influence on energy demand since 2001. Total energy consumption is higher than 2001 levels, driven by strong activity. The Canadian economy fared better than many OECD countries during the recession of 2008 and the post-recession period.

Figure 5.4 Decomposition of Canadian energy use



Energy efficiency market activity

Market driver: Energy efficiency policies and programmes

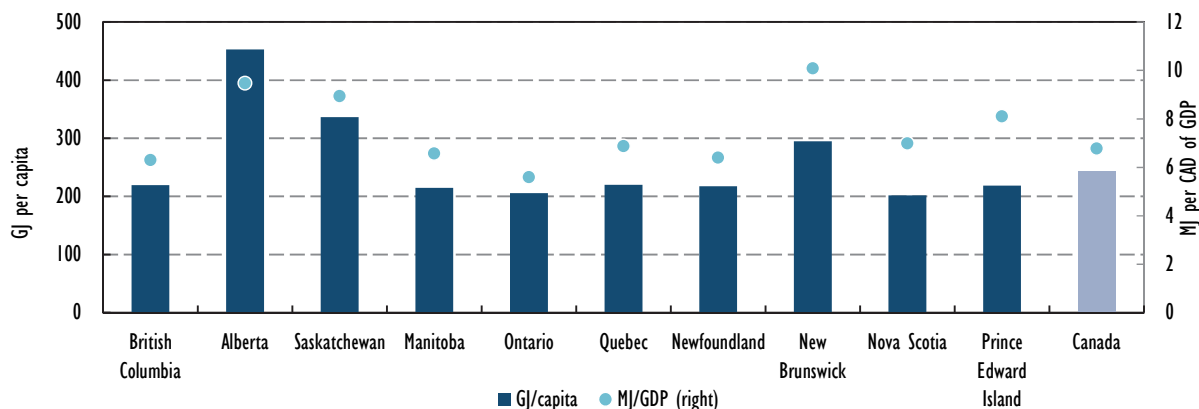
Evaluating the performance of Canadian energy efficiency initiatives and the reaction of markets requires detailed analysis of the sub-national context. As a decentralised federal state, energy efficiency in Canada is guided as much by the federal government as by the 13 provincial governments and territories. The federal government provides national leadership, enhances alignment with US initiatives and standards, and develops underlying measures (e.g. labels, codes, standards and rating systems) that complement delivery of provincial programmes. For example, it sets energy efficiency standards for equipment that cross international and provincial borders. It also leads the development of model codes and administers product testing and labelling, increasing consistency across the country and avoiding costly, duplicated efforts. Jurisdiction over energy resources, local matters and property rights (among others) lies with provincial governments. As a consequence, provincial and territorial governments set many policies affecting energy end use and energy intensity, such as codes and standards on buildings, highway systems, urban issues, and resource and power sector regulations.

An important variance in energy intensities exists between provinces and territories. Oil- and gas-producing Alberta and Saskatchewan have high energy intensity and energy per capita. Ontario is a large province with a significant manufacturing base, but it has among the lowest energy intensity in the country reflecting a large service-sector share (Figure 5.5). Energy efficiency potential and market activity can therefore change dramatically between provinces.

Every province and territory is engaged, in some manner, with achieving energy efficiency outcomes and most have frameworks for energy efficiency improvements across the residential, services and industry sectors. These programmes include grants and funding, financing and other incentives for energy

efficiency improvements for consumers, businesses and large industrial energy users. Programmes are administered either through provincial-territorial energy efficiency authorities or ministries, municipal governments, provincially regulated utilities and non-governmental organisations. There are approximately 100 specific programmes targeting different energy efficiency outcomes at various levels of government (NRCan, 2014). Box 5.1 describes the energy efficiency policy framework in Ontario.

Figure 5.5 Energy per capita and energy intensity in Canada by province



Note: GJ = gigajoule; MJ = megajoule.

Source: CESAR (2014), Sankey diagrams of Canada's energy systems, Canadian Energy Systems Analysis Research, www.cesar.net.ca/visualization/sankey-diagrams-canadas-energy-systems.

Box 5.1 Long-Term Energy Plan of the government of Ontario

Ontario released its updated Long-Term Energy Plan (LTEP) in December 2013. Conservation will be the first resource considered before building new generation and transmission facilities, and will be the preferred choice wherever cost-effective. Using conservation and energy demand programmes as well as improved codes and standards, the province expects to offset almost all of the growth in electricity demand to 2032. Ontario has set a long-term conservation target of 30 terawatt hours (TWh) in 2032, which exceeds the equivalent total power used by the city of Toronto in 2012.

Ontario will also use demand response to meet 10% of its electricity peak demand by 2025, equivalent to approximately 2 400 MW under forecast conditions. In the 2013 LTEP, the province committed to introducing a number of tools and programmes to encourage energy conservation. For example: on-bill financing for energy efficiency retrofits, social benchmarking for consumers to compare their energy usage to their neighbours, and the Green Button initiative that allows consumers to access their energy data through mobile and web-based applications.

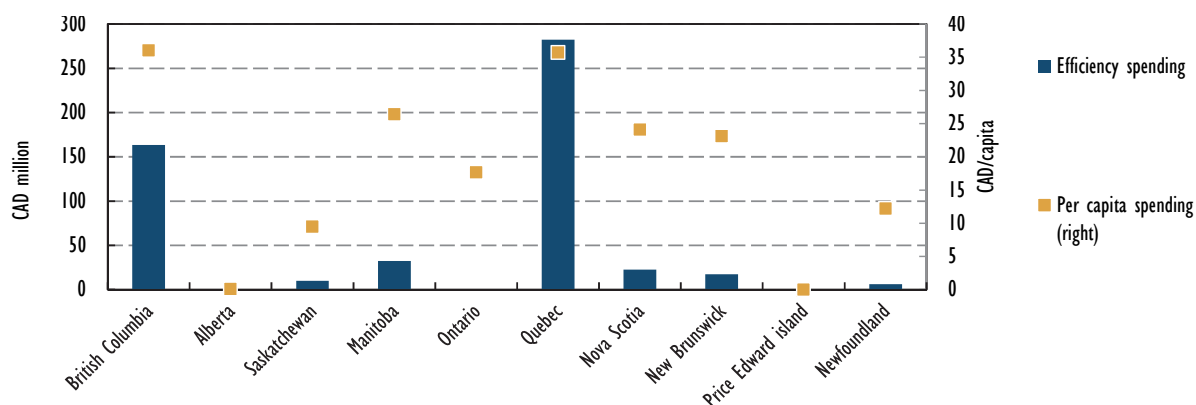
Source: IPEEC (2014), *Annual Report 2013* (Vol. 43), International Partnership for Energy Efficiency Cooperation, Paris.

Provinces and territories vary significantly by economy and population size. This affects total energy efficiency potential in each jurisdiction. Quebec spends the most on energy efficiency programmes and British Columbia (BC) has the highest per capita spending at CAD 36 per person (Figure 5.6) (IndEco, 2011a).

Provincial and territorial programmes often leverage federal activities. Agreements with federal government departments, such as Natural Resources Canada, enable provinces and territories to develop and deliver programmes based on federal standards, tools, data, and technical expertise. This approach

to standards-setting, labelling, and enforcement helps create consistency in the Canadian marketplace and is a major cost saving for provinces and territories. Examples include provincial-territorial leveraging of the federal EnerGuide home rating system and the Energy Star labelling system to qualify recipients of incentives. Provinces and territories can choose which federal programmes to use and have the flexibility to tailor these programmes to their region's needs.

Figure 5.6 Total and per capita energy efficiency spending by province, 2010



Notes: Per capita spending in Ontario is for 2009. Data for Prince Edward Island were not available.

Source: IndEco (2011a), *Canadian Energy Efficiency Program Study*, IndEco Strategic Consulting Inc., Toronto.

Current energy efficiency market activity

Demand-side management programmes and electric utilities

Electric utilities in Canada are regulated by provincial regulators, and market structures can vary significantly across provincial borders.¹ However, the majority of electrical capacity in Canada is publicly owned in all but three provinces. Public utilities' emphasis on efficiency improvements can be less in response to regulators wishing to stimulate efficiency as a market-based resource and more as an act of government policy. At the same time, public utilities are also corporations that respond to market signals and, in general, must answer to independent regulators on electricity rates and new acquisitions. In this role, public utilities can be compelled by regulators to offer energy efficiency programmes as a means to avoid new costly electricity supply.

Electric utility efficiency programmes are a significant part of the efficiency market in Canada. The reliance on demand-side management (DSM) programmes from utilities spans most provinces, and these programmes are a key plank of energy efficiency strategies at the provincial level. A 2011 review of programmes with specific goals to improve energy efficiency identified over 70 different electric utility-based DSM programmes in seven provinces and territories (IndEco, 2011b). Electric utility efficiency programmes provided over half of the rebate, financing, and consulting programmes offered sub-nationally. The most popular area of focus was building retrofits, primarily using rebates and cash grants (Table 5.1). Utility-run retrofit programmes comprised 42% of energy efficiency focused programmes in 2011.

Electric utility-led DSM programmes make up between 35% and 48% all of residential and service-based energy efficiency programmes in Canada. Demand-side management spending was up by 45% in 2013

¹ This chapter focuses on DSM from electricity utilities but natural gas utilities also offer DSM and efficiency-based programmes. Natural gas markets can vary significantly between provinces and are not as easily comparable.

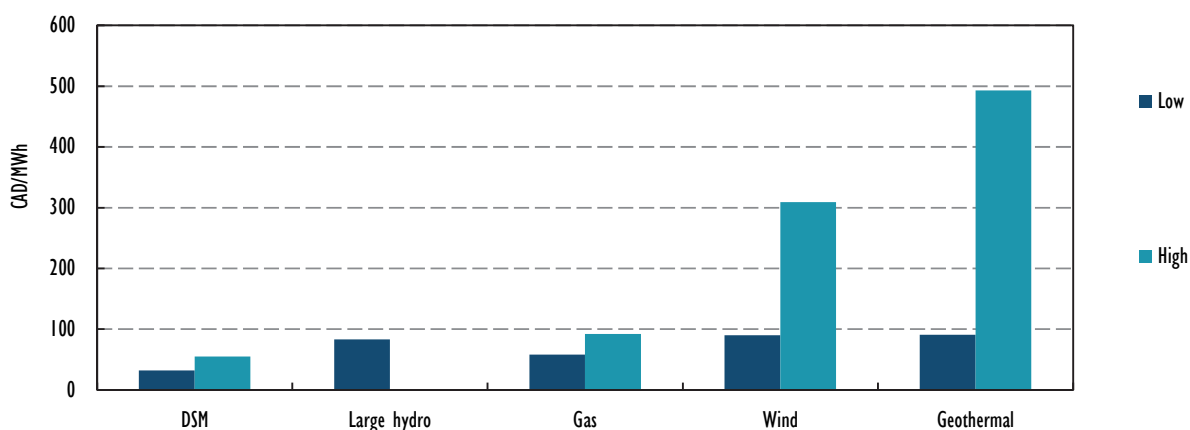
compared with 2008 to CAD 696 million (Forster, Wallace and Dahlberg, 2014).² Total DSM spending from both electric and natural gas utilities in Canada was CAD 800 million. These programmes, entirely within the purview of either provincially owned utilities or through provincially regulated private markets, are a significant component of the energy efficiency market in Canada.

Table 5.1 Number of Canadian electric utility energy efficiency programmes by improvement type and policy instrument

	Building retrofit	Appliance replacement	Lighting	Equipment and heating systems	New buildings
Rebate and grants	4	8	7	7	2
Energy audit and consulting	7	0	1	1	0
Financing	7	1	0	2	2
Total	18	9	8	10	4

Market forces also are a key driver for the number of utility-offered DSM programmes and energy efficiency programmes in general. Energy efficiency is seen to be a cost-effective source of energy supply. For example, resource acquisition planning for BC Hydro and Manitoba Hydro reveals the economic case for DSM, where both utilities consider efficiency on an equal basis with supply options. DSM efficiency measures defer the need for new capital-intensive generating assets by at least five years. DSM in BC Hydro is estimated to be the least expensive resource option (BC Hydro, 2013a) (Figure 5.7). To this end, both utilities are planning to commit significant expenditure to DSM. BC Hydro plans to spend CAD 445 million on conservation and efficiency between 2014 and 2016 (BC Hydro, 2013b), while Manitoba Hydro has budgeted CAD 326 million for energy efficiency opportunities after 2016 (MB Hydro, 2014). The electricity savings from DSM are reported to be 1 123 gigawatt hours (GWh) in BC, 1 832 GWh in Manitoba and 965 GWh in Quebec.³

Figure 5.7 Estimated costs per unit of delivered energy for new resource types in British Columbia



Sources: BC Hydro (2013a), 2013 Resource Options Report Update, BC Hydro, Vancouver.

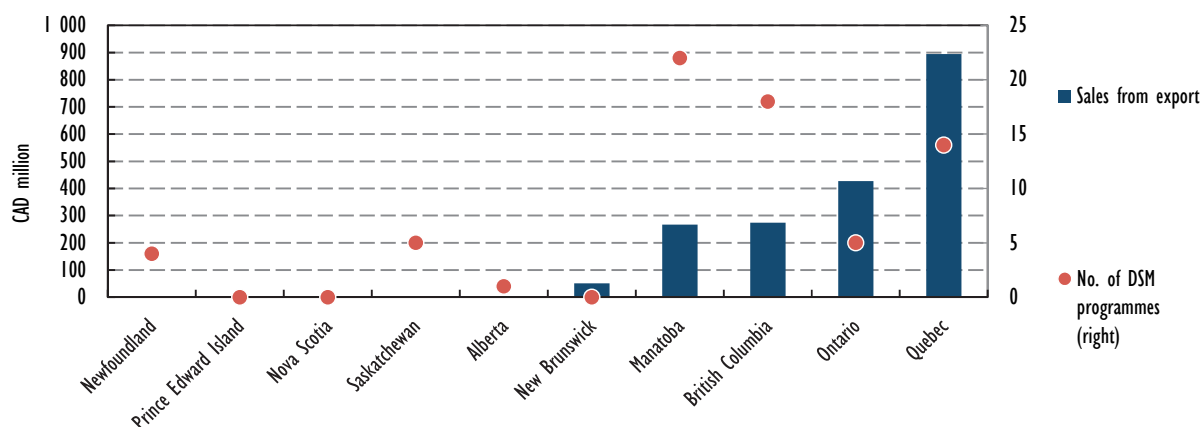
Provincial utilities with greater export sales of electricity tend to offer a larger number of DSM programmes (Figure 5.8). The range of DSM programmes offered is determined by a number of factors, and the number of programmes is not necessarily a proxy for commitment to energy efficiency. Yet,

² This includes DSM spending from natural gas utilities.

³ There is no provincially consistent methodology for quantifying DSM savings limiting the usefulness of inter-provincial comparison.

intuitively, utilities with important trade relationships and large export receipts may have greater incentive to reduce domestic electricity consumption by improving efficiency. Each kWh that is reduced through efficiency domestically potentially releases a kWh that can be exported often for higher prices. This emphasises the importance of larger energy market dynamics for provisioning energy efficiency.

Figure 5.8 Sales from electricity exports and number of utility-led DSM programmes



Energy efficiency employment

Another measure of the energy efficiency market is the amount of employment in the industry. Core workers are those directly involved in energy efficiency either through designing, improving or managing equipment, products and technologies that improve energy efficiency. Based on 2011 employment data, an estimated 100 000 core energy efficiency workers in Canada (0.6% of the total workforce) earned an estimated USD 7.7 billion. Total wages are expected to grow to an estimated USD 8.27 billion in 2014 (ECO Canada, 2014).

Opportunities and challenges of federalism

Energy efficiency markets are influenced more by provincial-level actions than by the federal government. Businesses seeking support need to be aware of activity at the local provincial level as well as that occurring at the national level. Provincial energy markets are highly differentiated in their market structure and energy portfolios. Ideally, regionally specific strategies that leverage existing business and policy frameworks within each province should coincide with specific actions that address each province's key efficiency potential. For example, building shell insulation requirements can vary significantly across provinces, meaning that cost-effective retrofit opportunities change across provincial borders. Large numbers of fuel oil heating systems still exist in eastern Canadian provinces, while the west uses more efficient natural gas and electricity. As such, household energy prices, efficiency potential and paybacks are provincially specific.

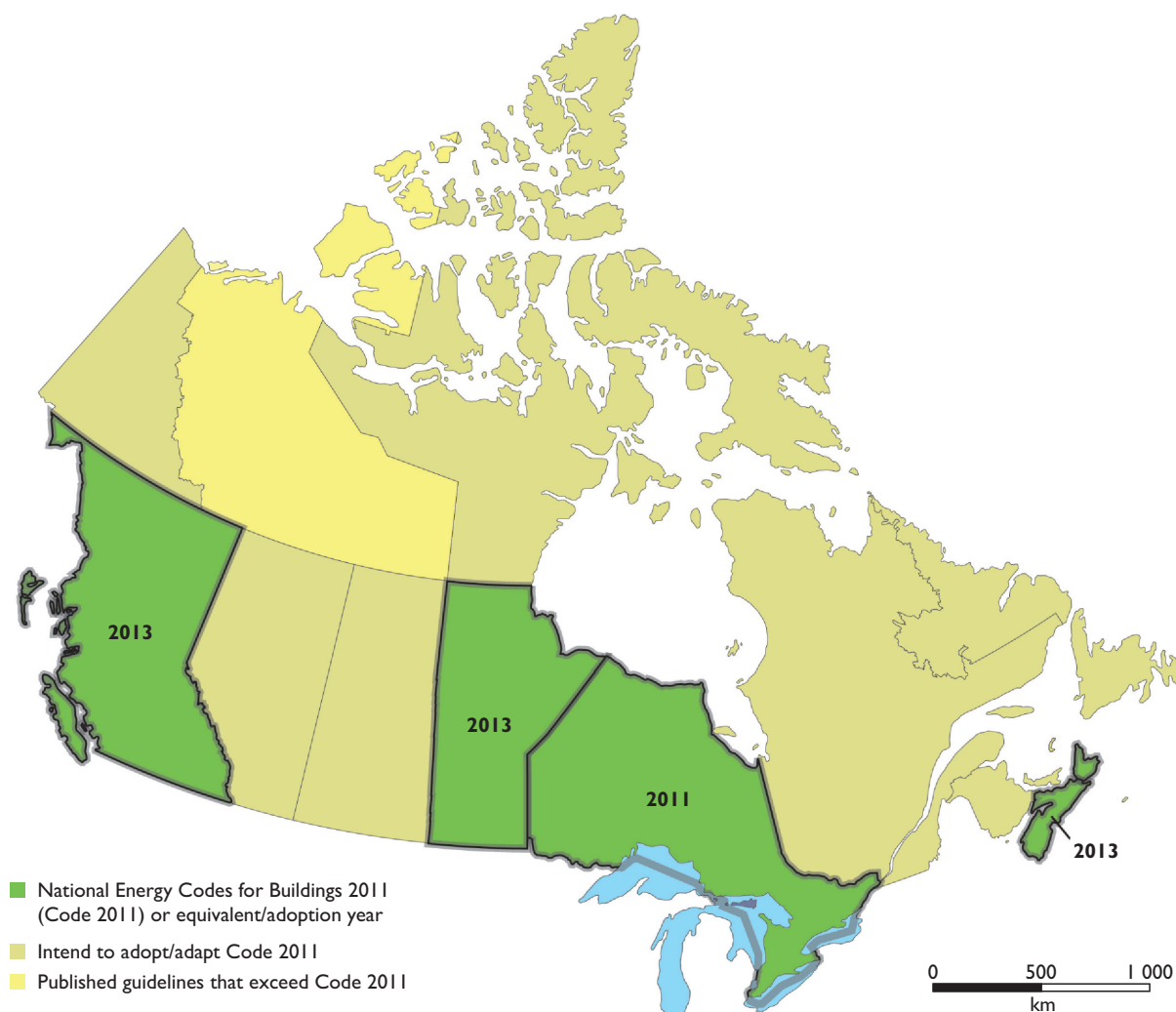
Prospects for energy efficiency market activity

Model National Energy Code for Buildings

The federal government has a role as a capacity builder for provincial and territorial governments. This is demonstrated through the development of the Model National Energy Code for Buildings (MNECB), released in 2011. The federal government does not have jurisdiction to unilaterally implement a model national energy building code across Canada. Instead, it can use its research and analytical capacity, national reach and stakeholder relationships to co-develop a code based on the broad but

similar makeup of Canadian buildings across the country. Provinces and territories are then able to adopt the building code and adapt it to their specific regional context. Under this arrangement, effort is not duplicated in developing simultaneous building codes across provinces, national priorities for environmental and safety outcomes are achieved, and provinces and territories are able to adopt measures at their own schedule with their own issues incorporated. The code is now implemented in four provinces, with six other provinces and territories adopting the code by 2015 (Figure 5.9).

Figure 5.9 Federal building code adoption by province in Canada



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.

Note: information provided by Natural Resources Canada.

The code will lead to an estimated 25% efficiency improvement compared to the previous code for commercial and multi-storey residential building types.⁴ The code looks at complete building energy use, including thermal shell, lighting, heating systems, water heating and motors and auxiliary equipment. Builders can achieve the code by three different paths: (a) prescriptive – builders can follow a checklist of features; (b) trade-off – builders are allowed flexibility to trade off lower-performing actions in one

⁴The code applies only to residential buildings larger than 600 m² or higher than three storeys.

building component for higher performance in other components; and (c) performance compliance – builders can achieve a total building performance outcome of their own design. This pathway system provides flexibility to builders both to install efficient equipment and also to incorporate efficiency at the design level.

The market impacts of a broadly adopted energy building code that achieves a 25% efficiency improvement could be significant. By 2016, it is expected that new building owners will save CAD 70 million in energy costs as a direct result of the code. Market outcomes will depend on compliance and enforcement as well as the scale of new building construction. Code adoption and implementation may create new market opportunities for energy efficiency equipment, installation and design, as demand for efficient building materials, equipment, heating systems as well as design and engineering of efficient buildings increases as provinces implement the code.

Challenges

Oil and gas extraction and the efficiency of energy supply

Focusing on TFC can overlook other important energy system trends. Canada is relatively unique among OECD member countries in that it is a net energy producer and exporter. From 2008 to 2012, oil production increased by 18%. Total production of fossil fuels increased by 12% – from 311 Mtoe in 2000 to 350 Mtoe in 2012 – with production of crude oil and other liquid fossil fuels increasing by 45%. Growth in oil production is the single largest factor creating upward pressure on Canada's energy intensity (Torrie, Layzell and Stone, 2014).

Therefore a key challenge for Canada is to continue to improve the energy efficiency of the energy supply sectors. Oil and gas production accounts for over 20% of Canada's estimated total energy conversion losses and has been increasing over the past 20 years (CESAR, 2014). Total losses in the energy supply sector are closely related to total energy production, which broadly explains the increase over the past ten years in oil conversion losses and the decline in natural gas losses as both sectors experienced commensurate changes in production. However, Canada's oil extraction sector is changing rapidly and this structural change is having important efficiency outcomes. Declining production from conventional oil reserves is being replaced by unconventional reserves that have energy efficiency impacts, as unconventional sources are more energy intensive to produce (Evans and Bryant, 2014).

Industry is co-operating on new technologies and innovation through Canada's Oil Sands Innovation Alliance (COSIA), and NRCan and the provincial governments are making their own research and development investments. Furthermore, the government of Alberta has a regulation in place to reduce the greenhouse gas emissions intensity of the oil sands, which will have attendant energy intensity benefits, and the federal government plans to introduce regulations to complement those in Alberta.

Conclusions

Canada has experienced large efficiency gains in many of its end-use energy sectors, most notably in residential and commercial buildings. The MNECB and its provincial adoption will provide fresh impetus to efficient building design and equipment markets. Provincial governments and utilities will continue to play a key role in implementing energy efficiency activities and running financing, rebates and other incentive-based energy efficiency programmes. Looking ahead, Canada needs to pursue efficiency improvements in the energy supply sectors to continue the downward trend in energy intensity of its economy.

Political, economic and environmental factors are likely to place strong signals in the oil extraction industry for continued investment in efficiency improvement. Regulatory mechanisms on the oil and gas sector, which focus on carbon or energy intensity improvements, are important for reversing the worsening energy efficiency trend in the sector.

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6. CHINA

As the world's largest energy consumer, China is also home to one of the most active energy efficiency service and investment markets in the world. Improving energy efficiency in the industrial sector is a priority for government policy, but the buildings energy efficiency market also is large, varied and growing.

China's demand for energy efficiency services and investment is driven to a large extent by the government's strong and comprehensive energy conservation policies and programmes. Government policies include a variety of administrative programmes, such as mandatory energy savings agreements with all large and medium-sized enterprises. Policies and programmes also promote a series of market-based initiatives. China's energy performance contracting project investments surpassed USD 12 billion in 2013.¹

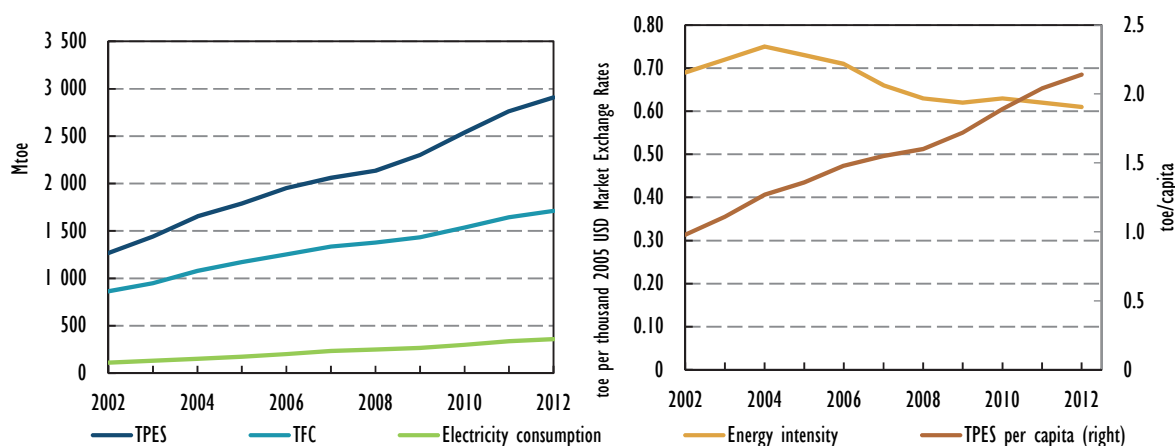
The *Energy Efficiency Market Report 2013 (EEMR 2013)* included a chapter on China that touched upon a variety of energy efficiency policies and market activity. This year, a different range of important energy efficiency market activities are highlighted.

By 2030, 45 exajoules (EJ) of energy efficiency savings could be achieved with strengthened minimum energy performance requirements for buildings, vehicles and equipment and with use of more efficient fuels in industry and improved public transport.

Energy profile and context

China's total energy use is now the highest of any country in the world. According to Chinese energy balances, total primary energy supply (TPES) more than doubled between 2001 and 2012, reaching 2 532 million tonnes of oil-equivalent (Mtoe) – about one-fifth of the world total in 2012. Total final energy consumption (TFC) grew to 1 702 Mtoe in 2012. This strong increase was driven by even faster economic growth.

Figure 6.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita in China, 2002-12

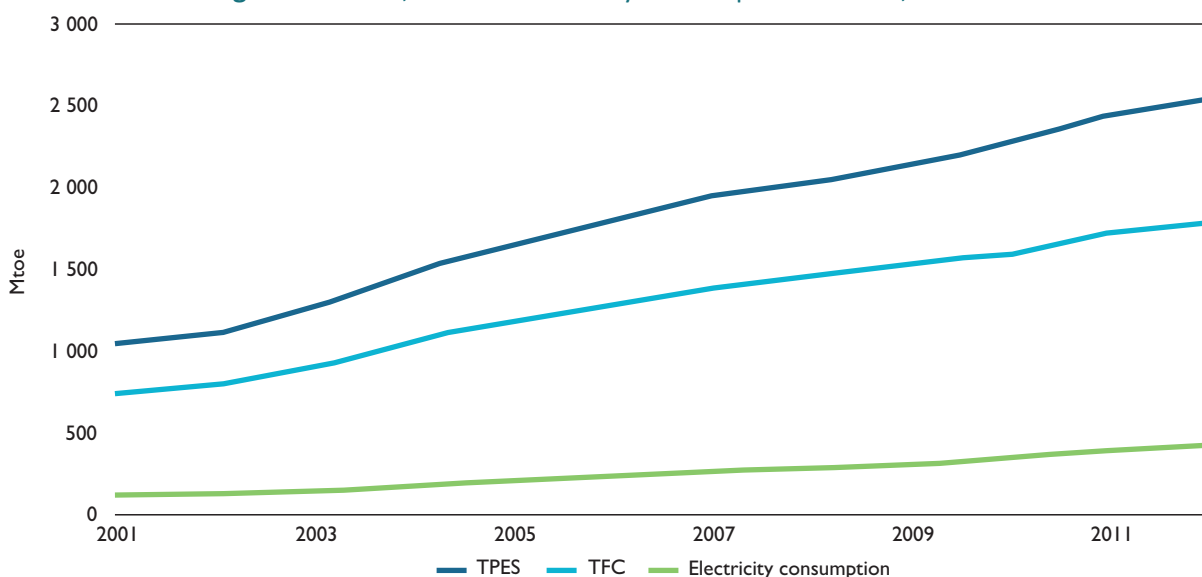


Note: toe = tonnes of oil-equivalent.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

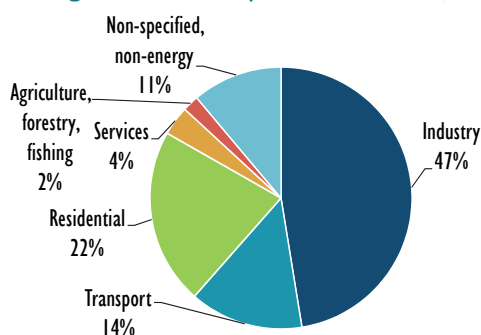
As shown in Figure 6.1, the intensity of China’s energy use per unit of gross domestic product (GDP) rose between 2002 and 2004, but then fell every year between 2005 and 2012, with a reduction of over 30% during that period. Because China is still a developing country and also has the largest population of any country, both GDP and energy use per capita remain far behind levels in more developed countries. China’s GDP per capita is one-eighth to one-tenth of that in the United Kingdom, France, Germany, Japan and the United States. In 2010, China’s energy use per capita was less than half that of Japan, Germany or France, and about one-quarter that of the United States and Canada.

Figure 6.2 TPES, TFC and electricity consumption in China, 2001-12



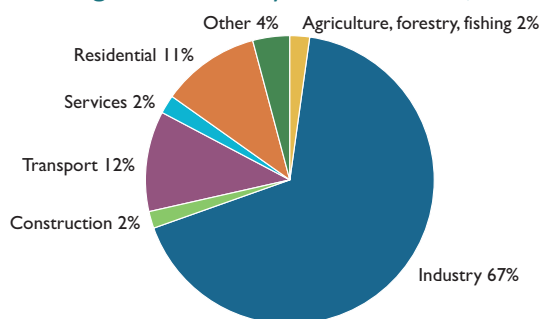
Source: China National Bureau of Statistics, *China Energy Statistical Yearbooks 2009-2013*, Beijing.

Figure 6.3 TFC by sector in China, 2012



Note: includes biomass fuels.

Figure 6.4 TFC by sector in China, 2012



Note: excludes biomass fuels.

Source: China National Bureau of Statistics, *China Energy Statistical Yearbooks 2009-2013*, Beijing.

Unlike most other countries, China’s energy use is heavily concentrated in industry. Despite recent sharp increases in energy use, transport and residential buildings still accounted for just 12% and 11% of 2012 TFC respectively. Including biomass fuels, the residential sector increases its share to 22% and industry accounts for around 47% of TFC (Figure 6.3). Excluding biomass fuels from energy balances,¹ industry

¹ China excludes biomass fuels from its official energy statistics because these fuels are not commercial, i.e. they are mostly collected and used by rural households. The IEA includes biofuels in its energy balances in order to show that a large amount of energy is used by rural households that will eventually require commercial fuels. The share of residential energy increases sharply (and industry’s share decreases) when biomass fuels are included (Figure 6.3).

accounted for 67% of final energy use in 2012 according to Chinese energy balances (Figure 6.4). Coal still accounts for the largest share of TFC in industry. Coal use in industry is concentrated in the steel and cement sectors. China is a major producer of steel for both domestic use and export. The development of the Chinese economy and housing sectors has coincided with significant increases in demand for cement. China accounts for almost 60% of global cement production. Electricity use in dwellings and the commercial sector is growing, but industry still continues its overall domination of electricity use, led by growth in the steel industry.

Figure 6.5 TFC in China by sector and by energy source, 2002 and 2012

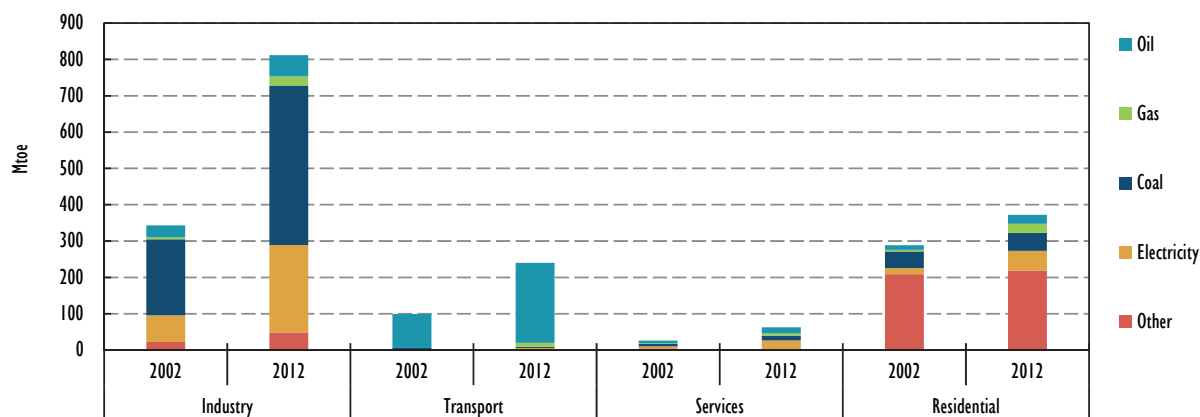
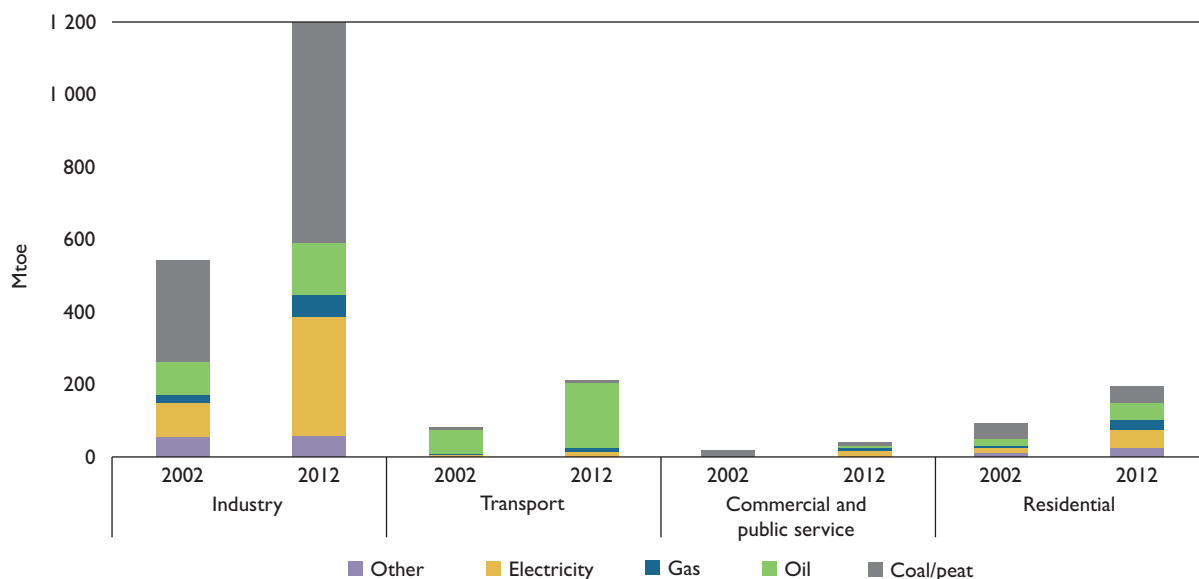


Figure 6.6 TFC in China by sector and by energy source, 2002 and 2012



Source: China National Bureau of Statistics, *China Energy Statistical Yearbooks 2009-2013*, Beijing.

Energy efficiency market activity

Market supply: Potential for energy savings

Great potential exists for energy savings across all sectors and fuels in China, despite steady investment in energy efficiency in recent years. Because of its large footprint, energy efficiency measures in the industrial sector are expected to continue to dominate the market and require a broadening of

approaches, especially towards system optimisation and energy management geared to continuous improvement. Much untapped potential remains to enhance energy efficiency in new and existing buildings, and to reduce energy consumption through improved spatial and urban planning in response to the country's rapid urbanisation.

An analysis of China's technical energy efficiency potential estimates that making large improvements can continue. By 2030, 45 EJ of energy efficiency savings could be achieved with strengthened minimum energy performance requirements for buildings, vehicles and equipment and with use of more efficient fuels in industry and improved public transport (Zhou et al., 2013). Because of its size relative to other energy-using sectors, the vast majority of these savings are in industry.

Market driver: Energy efficiency policies and programmes

China has among the most comprehensive and aggressive set of energy conservation policies and programmes in the world. Government policy, programmes and investment have been a key driver of end-user investment in energy efficiency.

The nation's highest level of government sets five-year national energy conservation targets that define the intensity and breadth of the country's energy conservation activities. These targets serve as the platform for more detailed policies and the development and implementation of a host of programmes. The five-year targets are translated into annual targets, and into both a series of (a) mandatory targets at provincial, prefecture and county levels, and (b) sector and sub-sector targets. Since 2006, target compliance has been a serious performance indicator for the various government administrations. Target implementation relies on both administrative and market-based measures and programmes.

China's energy conservation programmes are implemented through a system of dedicated government departments and agencies, running through the country's national-provincial-local government hierarchy. These departments supervise implementation of administrative measures, such as enterprise savings agreements, conduct training and outreach, and implement public support measures for market-based initiatives.

Industry

Chinese programmes in the industrial sector include:

- mandatory and supervised energy savings agreements with all large and medium-sized enterprises, through the Top 10 000 Energy-using Enterprise Program, which covers over 15 000 enterprises (mainly industrial) that consume more than 10 000 tonnes of coal-equivalent (tce) per year, as well as around 160 large transport enterprises, public buildings, hotels and enterprises that use more than 5 000 tce per year
- comprehensive and periodically strengthened minimum energy performance requirements for all key industrial processes and equipment
- aggressive programmes to eliminate inefficient industrial capacity that fails to meet the industrial energy use standards
- a new mandatory system for energy efficiency assessment approvals for major new fixed asset investment projects
- requirements for placement of energy managers, energy use reporting and energy auditing.

Moreover, in 2010, China's central government issued a decree on "Electricity Demand-side Management (DSM) Implementation Measures", which for the first time required China's electricity grid companies to deliver energy and peak load savings in parallel with, and in addition to, the country's other energy conservation programmes. The decree requires the delivery of electricity savings of at least 0.3% of grid company sales in the previous year, and peak load savings of at least 0.3% of peak load in the previous year. In one response measure, grid companies have set up new subsidiary energy service companies (ESCOs) to deliver the required savings. In addition, four pilot cities were selected by the government in 2011 to develop new electricity load and consumption monitoring platforms, to implement pilot load and electricity use reduction projects (organised as "energy efficiency power plants") and build delivery capacity for the future. Energy savings from the various DSM programmes are reported seasonally and annually, involving aggregation of supervised savings from enterprises, and then upward aggregation of total savings at local level, at provincial level, and, finally, at national level.

Transport

In China's fast-growing transport sector, a central issue is to promote public transport and more efficient light and heavy-duty vehicles to reduce air pollution and congestion. China has recently upgraded its passenger vehicle fuel economy (VFE) standards, for example, and shifted to approaches that focus on the overall fuel economy of manufacturers' fleets (Table 6.1).

Table 6.1 China's passenger VFE standards (litres/100 kilometres)

Vehicle weight (kg)	Stage 1 fuel use limit*	Stage 2 fuel use limit*	Stage 3 fuel use target**
1 090-1 205	8.9	8.1	6.5
1 205-1 320	9.5	8.6	6.9
1 320-1 430	10.1	9.2	7.3

* Stage 1 and Stage 2 fuel use limits are set out in National Standard 19578-2004, with compliance required for the manufacture of new vehicles by July 2006 for Stage 1 and January 2009 for Stage 2.

** China's new Stage 3 standard, National Standard 27999-2011, requires manufacturers to meet the standard gradually by 2015.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

Box 6.1 Air pollution reduction requirements

In 2013, China's central government issued new requirements for key cities and regions to reduce air pollution concentrations of particles less than 2.5 micrometres in diameter (PM_{2.5}) by between 15% and 25% by 2017 (State Council, 2013). With only four years to achieve these results and local economies continuing to grow at annual rates of over 7%, this will require very large planning and implementation efforts. Although programme development is still evolving, the drive to reduce air pollution should also affect energy efficiency project development and investment.

Source: State Council (2013), "Air Pollution Control Action Plan", State Council of the People's Republic of China, in Chinese, 10 September 2013, Beijing.

China is also promoting less energy-intensive transport modes and public transport in development and investment planning. China's investments in public transport have been impressive, with over USD 140 billion due to be invested in urban rail systems by 2020 across ten different cities. This investment will lay 6 100 kilometres (km) of metro rail. This continues the current trend of large

investments in more efficient modes. Beijing and Shanghai have invested an annual average of USD 1 billion and USD 1.7 billion respectively in their urban metro systems between 2001 and 2010 (Peng et al., 2012). In addition to intra-city transit investments, inter-city high-speed rail investments are also sizeable. China is home to more kilometres of high-speed rail than all other countries combined, and is expanding a system that was 8 500 km long in 2011 to 16 000 km by 2016 (Peng et al., 2012).

Current energy efficiency market activity

Overview of China's energy efficiency investment during the 11th and 12th Five-Year Plans

During the 11th Five-Year Plan (FYP) of 2006 to 2010, China succeeded in breaking the trend of increasing energy intensity per unit of GDP seen in the previous five years, with an energy intensity reduction of 19.1%, almost achieving the targeted reduction of 20%. This achievement required a massive programme of implementation, especially as output of many basic energy-intensive industrial goods soared. Total energy savings (relative to a fixed-intensity baseline) reached 441 Mtoe. Energy efficiency investment surpassed USD 100 billion (Qi, 2013). Commercially raised funds accounted for approximately 82% of the total, while public funds contributed the balance (Table 6.2).

Although the energy intensity reduction mandate of 16% set out in the 12th FYP (2011 to 2015) is lower than that achieved in the 11th, corresponding delivery of energy savings must be slightly higher at 469 Mtoe, due to growth in the economy. The energy efficiency investment necessary to support the achievement of such savings is estimated at between USD 200 billion and USD 270 billion for the five-year period.

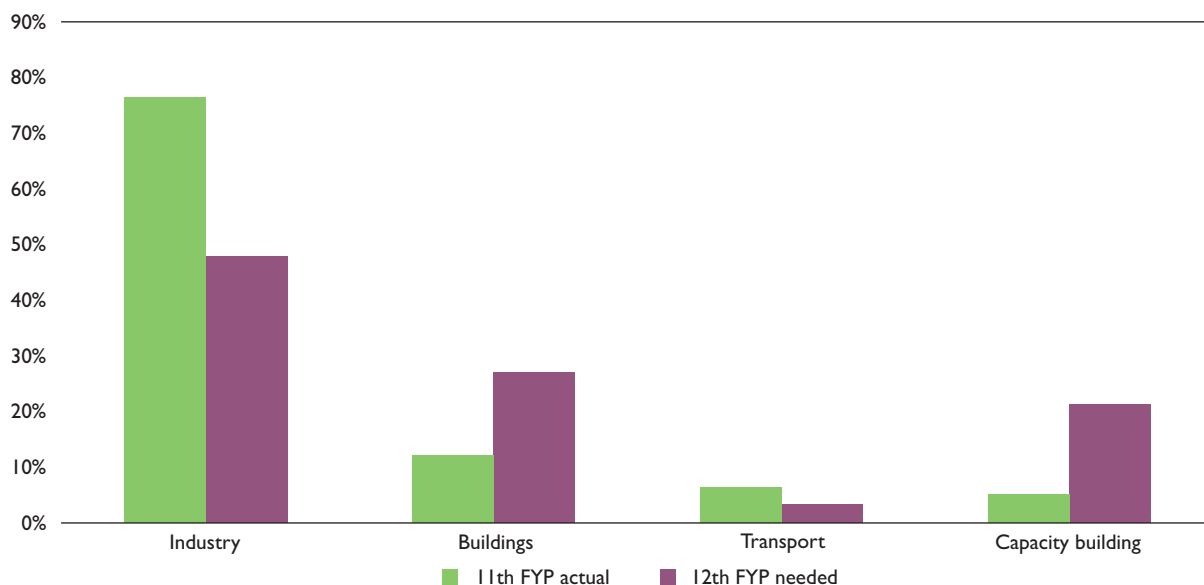
Table 6.2 Overview of China's energy efficiency investment

	Energy savings (Mtoe)		Investment		
	Total	Savings achieved by energy efficiency investment	Total (USD billion)	Public funds (%)	Commercial funds (%)
11th FYP actual	441 [*]	238-287 ^{**}	120 ^{***}	18%-19% ^{****}	81%-82% ^{*****}
12th FYP needed	469 [*]	235-268 ^{***}	200-270 ^{****}	-	-

Notes: Energy savings from energy efficiency investment include direct and indirect energy savings from investment in industrial energy efficiency, technology renovations, elimination of obsolete industrial capacity, energy efficiency renovations in buildings, investment in the government's energy efficiency supervision and oversight system, energy savings in transport (including modal shift), and capacity building. Public funds include central and local government funding. Commercial funds include retained enterprise funds, bank financing, financing from ESCOs, international funding, and others. CNY converted to USD at CNY 6.945 per USD for the 11th FYP and CNY 6.193 per USD for the 12th FYP.

Sources: This table has been compiled from information taken from: * State Council (2012a), *12th Five-Year Plan Energy Conservation and Environmental Protection Industry Development Plan*, State Council of the People's Republic of China, in Chinese, Beijing; State Council (2012b), *12th Five-year Plan Energy Conservation and Emissions Reduction Plan*, State Council of the People's Republic of China, in Chinese, Beijing; ** Lower figures from Dai et al. (2011), *China Energy Efficiency Investment Progress Report 2010*, in Chinese, China Science and Technology Publishing House; higher from Qi, Y. (2013), *China Low-Carbon Development Report*, in Chinese, Social Science Publishing House, Beijing; *** Qi, Y. (2013), *China Low-Carbon Development Report*, in Chinese, Social Science Publishing House, Beijing; **** Lower figure from Qi, 2013; higher from ZICSC (2013), *China Energy Efficiency Investment Progress Report 2012*, in Chinese, China Science and Technology Publishing House, Beijing; ***** Dai et al. (2011), *China Energy Efficiency Investment Progress Report 2010*, in Chinese, China Science and Technology Publishing House.

The industrial sector accounted for the bulk of energy efficiency investment (77%) during the 11th FYP. Energy efficiency investment in buildings and transport accounted for 12% and 6% of the total, respectively (Dai et al., 2011). The share of industry in total energy efficiency investment is expected to fall during the 12th FYP in favour of other sectors, but experts continue to debate by how much. Some predict a dramatic shift in the share of investment from industry to buildings and capacity building (Figure 6.8). Others (Qi, 2013) predict a substantially smaller shift.

Figure 6.7 China's energy efficiency investment by sector

Notes: The industrial sector mainly includes investment in technical renovation and elimination of obsolete capacity; the building sector mainly includes investment in technical renovation and government oversight; the transport sector mainly includes investment in modal shift; and investment in capacity building mainly includes technical research, institutional capacity building, promotion of energy-efficient technology, etc.

Sources: This figure has been compiled from information taken from 11th FYP: Dai et al. (2011), *China Energy Efficiency Investment Progress Report 2010*, in Chinese, China Science and Technology Publishing House, Beijing; 12th FYP forecast: ZICSC (2013), *China Energy Efficiency Investment Progress Report 2012*, in Chinese, China Science and Technology Publishing House, Beijing.

Commercial energy efficiency financing

As described previously, more than 80% of energy efficiency investment in China is financed commercially, using a combination of enterprise retained earnings and third-party finance. Third-party credit finance includes bank loans, loans from investment and trust companies, leasing arrangements, and finance from ESCOs under various energy performance contracting (EPC) arrangements (Taylor, 2012). National banks that are particularly active in energy efficiency financing include the China Export-Import Bank, Shanghai Pudong Development Bank, Industrial Bank, Huaxia Bank, Bank of Beijing, and others. Most such banks with specialised energy efficiency financing programmes launched them with support from international multilateral and bilateral development finance institutions (World Bank, Asian Development Bank, International Finance Corporation, AfD, KfW, etc.).

Box 6.2 China's growing energy service industry

The "third-party" energy efficiency service community has been growing rapidly in China, but still cannot meet government and market demands for reputable, quality and technically up-to-date service. The market needs energy auditors, specialists in diagnostic tools, trainers, project developers, energy monitoring and verification entities, ESCOs and other parties that can combine technical and financial or business skills. In 2012, the State Council issued specific policies to further encourage the more rapid development of the energy and environmental service industries. While market understanding of the value of quality service providers is still developing, the energy efficiency service industry is virtually certain to experience growth.

China's ESCO sector

China's EPC sector is among the largest in the world. Annual EPC investment topped USD 12 billion in 2013, producing an estimated 17 Mtoe of annual energy savings capacity (EMCA, 2013). The number of registered ESCO companies conducting EPC business totals over 4 800. Although most of these companies are small, China's ESCO industry now includes a wide variety of company types, including companies with equipment sales experience, patented technology, wide-ranging energy diagnostic skills and capacity to undertake diverse project types, with strong financing backgrounds, or with prominent utility or large industrial holding company shareholders. In 2010, China introduced a series of strong support measures to further expand the industry, including favourable tax treatment and publicly financed project completion incentives.

China's ESCO sector has evolved into a productive and profitable business quite different from that abroad, especially in North America, as it targets industry, as opposed to the buildings sector. ESCOs often provide the dominant share of project investment financing, and such off-balance-sheet financing is often a key project selling point. Accordingly, managing financial repayment risks is one of the most important concerns of Chinese ESCOs (Sun, Lin and Taylor, 2011).

Prospects for energy efficiency market activity

Industry

Many Chinese industrial enterprises have been pursuing energy efficiency projects for years, and are beginning to feel that they have already exhausted the most economic and easily implemented measures. This presents the need to shift focus from relatively simple equipment or specific process-focused "switch-out" retrofits to deeper, system-wide or system-design approaches. Enterprise-wide energy management systems, based on continuous improvement, provide a good platform for such combinations of both "soft" and "hard" technology. Energy system optimisation in large, complex plants is a promising approach. In addition, sub-sectoral coverage of industrial energy efficiency initiatives needs to be broader. Upstream supply-chain initiatives by multinational corporates are another potential growth area. Energy efficiency service businesses can expect good opportunities if their services are well aligned with the business interests of the enterprises they serve. Innovative financing offerings can also further expand energy efficiency service business opportunities.

Buildings

Improving energy efficiency in both new and existing buildings is a growth area. The cost-effective renovation of existing, energy-wasting and uncomfortable buildings demands business approaches that are suited to the Chinese market. Business solutions are also needed to pursue energy efficiency in the largely untapped public buildings market (government, hospitals, schools, etc.), where policy development is nascent. The demand for large volumes of new housing and commercial space is a clear opportunity for efficiency potential. With millions of migrants moving to urban areas, the demand for new housing space is likely to remain strong. Implementing stronger building codes for new buildings is potentially the greatest lever for achieving efficiency improvements, as the market would respond accordingly.

Better urban planning could also go a long way to improving energy efficiency in the residential sector. The development of less resource-intensive new and revitalised urban neighbourhoods is a major challenge, where new approaches to design, development and investment continue to be needed.

Challenges

Efforts to expand dedicated commercial energy efficiency financing continue to face challenges similar to those in other countries. These include insufficient mutual understanding between the energy efficiency and finance communities of their respective business practices, and the need for specific approaches to reduce transaction costs and to efficiently originate loans. In China's case, the incomplete status of financial sector reforms also poses additional challenges, further reducing bank appetite for incurring risk as upside reward potential is limited.

Conclusions

Continuing strong economic development in China requires similarly strong improvements in resource efficiency. The aggressive energy efficiency policies and programmes that the Chinese government has committed to will remain a long-term fixture of Chinese economic and social policy as well as a key influencer of energy markets. However, policies and programmes also must continue to evolve in order to elicit the market responses desired.

Chinese industry is facing major shifts in product demand, especially at home, affecting future patterns of growth and carrying implications for energy efficiency efforts. Past growth patterns, built on very robust growth in fixed asset investment, led to rapid increases in the outputs and production efficiency of basic energy-intensive industrial commodities, such as iron, steel and cement. Growth patterns are expected to shift over time towards more domestic consumption. Within this trend, demand growth for basic commodities will soften but will strengthen for higher value-added, higher quality, more diverse goods. Industrial energy efficiency investors, therefore, are beginning to face an environment of slow or no growth among key energy-intensive industrial clients. This brings both challenges and opportunities. Many of these clients face difficult economic times, with corresponding declines in their capacity to invest and posing greater financial risks to banks and ESCO project developers. However, interest also increases in reducing energy operating costs as a means to maintaining competitive strength in a tough market. Moreover, new opportunities for investment exist in strong growth industries, such as many types of machinery and high-value chemicals.

Further key economic reforms are needed in the coming years to complete China's transition to a true market economy. Although expected to have positive impacts on the push for energy efficiency, further progress on reform of the financial sector and electric power sector is also likely to change certain institutional arrangements and incentives that shape the current energy efficiency framework.

The balance between administrative measures and market-based energy efficiency initiatives needs to shift further towards the latter to best meet growing need for increasingly sophisticated, customised, system-specific and multiple-measure energy efficiency solutions. Growth in the capacity of the energy efficiency service industry is essential for market-based approaches to work.

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7. EUROPEAN UNION

Over the past decade, the European Union has implemented a range of regulations and directives that have transformed the market for energy efficiency in its member states. It has complemented these policies with incentive schemes and financing measures to leverage national and private sector energy efficiency investments. For example, over the period from 2006 to 2013, European Structural and Investment Funds allocated EUR 5.6 billion to energy efficiency. During the new programming period from 2014 to 2020, energy efficiency funding is expected to at least double.

The European Union is now making a long-term commitment, through its January 2014 Policy Framework for Climate and Energy (2020 to 2030), to three key drivers of energy efficiency markets: cost-reflective energy markets, a substantial cross-sectoral portfolio of energy efficiency policies and scaled-up energy efficiency financing schemes. Through these commitments and funding programmes, investors should have the policy stability and support needed to make long-term energy efficiency investments.*

This chapter focuses on EU-level support for energy efficiency and only briefly touches on energy efficiency investments initiated at the level of EU member states.**

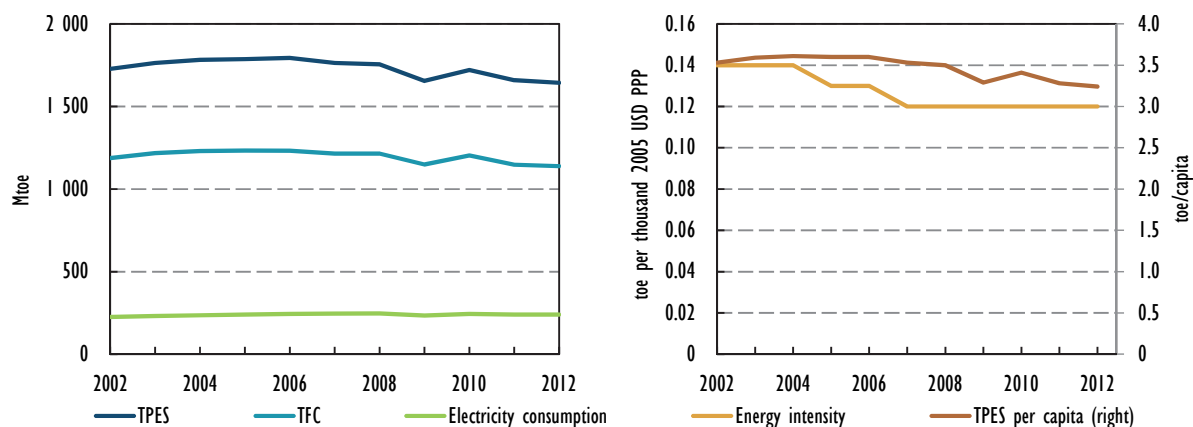
* The *Energy Efficiency Market Report 2013* included a chapter on the European Union that touched upon a variety of energy efficiency policies and market activity. This year, a different range of important energy efficiency market activities are highlighted.

** For more information on policies of the European Union, see the forthcoming IEA publication *Energy Policies of IEA Countries: European Union 2014*.

Energy profile and context

The European Union is a political and economic community comprising 28 member states, half a billion inhabitants and a gross domestic product (GDP) of over EUR 13 trillion in 2013. Improving energy efficiency is an important part of European Union (EU) strategy to reduce energy import dependence, improve productivity and competitiveness, enhance health and well-being and temper the impact of growing energy prices. After being hit by a recession since 2008, a slow recovery is under way in the European Union, and modest economic growth has returned to a large majority of member states over the last year. Total final consumption (TFC) of energy was 1 139 million tonnes of oil-equivalent (Mtoe) (47.7 exajoules [EJ]) in 2012, and is still below its 2005 peak of 1 234 Mtoe (51.7 EJ) (Figure 7.1).

Figure 7.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12

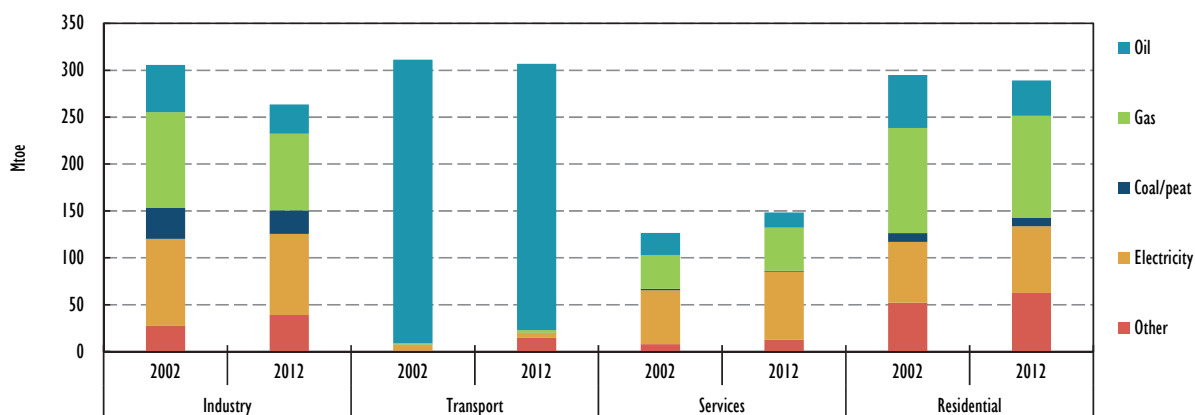


Note: PPP = purchasing power parity; toe = tonne of oil-equivalent; TPES = total primary energy supply.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

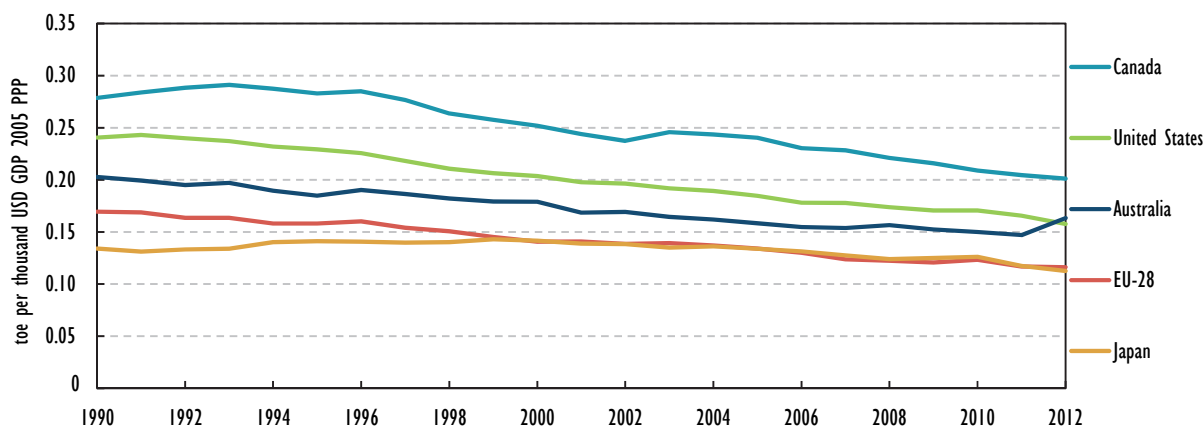
In 2012, oil represented 41.2% of TFC in the European Union, with more than 60% of this consumed by transport. The remainder was consumed by industry and the residential sector. Natural gas represented 22.7% of TFC, and was consumed primarily in the commercial and residential sectors, with one-third consumed in industry. Similarly, electricity accounted for 21.1% of TFC and was primarily used in residential, commercial and industrial sectors. In 2012, industry accounted for 31.8% of TFC, transport 26.9%, the residential sector 25.4% and the commercial sector 15.9%.

Figure 7.2 TFC by sector and by energy source, 2002 and 2012



Steady improvements in energy intensity have been made in most EU member states since the 1990s, with an overall decline of 31.5% since 1990. Collectively, the European Union has the lowest energy intensity, alongside Japan, of developed economies (Figure 7.3). Energy intensity, measured as the ratio of energy supply to GDP, was 0.12 toe per 1 000 USD PPP in 2012, which is lower than the IEA member country average of 0.14 toe per 1 000 USD PPP.

Figure 7.3 Energy intensity in the European Union and in selected IEA member countries, 1990-2012



Energy efficiency market activity

Market drivers: Energy efficiency policies and programmes

To scale up energy efficiency investments and tap the savings potential of energy efficiency across sectors, the European Union is adopting a range of regulations and directives aimed at removing energy efficiency market barriers and failures.

The 2012 **Energy Efficiency Directive** (EED) was developed in response to concerns that the European Union was unlikely to achieve its goal of cutting primary energy consumption by 20% by 2020. The EED requires each member state to:

- Set an indicative national energy savings target for the period 2014 to 2020 in line with the EU-wide target of 20% improvement in energy efficiency.
- Establish a long-term strategy for renovating the building stock, including a renovation rate of 3% per year of floor space for central government buildings over 500 square metres (m²). This will expand to buildings over 250 m² from July 2015.
- Develop public procurement rules ensuring that central governments purchase only high-efficiency products.
- Oblige energy providers to achieve cumulative end-use energy savings by 2020 equivalent to 1.5% of annual energy sales over the period 2014 to 2020.

The **Directive on Energy End-Use Efficiency and Energy Services** requires member states to develop national energy efficiency action plans (NEEAPs) every three years, including 2014, and to meet an indicative target to reduce final energy use in sectors not covered by the EU Emissions Trading Scheme (EU-ETS)¹ by 9% by 2016. However, only 13 NEEAPs had been submitted by the 30 April 2014 deadline.

The 2002 **Energy Performance of Buildings Directive**, and its 2010 successor, established minimum energy performance requirements (MEPS) for building codes and introduced a framework for energy performance certification. The 2010 recast requires new buildings to be at “nearly zero energy” performance by the end of 2020.

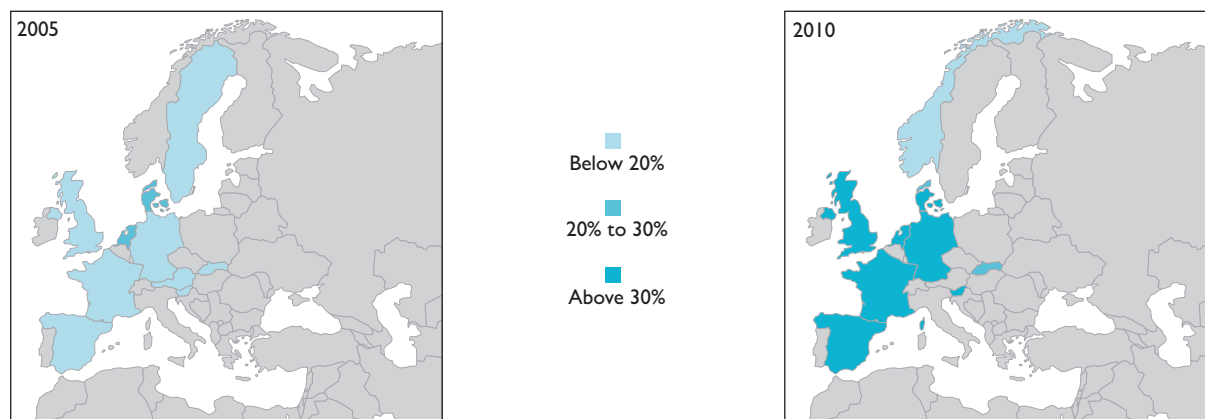
The **Ecodesign Directive**, first passed in 2005 and subsequently updated, makes provision for MEPS for energy-using and energy-related products with the objective of reducing their environmental impacts and energy consumption, throughout the entire life cycle. To date, MEPS have been developed for 16 product groups.

The Ecodesign Directive can be a particularly important lever for energy efficiency improvements when applied to industrial equipment. The first four ecodesign regulations on electric industrial products (motors, circulators, fans and water pumps) are expected to lead to annual energy savings by 2020 equivalent to the current TFC of Hungary (195 terawatt hours) and contribute significantly to the EED 2020 targets. These regulations are the first in the world to take into account an extended product approach as well as the needs and changing use patterns of the consumer. The innovative nature of the legislation has already led to significant technology development and triggered a European and global standardisation process (European Commission, 2013a). The related **Energy Labelling Directive** of 2010 established an energy consumption labelling scheme that rates the energy efficiency of a product on a scale from A to G, with “A” the most efficient (Figure 7.4).

Most member states have experienced a transformation of the market for appliances covered by the Ecodesign Directive over the past few years. Denmark, for example, went from fewer than 30% of refrigerators sold in 2005 being in the A+ efficiency class, to more than 80% in 2012. Germany went from fewer than 10% of refrigerators sold in 2004, to more than 70% in 2010 being in the A+ class (Odyssey-MURE, 2014).

¹ As of 2013, the EU-ETS covers carbon dioxide (CO₂) emissions from: power and heat generation; energy-intensive industrial sectors including oil refineries, steel work and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals; and civil aviation.

Figure 7.4 Share of refrigerator sales in 2005 (left) and 2010 (right) with energy class equal to or greater than A+

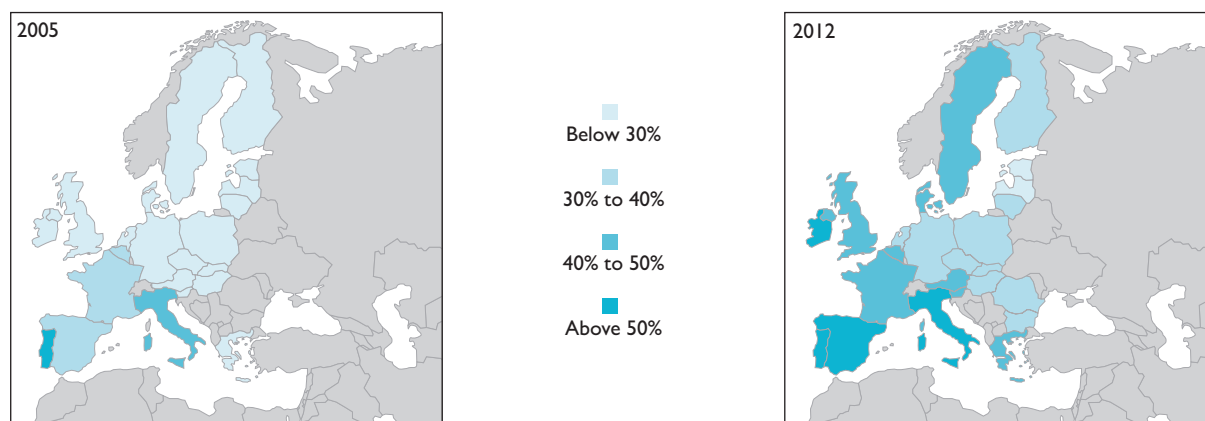


These maps are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Odyssee-MURE (2014), *Database on Energy Efficiency Indicators and Data*, project managed by Enerdata, www.indicators.odyssee-mure.eu/.

Since May 2009, new passenger cars in the European Union fall under a **CO₂ emissions regulation that limits vehicle emissions**. The weight-based corporate fleet average to be achieved by all new cars is 130 grammes of CO₂ per kilometre (g CO₂/km) by 2015 – with the target phased in from 2012 – and 95 g CO₂/km by 2021, phased in from 2020. A regulation for vans was introduced in 2014, with limits of 175 g CO₂/km to be met by 2017, and 147 g CO₂/km to be met by 2020. Figure 7.5 shows the share of new cars sold with emissions of less than 130 g CO₂/km in 2005 versus 2012.

Figure 7.5 Share of efficient cars (less than 130 g CO₂/km) in total sales, 2005 (left) and 2012 (right)



These maps are 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: Odyssee-MURE (2014), *Database on Energy Efficiency Indicators and Data*, project managed by Enerdata, www.indicators.odyssee-mure.eu/.

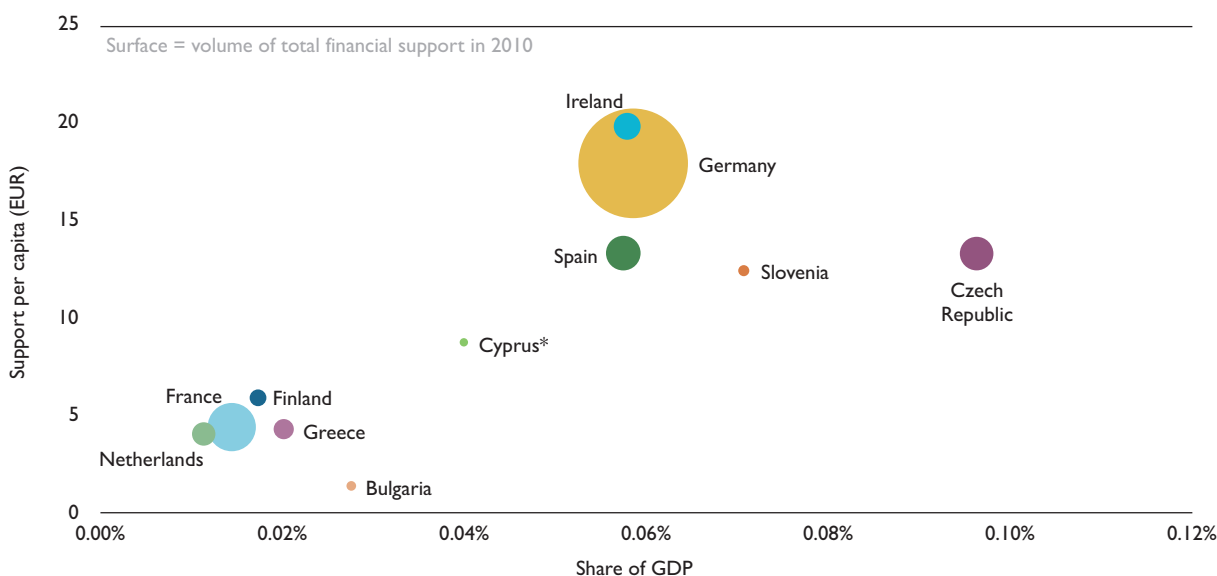
Current energy efficiency market activity

To complement the measures outlined in the previous section, and to further expand the market for energy efficiency, the European Union and its member states developed a range of investment funds and financing measures. This section analyses national-level public investments, EU-level funding and funding by international financial institutions (IFIs).

National-level public investment in energy efficiency markets

Public investment in energy efficiency in 2010 across 11 member states averaged between EUR 4 and EUR 20 per capita (Figure 7.6) (Scheuer, 2013). The public-private leverage ratio was between EUR 1:3 and EUR 1:20 per capita for publicly financed energy efficiency measures, such as the German KfW credit support schemes.² Fiscal incentives, like multi-year tax rebates, were found to have lower leverage ratios but larger budgets.

Figure 7.6 Public investment in energy efficiency by share of GDP for selected member states



Note: BG = Belgium; CY = Cyprus; * CZ = Czech Republic; DE = Germany; ES = Spain; FR = France; FI = Finland; GR = Greece; IE = Ireland; NL = Netherlands; SI = Slovenia.

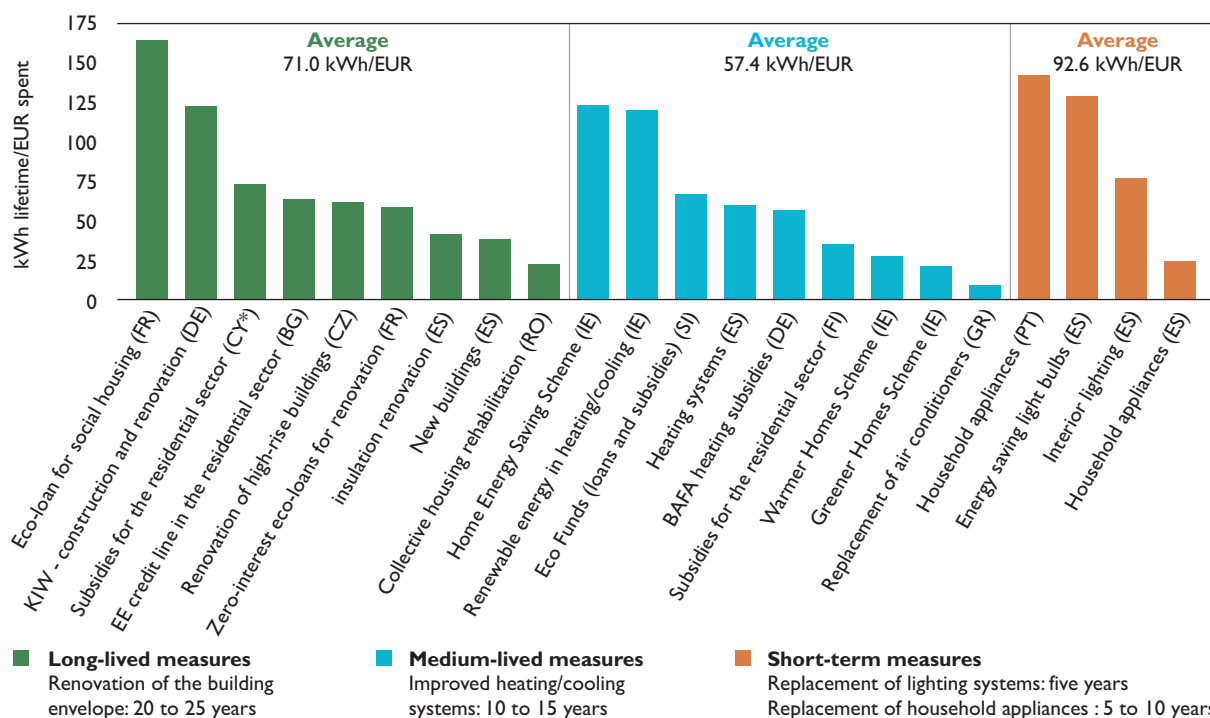
* Footnote by Turkey: The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the “Cyprus issue”.

Footnote by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: Scheuer, S. (2013), *Energy Efficiency: How Effective are Public Support Schemes?*, European Energy Network (EnR), based on a study commissioned by ADEME.

The effectiveness of these incentive and financial support schemes was assessed for the implementation of short-, medium- and long-lived energy efficiency improvements, as a measure of lifetime energy savings in kilowatt hour (kWh) per EUR of public support (Figure 7.7). For each of the short-, medium- and long-lived efficiency measures, the greatest energy savings per EUR spent were in the housing sector. Short-term measures yielded greater average energy savings per EUR spent, over shorter lifetimes (five to ten years).

² The IEA *Energy Efficiency Market Report 2013* reported that KfW funding initiatives of EUR 6 billion were leveraged 1:9 to a final investment of EUR 54 billion. The KfW programme is one of Europe’s most successful financing schemes for energy efficiency, and will be followed by a long-term renovation roadmap targeting near-zero energy building standards by 2050 (European Commission, 2014b).

Figure 7.7 Lifetime energy savings achieved by energy efficiency improvements per EUR spent


Note: BG = Belgium; CY = Cyprus; * CZ = Czech Republic; DE = Germany; ES = Spain; FR = France; FI = Finland; GR = Greece; IE = Ireland; NL = Netherlands; PT = Portugal; RO = Romania; SI = Slovenia.

* Footnote by Turkey: The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the “Cyprus issue”.

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Source: Scheuer, S. (2013), *Energy Efficiency: How Effective are Public Support Schemes?*, European Energy Network (EnR), based on a study commissioned by ADEME.

EU-level investment in energy efficiency

The European Union is funding energy efficiency through several mechanisms including the **European Structural and Investment Funds (ESIF)**, which seek to support economic development across EU member states, in line with the objectives set in the Europe 2020 strategy.

Over the 2006 to 2013 period, ESIF funds allocated EUR 5.6 billion to energy efficiency, co-generation and energy management. During the new programming period from 2014 to 2020, energy efficiency funding is expected to at least double (European Commission, 2014b). Moreover, along with ramped-up funding for energy efficiency, the 2014 to 2020 ESIF framework provides for tailored financial instruments and other mechanisms to attract private capital and bring longer-term, affordable financing to the energy efficiency market.

ESIF is the umbrella for five main funds, including the European Regional Development Fund (ERDF). In 2009, ERDF allocations for energy efficiency were increased, and funding that was once only available to public and commercial buildings became available for investments in the residential sector. In fact,

4% of national ERDF allocations could be used for energy efficiency improvements in existing housing. As a result, around half of EU member states invested in residential energy efficiency, including Estonia (EUR 49 million) and Lithuania (EUR 227 million). A project to develop energy efficiency in social housing in France leveraged ERDF funds amounting to approximately EUR 1 billion, or seven times the initial amount committed by ERDF. The legislative package for the 2014 to 2020 Multiannual Financial Framework imposes obligatory minimum percentages on ERDF investments in energy efficiency, including at least 12% for less developed regions, 15% for transition regions and 20% for more developed regions.

In addition to funding energy efficiency projects through ESIF, the European Union provides financial support to energy efficiency projects through the **European Energy Efficiency Fund (EEEF)**. The EEEF was established in 2011 to advance the market for energy efficiency and renewable energy in Europe. The fund was capitalised with an initial volume of EUR 265 million by the European Commission, the European Investment Bank (EIB), Cassa Depositi e Prestiti and Deutsche Bank. A EUR 20 million Technical Assistance Facility was also established by the European Commission under EEEF's management. EEEF finances, and provides technical assistance to, municipal, local and regional authorities and energy service companies (ESCOs).

In 2013, EEEF committed a total of EUR 101 million to seven partner institutions. These institutions and investments were concentrated in France (EUR 42.5 million), Germany (EUR 2.3 million), Romania (EUR 25 million) and Italy (EUR 31.8 million). A further EUR 8.7 million was committed to nine technical assistance projects through the Technical Assistance Facility, mostly in the form of public lighting and building retrofits throughout Spain. The facility was allocated almost entirely to public beneficiaries, creating a total project volume of EUR 322 million in 2013 (EEEF, 2013).

In total, EEEF has successfully allocated EUR 217 million through debt and equity instruments. It will seek to leverage its ongoing contributions to target a total volume of EUR 600 million to EUR 700 million in investment from public and private actors at the EU, national and sub-national levels.

The European Union promotes energy efficiency research and innovation through its **Horizon 2020 Programme** (previously the 7th Framework Programme). Between 2006 and 2013, EUR 285 million was allocated to energy efficiency. More than EUR 840 million has been allocated to energy efficiency research and innovation over the period 2014 to 2020. Horizon 2020's energy efficiency budget for 2014 is EUR 98 million (BUILD UP, 2014) and targets buildings, industry, heating and cooling, small and medium-sized enterprises, energy-related products and services, integration of ICT and co-operation with the telecoms sector. Intelligent Energy Europe (IEE), a ten-year EUR 730 million programme to facilitate market uptake of sustainable energy (about 50% for energy efficiency), has been subsumed into Horizon 2020.

Funding for energy efficiency by IFIs

European IFIs, including the EIB, the European Bank for Reconstruction and Development (EBRD), the Council for Europe Development Bank and the Project Development Assistance (PDA) schemes, facilitate implementation of many of the EU funding programmes described in this chapter, and operate their own investment instruments for energy efficiency. The energy efficiency activities of these financial institutions are described here.

EIB has sought to mainstream energy efficiency in its operations since 2008. Energy efficiency investments over the period of 2008 to 2011 surpassed EUR 4.8 billion, EUR 1.7 billion of which was in the buildings sector (Table 7.1) (European Commission, 2013b).

Table 7.1 EIB funding to EU efficiency projects, 2008-11 (EUR million)

	Buildings	Combined heat and power	District heating	Industry	Multi-sector	Other	Total
2008	68	219	-	-	393	121	800
2009	474	547	-	60	448	-	1 528
2010	759	125	116	391	227	782	2400
2011	424	205	95	51	264	-	1 039

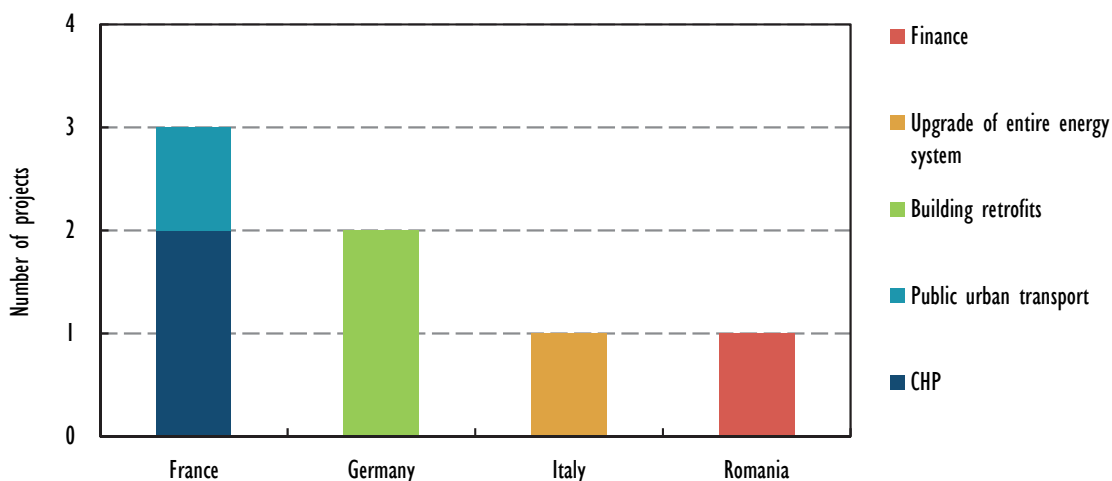
Source: European Commission (2013b), *Financial Support for Energy Efficiency in Buildings*, European Commission, Brussels; European Investment Bank (2013), *Energy Lending Criteria*, EIB, Luxembourg.

It is estimated that the energy efficiency projects undertaken as a result of EIB funding have reduced annual emissions by 3 523 000 tonnes of carbon dioxide equivalent (CO₂-eq) (or 1 005 CO₂-eq when prorated to EIB financing) in 2010 and 679 000 kilotonnes CO₂-eq (or 379 000 CO₂-eq when prorated to EIB financing) in 2011.

Finally, since 2002, the **Council of Europe Development Bank** (CEB) has invested EUR 1.9 billion in projects focused on energy efficiency. An additional EUR 181 million in funding has been received from the European Union in support of these investments (European Commission, 2013b).

European Local Energy Assistance (ELENA) provides grant support to local and regional authorities for developing, structuring and launching investments in energy efficiency and renewable energy. The facility is implemented through EIB, KfW, CEB and EBRD, and covers up to 90% of costs incurred for technical support. The instrument has total resources of EUR 30 million over 2014/15.

Figure 7.8 Number of EIB-ELENA PDA facilities by country and by project type, 2010-14



Note: DH = district heating; CHP = combined heat and power.

Source: EIB (2014), *Maximising Investment in Sustainable Energy (ELENA)*, European Investment Bank, www.eib.org/products/elena/index.htm.

Prospects for energy efficiency market activity

With the 2030 policy package announced in January 2014, the European Commission enhanced its commitment to energy efficiency as a key strategy to achieving social and economic outcomes as well as energy and climate objectives. According to a European Commission press release (January 2014), “Improved energy efficiency will contribute to all objectives of EU energy policy and no transition towards a competitive, secure and sustainable energy system is possible without it” (European Commission, 2014a). This renewed commitment creates a new paradigm for energy efficiency in the European Union, evolving beyond the traditional “energy saving” definition to incorporate multiple social and economic benefits (the EU objectives of competitiveness, security and sustainability), alongside reductions in energy consumption and greenhouse gas emissions. The role of energy efficiency in the 2030 framework will be further considered in a review of the EED due to be concluded later this year.

Challenges

With many funds, directives, targets and goals, the challenge is seeing them all implemented and working together. Few evaluations have been conducted to assess the effectiveness of these various drivers of energy efficiency markets. European Union instruments will only be effective if favourable investment conditions are created at member-state level, notably through transposition and full implementation of EU directives. The role of long-term political commitment towards energy efficiency is key and has a strong signalling effect for markets and investors.

Conclusions

Improving energy efficiency is an important part of EU strategy to reduce dependence on energy imports, improve productivity and competitiveness, enhance health and well-being and temper the impact of growing energy prices. Over the past decade, the European Union has implemented several directives that have transformed the market for energy efficiency in member states, with incentive schemes and financing measures to leverage national and private sector energy efficiency investment.

The European Union is now making a long-term commitment, through its January 2014 Policy Framework for Climate and Energy (2020 to 2030), to three key drivers of energy efficiency markets: cost-reflective energy markets, a substantial cross-sectoral portfolio of energy efficiency policies, and scaled-up energy efficiency financing schemes. The 2012 EED and the ramped-up investment commitments for the 2014 to 2020 programming period will be key drivers in the medium term. Through these commitments and funding programmes, investors should have the policy stability and support needed to make long-term energy efficiency investments.

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8. INDIA

To meet growing energy demand across sectors and to expand residential access to electricity, India is increasingly implementing market-based instruments that seek to scale up energy efficiency.

The *Energy Efficiency Market Report 2013 (EEMR 2013)* highlighted key energy efficiency activities implemented in line with the 2009 Indian National Mission for Enhanced Energy Efficiency. These activities included the Perform, Achieve and Trade (PAT) mechanism to improve energy efficiency in the industrial sector.

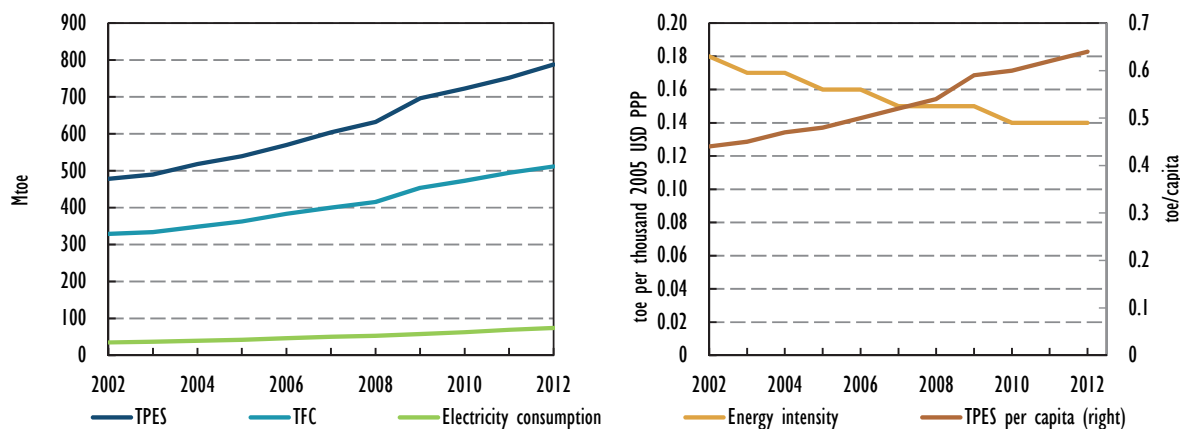
This year's report focuses on market developments in the lighting sector, which accounts for almost 28% of total Indian residential electricity consumption and is a major contributor to peak load. India faces daily peak power shortfalls as a result of peak demand outpacing supply. Improving the energy efficiency of lighting products is thus a priority for the government and a huge growth market for energy efficiency.

A particular highlight is the case study on the roll-out of light-emitting diode (LED) lamps by the Indian company Energy Efficiency Services Limited (EESL). This roll-out, as part of the Demand-side management-based Efficient Lighting Program (DELP), was launched in Puducherry, India in February 2014 and will be expanded nationally. DELP targets sales and distribution of 33.96 million LED bulbs by 2016/17.

Energy profile and context

India is the third-largest energy consumer in the world, and its energy demand is expected to grow more than fourfold over the coming decades (IEA, 2012). India relies heavily on fossil fuels, with coal accounting for 45% of its primary energy supply and over 70% of its electricity supply. Total final energy consumption (TFC) and total primary energy supply (TPES) continue to increase with India's economic development, and in 2012 reached 788 million tonnes of oil-equivalent (Mtoe) and 512 Mtoe respectively (Figure 8.1).

Figure 8.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12



Note: PPP = purchasing power parity.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

TFC increased across all sectors between 2002 and 2012 in line with India’s economic development. Energy consumption in the residential sector accounted for 36% of TFC in 2012 (Figure 8.2). It grew by 22% between 2002 and 2012 and is set to grow further as a result of increased urbanisation and access to electricity for water heating, cooling and appliances. TFC almost doubled in the industrial sector between 2002 and 2012, rising by 93%. TFC increased by 123% in transport and by 63% in commercial and public services.

Energy intensity, measured in terms of TPES per unit of gross domestic product (GDP), significantly improved in India from 2002 to 2012. Energy intensity was 0.14 tonnes of oil-equivalent (toe) per thousand 2005 USD PPP in 2012, compared with the IEA member country average of 0.13.

Figure 8.2 TFC by sector, 2012

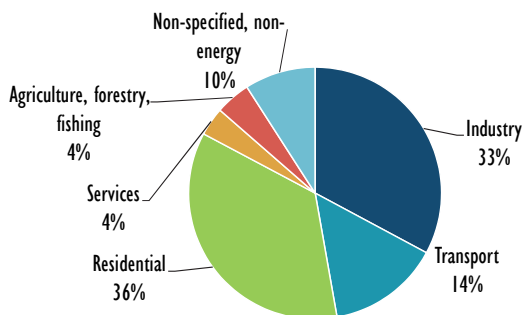
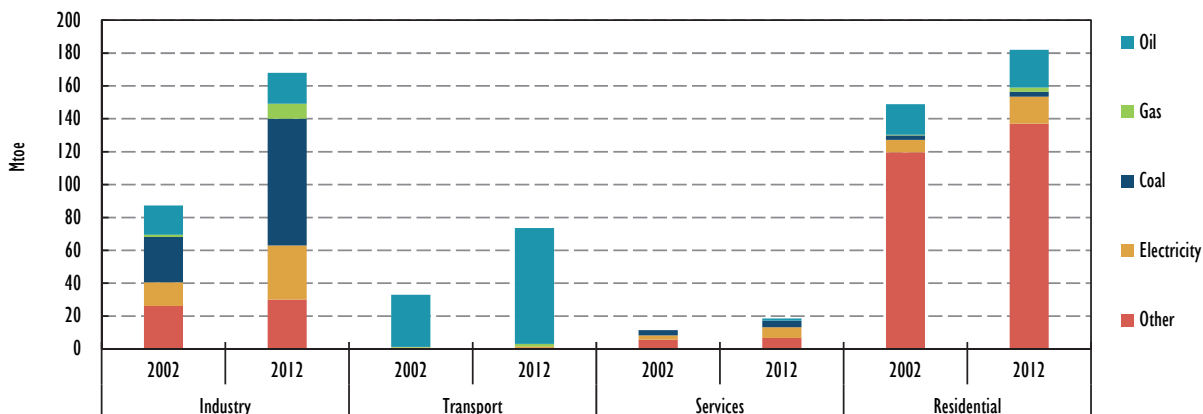


Figure 8.3 TFC by sector and by energy source, 2002 and 2012



Electricity use per capita increased by 82% from 2002 to 2012, and is expected to continue to rise. One important issue in India is increasing access to modern energy sources. In 2011, an estimated 818 million Indians had no access to clean cooking facilities, equivalent to around 66% of its population (IEA, 2014). Most of these households are in rural areas, and most depend on kerosene for basic lighting needs. Expanding access to electricity and meeting growing demand from those who already have access is a huge challenge. Advances are being made; for example, electricity generation capacity increased by nearly 5% over the first six months of 2013/14, while the peak deficit decreased. However, demand is increasing faster, resulting in regular power shortfalls in parts of the country. Improving energy efficiency is a priority to moderate demand growth and to expand access to more of the population.

Energy efficiency market activity

Market driver: Energy efficiency policies and programmes

India has successfully promoted energy efficiency policies over the last decade, and is increasingly piloting innovative market-based instruments. The National Mission for Enhanced Energy Efficiency (NMEEE), under India's National Action Plan on Climate Change, seeks to unlock more than EUR 9 billion (INR 740 billion) of market potential for energy savings across different sectors, including lighting. A dedicated Bureau of Energy Efficiency (BEE) was established in 2002 and acts as the secretariat and nodal agency for the National Mission. BEE has implemented several pioneering energy efficiency programmes since 2002, including those mentioned in Table 8.1. These activities were highlighted in the *EEMR 2013* and will only be briefly covered in this chapter.

Table 8.1 Overview of key energy efficiency policies in India

Buildings, appliances, equipment and lighting	Transport	Industry	Cross-sectoral
Energy Conservation Building Code (2007), with voluntary requirements for commercial and residential buildings.	Standards for passenger light-duty vehicles mandatory for manufacturers in place for 2017 and 2022. Heavy-duty vehicles: currently no policies.	PAT in force since 2011. Audits mandated for designated consumers.	11th Five-Year Plan (2007-12): target to improve energy efficiency by 20%.
Voluntary star ratings for office buildings.	Registration taxes by vehicle and engine size, sales incentives for advanced vehicles.		12th Five-Year Plan (2013-17): target to improve energy efficiency by 20% by 2016-17.
Mandatory standards and labelling for air conditioners and refrigerators, voluntary for five other products.			

Source: IEA (2013), *Energy Efficiency Market Report*, OECD/IEA, Paris.

Selected energy efficiency activities across sectors

Industry: Emphasis has been placed on improving energy efficiency in the industrial sector. India's flagship industrial sector energy efficiency policy is the PAT mechanism. Launched in July 2012, this programme is intended to improve the cost-effectiveness of energy efficiency investments in the industrial sector by creating a market for tradable energy savings certificates. This scheme was described in detail in 2013 and will not be the focus of this chapter.

Transport: It is expected that over the next 40 years India will have one of the largest increases in passenger light-duty vehicle (PLDV) ownership and travel of any country in the world. PLDV ownership could increase over 20-fold from 2 million in 2009 to over 40 million in 2050 (IEA, 2012). To address increasing fuel consumption due to higher numbers of PLDVs on the road, BEE, tasked by the Prime Minister's Office, finalised fuel economy standards, which will be binding for car manufacturers starting in 2017. The fuel efficiency of cars is expected to improve by 10% and 15% in 2017 and 2022, respectively, compared to a 2009/10 base year. The norms are based on a corporate average fuel efficiency (CAFE) system. Manufacturers would have to take a weighted average of fuel consumption of all the cars they sell during a year, which should be less than the CAFE standard for that year. Passenger light-duty vehicle labelling is also under development.

Buildings and appliances: The Energy Conservation Building Code (ECBC), launched in 2007, is a voluntary building code that sets minimum energy performance standards for new commercial buildings

with a connected load of 100 kilowatts or a contract demand of 120 kilovolt amperes. ECBC has been implemented in several states and amended according to local and regional climatic conditions (IEA, 2013).

Minimum energy performance standards (MEPS) and labels are in place in India; however, not all the main appliance categories have mandatory MEPS or labels. The increased living standard of Indian households is leading to greater ownership of a range of appliances and air-conditioning devices (IEA, 2013).

Current energy efficiency market activity: Focus on lighting

This report focuses on energy efficiency market developments in the lighting sector, which accounts for almost 28% of total Indian residential electricity consumption and is a major contributor to peak load. The Indian government has targeted the lighting sector for energy efficiency activity because decreasing lighting electricity consumption could help lower peak demand and decrease blackouts.

Bachat Lamp Yojana (BLY) programme

Incandescent lamps (ICLs) are the primary lighting technology used in India, particularly in the residential sector. To help phase out inefficient ICLs, which convert only 10% of electricity consumed into electricity, the government put in place the BLY compact fluorescent lamp (CFL) distribution programme.

Under the BLY programme, which ran from 2010 to 2013, CFLs were distributed to grid-connected residential households on the basis of one CFL in exchange for one ICL and a concessional price of INR 15. The programme was registered through the Clean Development Mechanism (CDM) of the Kyoto Protocol, and the costs were recovered through the sale of certified emission reductions (CERs).

More than 29.5 million CFLs were distributed across eight Indian states over the period 2010-13 as a result of the BLY programme, and led to an avoided generation capacity of 415 megawatts (MW) (BEE, 2013).

India-wide CFL sales grew to 340 million a year in 2011, up from 199 million a year in 2008 when the BLY programme was first conceptualised. Analysis by the Indian government shows that the impacts of the BLY programme, including awareness about CFLs and improvements in lamp quality, have helped transform the Indian lighting market.

Table 8.2 Sale of lamps by technology

Category	2005	2006	2007	2008	2009	2010	2011	% change 2010-11
Incandescent lamps	711	757	779	734	766	797	757	-5%
Fluorescent lamps	180	186	190	186	179	182	194	+7%
CFLs	67	100	140	199	255	304	340	+12%

Source: Electric Lamp and Component Manufacturer's Association of India (2014), www.elcomaindia.com/.

Prospects for energy efficiency market activity

DELP Program

Based on the BLY model, the Indian government has decided to roll out DELP. DELP is a large-scale ICL-replacement programme in which LED lamps are provided to households at a price similar to ICLs.¹

¹ Eight watt (or less) LED to replace 60 watt ICL; five- to six-year free replacement warranty on lamps against technical defects; distribution of three LEDs per household for each working ICL; project monitoring based on international standard methodology approved by CDM Executive Board for BLY.

The government estimates that replacing ICLs with LED lamps, which use 85% less electricity for the same light output, could reduce electricity demand by over 50 billion kilowatt hours (equivalent to around 19 000 MW of avoided capacity) every year and decrease consumer bills by over EUR 3.1 billion (INR 250 billion).

DELP is implemented and financed by EESL² as a Standard Offer Program (SOP), where a utility or government can purchase energy savings at a pre-determined rate, in a manner similar to purchasing electricity generation.

Box 8.1 Indian Energy Efficiency Services Limited (EESL)

EESL was created in support of the 2009 NMEEE, which recognises the importance of providing innovative financing schemes and capacity building for energy efficiency programmes. EESL, a joint venture sponsored by four Indian government-owned companies, leads market actions to develop a nation-wide energy service company (ESCO) industry, and is the first company registered exclusively for the implementation of energy efficiency in South Asia. One of EESL's innovative projects applies the logic of the feed-in tariff, used to promote renewable energy, to the energy efficiency sector by allowing a utility to make a pre-determined payment for a unit of electricity that has not been used.

The first roll-out of the DELP project began in Puducherry in February 2014, and was launched by the electricity department of the government of Puducherry in co-operation with EESL. The goal of the project was to overcome the peak deficit and also to service potential new connection load requests from higher tariff customers in the industrial and commercial sectors.

Box 8.2 DELP roll-out in Puducherry

Electricity consumers in Puducherry are divided into two large-scale categories: low tension (LT) and high tension (HT). The LT consumers consist of five categories, namely domestic, commercial, agricultural, street lighting and industrial. The largest number of consumers is in the domestic category. They comprise 73% of the total numbers of consumers and account for around 25% of total electricity consumption, but only 10% of total revenue. The average cost of power is INR 3.18 per unit, whereas for domestic consumers it is only INR 1.76 per unit.

The domestic sector accounts for the largest growth in electricity demand (4% per year), followed by industry (3% per year). In 2013/14, Puducherry had a daily power demand of 350 MW and a peak deficit of 7 MW. Hence, the inefficiencies in the domestic segment contribute to the higher budget deficit.

Distribution utilities, implementing demand-side management (DSM) projects through EESL, can consider energy efficiency as a resource at a pre-determined SOP price³ measured per unit of energy saved. The SOP price is based on the cost to distribution companies of power procurement from the open market.

Source: Indian Energy Efficiency Services Company (EESL).

² This DELP case study was provided by EESL and edited by the IEA.

³ To ensure that the scheme is financially beneficial to the distribution company, the price of every unit of energy saved owing to DELP is set lower than the average power procurement cost or peak power procurement cost (on case to case basis). This results in cost savings/benefit to the distribution company against their existing power purchase agreements. In this specific case, talks are ongoing about setting aside a portion of these benefits for a State Energy Conservation Fund.

Challenges

In spite of the known advantages, there are many challenges to the wide-scale adoption of LED lamps. High upfront cost compared to other lighting technologies is a major barrier, as is the lack of awareness or marketing campaigns in major Indian languages. Moreover, government procurement policies, projects and programmes do not discourage inefficient lighting technologies.

Conclusions

In a large and populous country like India, even small measures such as encouraging switching over to more efficient lighting in the residential sector can have a large impact on energy savings. Programmes such as DELP reinforce the policy shift towards treating energy efficiency as an energy resource, and allow energy efficiency to compete on a more level playing field with supply-side options.

Successful implementation of the DELP in Puducherry is expected to lead to a mandate from the BEE and the Ministry of Power to roll out the DELP mechanism across the country. In fact, Delhi, Karnataka, Mumbai and Rajasthan are already developing DELP programmes based on the Puducherry pilot. Additional policies aimed at phasing out the most inefficient lighting technologies could go a long way to transforming the Indian lighting market.

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9. INDONESIA

Indonesia is the largest energy consumer in Southeast Asia, accounting for over 36% of the region's energy demand and consuming 69% more energy than Thailand, the region's second-largest energy consumer.

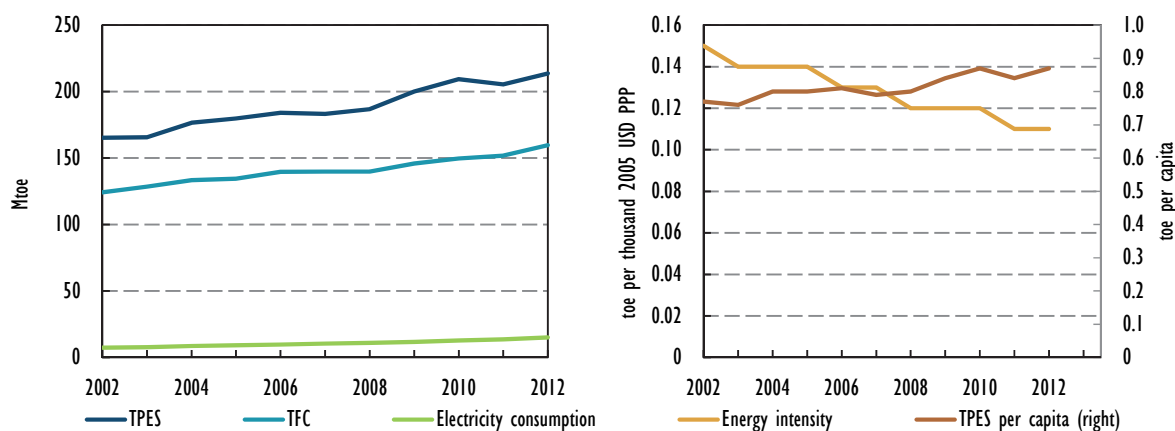
Although the market for energy efficiency in Indonesia is still in its early days, there is a significant potential for growth given government ramp-up of energy efficiency policies in the residential and industrial sectors. The potential market for energy efficiency in the transport sector is particularly great, and could benefit from government policy development and implementation.

Based on projections by the Asian Development Bank (ADB) and on national energy efficiency targets, Indonesia offers more than half of Southeast Asia's energy efficiency investment potential (57%) in the period to 2020.

Energy profile and context

Indonesia is the world's fourth most populous country and the 16th largest economy, and is growing rapidly on both counts. Between 2002 and 2012, total final energy consumption (TFC) increased in Indonesia by 2.6% per year on average, while gross domestic product (GDP) increased by 5.7% per year. Energy intensity declined by 27% as a result of urbanisation, a switch to more efficient commercial fuels, and the introduction of improved practices and technology in the industrial and buildings sectors (IEA, forthcoming).

Figure 9.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12

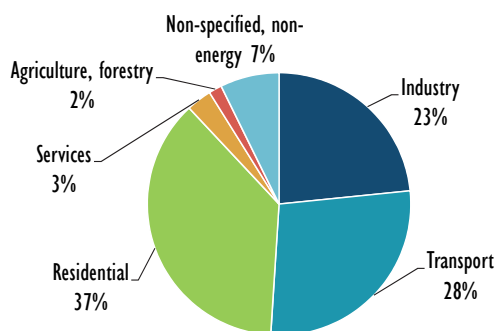


Note: PPP = purchasing power parity; toe = tonnes of oil-equivalent; TPES = total primary energy supply.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

Indonesia's residential sector accounts for 37% of energy demand, followed by the booming transport (28%) and industry (23%) sectors (Figure 9.2). The household and commercial sectors are projected to increase their share of energy consumption over the next ten years, as rising incomes and urbanisation shift output to a more consumer-based economy. The share of the Indonesian population living in cities is projected to increase from 53% to 71% in the next 20 years, which would coincide with a tripling of the consumer class over the same period (McKinsey, 2012). Services already accounted for more than half of total economic growth in 2012 (ADB, 2013).

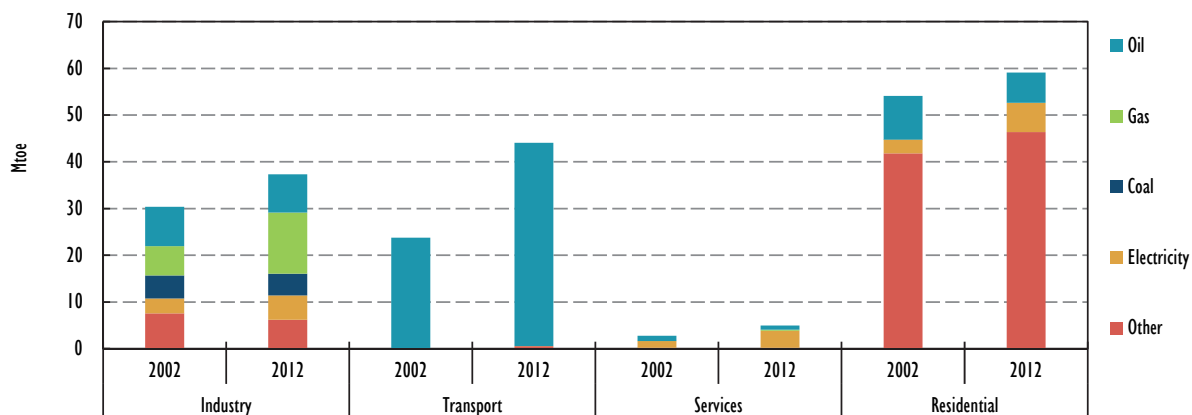
Figure 9.2 TFC by sector, 2012



Indonesia’s increasing urban population and prosperity is correlated with higher motor vehicle ownership, which is increasing congestion. In the capital city of Jakarta, the number of trips by road vehicle increased by 50% from 2002 to 2010 (Prasetya, 2013). One-third of Indonesian fuel use is wasted by vehicles stopped in traffic, and average speeds continue to decrease in all major Indonesian cities. Motorcycles account for 80% of transport, and that share is increasing rapidly at the expense of public transport. Moreover, segregated bus lanes are suffering from a lack of enforcement, which undermines their potential to become high-capacity bus rapid transit systems.

Indonesia’s final energy mix is dominated by oil (43%), followed by biofuels and waste (33%), natural gas (11%), electricity (9%), and coal (3%). Indonesia is seeking to expand the shares of renewables and natural gas by 2025.

Figure 9.3 Share of TFC by sector by source, 2002 and 2012



Fuel subsidies in Indonesia are some of the highest in the world, and work against the uptake of energy efficiency. Subsidies made up almost 20% of government spending (IDR 212 trillion) in 2012, equivalent to all of Indonesia’s capital and social spending combined (IEA, forthcoming). The transport sector uses 96% of the subsidised fuel. Indonesia has undertaken several reforms to reduce subsidy levels since 1997. In June 2013, the price of gasoline was increased by 44% and diesel by 22%, while electricity prices were increased by 15% during 2013 for households supplied 1 200 kilovolts (kV) to 5 500 kV. These efforts should help curb growing energy demand.

Energy efficiency market activity

Market supply: Potential for energy savings

Indonesia has a target to reduce TFC by 17% by 2025,¹ with a 17% decrease in industry, 20% in transport and 15% for the commercial and household sectors (Table 9.1). Indonesia also aims to achieve a 1% saving in energy transformation (comprising an electricity production saving of 0.5%, a transmission saving of 0.25%, and a saving from distribution and refineries of 0.25%). The agriculture, construction and mining sectors are not subject to energy savings targets. Presidential Instruction No. 13/2011 on Water and Energy Savings requires national, regional and local governments, as well as state-owned companies, to implement energy- and water-saving measures with the goal of achieving electricity savings of 20%, water savings of 10%, and fuel savings of 10%.

Table 9.1 Indonesia's energy savings potential by sector

Sector	Energy consumption, 2011 (million boe)	Energy conservation potential	Energy conservation target, 2025
Industry	316 (43%)	10%-30%	17%
Commercial	32 (4%)	10%-30%	15%
Transport	279 (38%)	15%-35%	20%
Household	85 (12%)	15%-30%	15%
Other*	25 (3%)	25%	x%

Note: boe = barrel of oil-equivalent; x = not applicable.

* Agriculture, construction and mining.

Source: Hutapea, Marit Je (2013), "Development of Indonesia's Energy Efficiency and Conservation Policies", presentation to Roundtable on Energy Efficiency Policies for South East Asia," Jakarta, 11-12 December 2013, www.iea.org/media/workshops/2014/eerssoutheastasia/2.1IbuMaritje_.pdf.

Market driver: Energy efficiency policies, programmes and prices

The Directorate of Energy Conservation is responsible for energy efficiency measures within the Ministry of Energy and Mineral Resources' Directorate General of New and Renewable Energy and Energy Conservation. Other ministries, such as the Ministry of Industry, the Ministry of Transport, the Ministry of National Development Planning, and the Ministry of Finance, also have duties and responsibilities for energy efficiency and are key to implementing standards and promoting financial support.

In January 2014, Indonesia's legislature passed the National Energy Policy, which is a new energy regulation designed to gradually end fuel and electricity subsidies, stop exports of coal and gas, increase the role of renewable energy in the country and scale up energy efficiency (Johnson, 2014). The National Energy Policy reconfirms long-term targets, including decreasing energy intensity by 1% per year and energy-GDP elasticity to below 1% by 2025. In order to meet these targets, investments of more than USD 6 billion will be needed (ADB, 2013).

Energy Law No. 30/2007 is the foundation for several government and ministerial regulations, including Government Regulation 70/2009 on energy conservation, Ministry Regulation No. 14/2012 on energy management in industry, Presidential Instruction No. 13/2011 on energy and water savings in the public sector, and Ministry Regulation No. 13/2012 on electricity savings in public buildings and street lighting. In the buildings sector, Law No. 28/2002 sets minimum requirements by reference to Indonesian standards, while the city of Jakarta has introduced stricter Green Building Codes.

¹ This reduction is compared with a business-as-usual scenario with annual energy growth of 7.1% a year.

In the **appliance, lighting and equipment sectors**, the Indonesian National Standard (SNI) is the quality standard, and provides national energy performance testing standards (EPTS) for electrical appliances. Products conforming to the SNI are registered with, and follow the guidelines of, the National Standardization Agency of Indonesia (BSN). Energy standards and labels are being developed and implemented for nine products, and incandescent lamps are the first to have regulations in place (Table 9.2).

Table 9.2 Products with standards and labels under development in Indonesia

Product	SNI EPTS reference
Ballast (magnetic)	SNI IEC 60929-2009
Fluorescent lamp	SNI IEC 60901-2009
Incandescent lamp	SNI IEC 60432-1-2009
Room air conditioner – split type	ISO 5151
Room air conditioner – window type	ISO 5151
Household refrigerator	SNI IEC 15502-2009
Clothes dryer	SNI IEC 60456-2009
Electric iron	SNI IEC 60311-2000
Vacuum cleaner	SNI IEC 60312-2009

Source: IEA (forthcoming), *Energy Policies of IEA Countries: Indonesia 2014*, OECD/IEA, Paris.

For industry, the regulation on energy management applies to companies with annual energy consumption of more than 6 000 toe or 70 gigawatt hours. Such companies are expected to appoint energy managers, perform energy audits, implement the recommendations of the energy audits, introduce energy management programmes, and report energy consumption to the authorities. Companies have recently been informed of their responsibility under this regulation, but enforcement actions have yet to be defined.

As part of Indonesia's commitment to mitigate greenhouse gas emissions **in the transport sector**, Transport Ministerial Regulation No. 201 (2013) aims to mitigate emissions in that sector through a complete "avoid, shift and improve" approach (see Chapter 3 in Part I on transport for definition). Policy is mainly focused on fuel substitution from oil to gas, although several "shift" policies have been implemented, including car-free days on weekends, transit-oriented development (TOD) planning, and encouragement of the use of non-motorised vehicles. Air quality remains a major issue, especially as Euro II standards are still not fully implemented, nor has lead been fully removed from fuel. Road pricing and parking management are still largely absent, although if implemented would lower energy use and emissions, and reduce the cost of congestion.

To further develop energy efficiency policies and programmes, Indonesia has increased its collaboration with international and bilateral organisations such as the Association of Southeast Asian Nations, Asia-Pacific Economic Cooperation, United Nations Development Programme and the International Energy Agency, as well as with countries such as Denmark, France, Japan and the United Kingdom. Indonesia is also a member of the Clean Energy Ministerial.

Energy efficiency market activity and prospects

Despite policy developments and major opportunities for low-cost energy efficiency improvements, there is little movement in the energy efficiency market in Indonesia and virtually no commercially attractive financing available for energy efficiency projects. The main barriers to development of the market are lack of knowledge about energy efficiency technologies and low confidence among facility owners that energy savings will be achieved (Dreesen, 2013).

Financing mechanisms

To help overcome the financing challenges facing the energy efficiency market in Indonesia, ADB and Indonesian partners have created two financial products: one that provides direct loans through Indonesia's Eximbank (established by the Indonesian government to provide funding to markets not served by commercial banks or financial institutions), and the second that provides an energy efficiency savings guarantee to commercial banks.

The **energy efficiency project loan product** provides loans to Indonesian export companies. The loans are structured in order to (a) avoid significant impact on the company's core credit capacity, (b) generate energy savings as collateral, and (c) generate a net positive cash flow. International energy efficiency experts are provided to perform feasibility analyses and develop structured finance documents.

The first project between ADB, Eximbank and the Indonesian Export Financing Agency (LPEI) was launched in January 2014 with a loan of USD 1.31 million to the publicly listed food company PT Tiga Pila Sejahtera Food (AISA). This loan aims to help AISA reduce energy costs to boost exports. Under the loan agreement, the company must implement six energy efficiency measures, including installing more efficient systems, insulation and temperature-control equipment.

The second ADB financing tool is the **energy efficiency savings guarantee**, which covers shortfalls in energy savings expected from energy efficiency projects. This guarantee will hopefully help overcome investor scepticism about the energy savings possible through energy efficiency technology investments.

Energy service companies

Growth in the Indonesian energy service company (ESCO) business has been slow. The reasons for this are multiple, including lack of regulatory frameworks for the ESCO industry, no ESCO accreditation body, no standard ESCO model, limited financial access for funding energy efficiency projects and limited understanding of energy efficiency projects and of the energy performance contracting concept (Indonesia ESCO Association, 2013).

There are, however, some positive market signs in the ESCO market. Several manufacturers and suppliers are creating ESCO models for energy efficiency projects that they support with their own capital, and a new Indonesian ESCO Association (APKENINDO) was launched in 2011.

Investments in public transport

Regarding public transport, the Indonesian government has developed right-of-way bus lanes and is planning metro, monorail and railway systems. In a joint venture with Japan, the government is scheduled to invest USD 400 million in a metro line and to build 54 kilometres of monorail lines to satellite communities for commuters. These projects have attracted financing, but are experiencing delays that are challenging for potential investors.

In the freight sector, policy aims to shift road freight traffic to rail, but investments have yet to materialise because of delays in implementing rail projects. Better freight transport integration between modes would increase efficiency while reducing the high cost of moving goods. A track-doubling project connecting Indonesia's two biggest cities, Jakarta and Surabaya, is under way.

Challenges

As in many countries, energy efficiency is not prioritised over other investments. The main obstacles to energy efficiency and conservation in Indonesia are subsidised fossil fuels and electricity and, as mentioned earlier, lack of knowledge about energy efficiency technologies and their benefits. Increased tariffs and fuel prices as a result of subsidy reform should help curb growing energy demand (without necessarily impeding economic growth). Another barrier to the energy efficiency market in Indonesia is the lack of government enforcement of laws and regulations – particularly of building codes.

Conclusions

The policies and measures undertaken by the Indonesian government and its partners are helping create a market for energy efficiency. In industry, for example, there are signs of an infant ESCO business. In the residential sector, the development of minimum energy performance standards and labelling will expand the market for more efficient appliances and equipment. More efficient products could increase Indonesia's ability to export goods to more highly regulated international markets.

Moreover, energy efficiency financial products made available by multilateral development banks, such as ADB, are beginning to gain traction in Indonesia and could go a long way to growing the energy efficiency market.

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10. IRELAND

Ireland experienced an economic boom during the 1990s that lasted until 2007, at which time there was a severe downturn. While Ireland's economy has recovered slightly in the past two years, energy demand has remained stable. Fuel import dependency is at its lowest level this century, but Ireland still imports 85% of its energy and spent EUR 6.5 billion on energy in 2012.

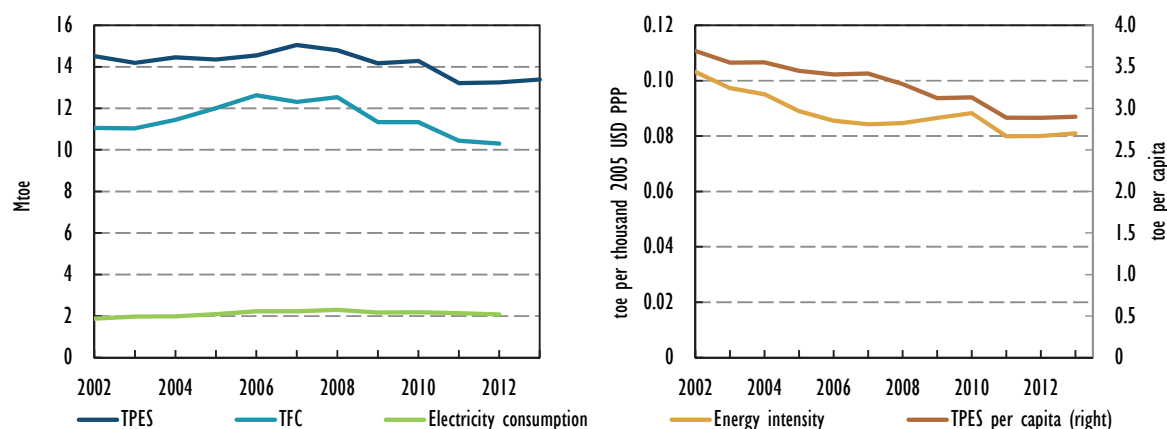
Ireland is actively seeking ways to scale up the market for energy efficiency, for example by publishing a National Energy Services Framework that provides a standard approach for the procurement of energy performance contracts (EPCs). Ireland has also put in place a range of energy efficiency grant schemes for households, and has committed EUR 35 million to the Energy Efficiency Fund, with a view to establishing a fund of over EUR 70 million when matched with investment from the private sector. It is expected that this fund will leverage EUR 300 million in investment in energy efficiency in the next three years.

Irish companies are well positioned to capture new business as a result of energy efficiency investment, both to meet domestic demand and by exporting energy efficiency-related products and services.

Energy profile and context

Ireland experienced an extended economic boom from the 1990s through to 2007. Total final energy consumption (TFC) increased by around 63% between 1990 and 2007. The period 2008 to 2010, by contrast, saw an average annual decline in gross domestic product (GDP) of -3.8%, and TFC levelled off and began to decline. Ireland's economy grew by 0.2% to EUR 163 billion in 2012, but TFC continued to fall, by 3.7%, to 10.8 million tonnes of oil-equivalent (Mtoe). Total primary energy supply (TPES) fell to 13.2 Mtoe in 2012, similar to the 1999 level, and increased by 1.1% in 2013.

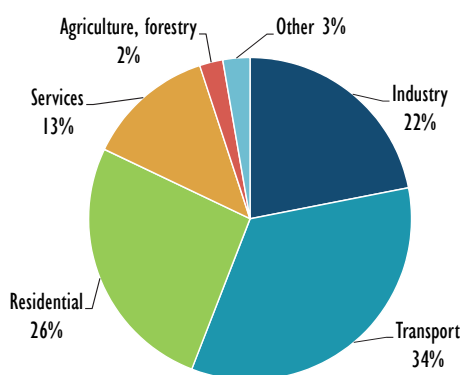
Figure 10.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13



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

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

Transport has been increasing its dominance as the largest energy-consuming sector on a TFC basis since the mid-1990s. The transport energy share grew to just over 43% in 2007, but has since dropped to around one-third of final energy use (Figure 10.2). At 3.5 Mtoe in 2012, transport TFC is down by 3% from 2011 levels and by 23% from 2007. Over half of all transport energy supply is from diesel.

Figure 10.2 TFC by sector, 2012

Private cars account for 46% of transport energy use. Private car numbers fell by 0.3% in 2012, following a cumulative 2.6% reduction in 2009 and 2010, and a small increase of 0.8% in 2011 (SEAI, 2013).

Freight transport energy demand has significantly decreased, down by 43% in 2012 from 2007 levels, due to the end of the construction boom and the subsequent economic recession. Air transport demand also suffered a severe reversal after 2007.

Residential energy use is responsible for around one-quarter of TFC and the service sector represents 13%. Primary energy use in buildings overall fell by 0.3% in 2012, having increased by 25% since 1990 (SEAI, 2013).

Industrial energy demand was 2.3 Mtoe in 2012 (equivalent to the 1999 level), falling by 1.1%, while economic output from industry fell by 0.4% (SEAI, 2013). That decrease in industrial energy demand is in contrast with growth rates of more than 5% per annum experienced in the late 1990s.

Figure 10.3 shows a slight decrease in TFC in industry, transport and services between 2002 and 2012, and a slight increase in residential TFC. Energy consumption in Ireland peaked in all sectors in 2007 and has been declining since then. While this is obviously partly a result of the recession in the Irish economy, clear trends of improvement in unit energy consumption are evident in both transport and households (SEAI, 2013). Energy demand reductions outpaced the contraction of the Irish economy: between 2007 and 2012, energy demand fell by 16% and reached 1999/2000 levels, while the 7.3% contraction in Ireland's GDP set it back to 2005/06 levels (SEAI, 2013).

In 2012, electricity amounted to one-fifth of Ireland's TFC. Natural gas demand fell 2.5% in 2012, the net result of a 7.7% decrease in its use for electricity generation and an 8.1% increase in final demand. The contributions of coal, peat and hydro to the electricity fuel mix all increased – by 27%, 16% and 14% respectively.

Coal demand overall grew by 15% in 2012, reflecting low international prices for coal and carbon. However, the share of renewable energy sources in Ireland's electricity generation increased by almost four times (from 4.9% to 19.2%) between 1990 and 2012, representing an almost eight-fold increase in real terms, and avoiding almost EUR 300 million in fossil fuel imports in 2012 alone (SEAI, 2013).

Decomposing Irish energy consumption reveals that both energy efficiency and structural change are helping to bring TFC in Ireland below 2001 levels (Figure 10.4). Activity levels in Ireland saw marked growth

from 2001 to 2007 but then stagnated in the wake of the 2008 recession. This is highlighted in the residential sector, where floor area in residential buildings grew by 44% over the decade to 2010, reflecting the impact of the housing boom. Lower absolute economic output in the recession led to a worsening energy intensity in industry, which explains the upward movement of the efficiency effect in 2008. Efficiency gains were greatest in the residential sector, which improved by over 20% in 2011 compared to 2001.

Figure 10.3 TFC by sector and by energy source, 2002 and 2012

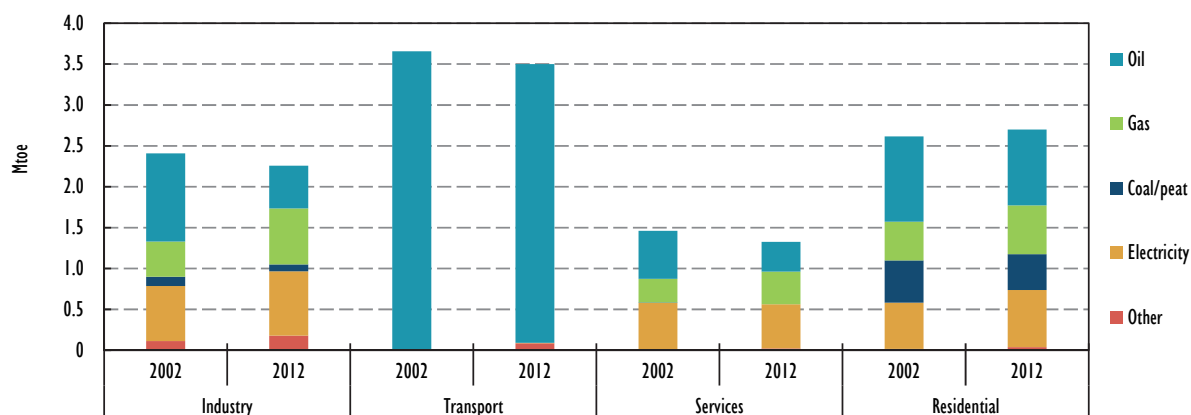
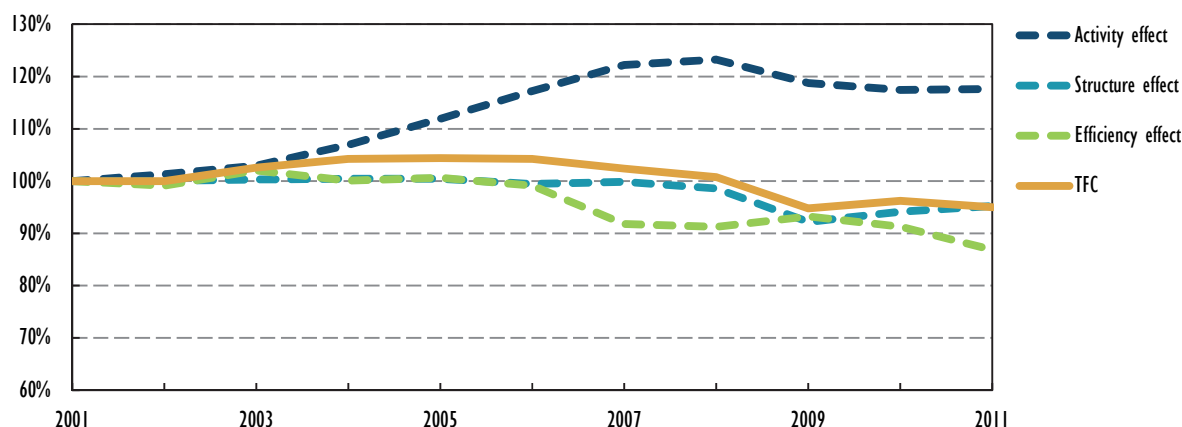


Figure 10.4 Decomposition of energy consumption in Ireland



Market variable: End-use energy prices

Since 2007, energy prices in Ireland have risen by 29% in real terms, compared with an average rise of 20% in OECD Europe. This price trend partly reflects Ireland's continued heavy dependence on imported oil and gas, and the introduction of a carbon tax. Fuel import dependency is at its lowest level this century, but Ireland still imports 85% of its energy, with an associated energy bill of EUR 6.5 billion in 2012.

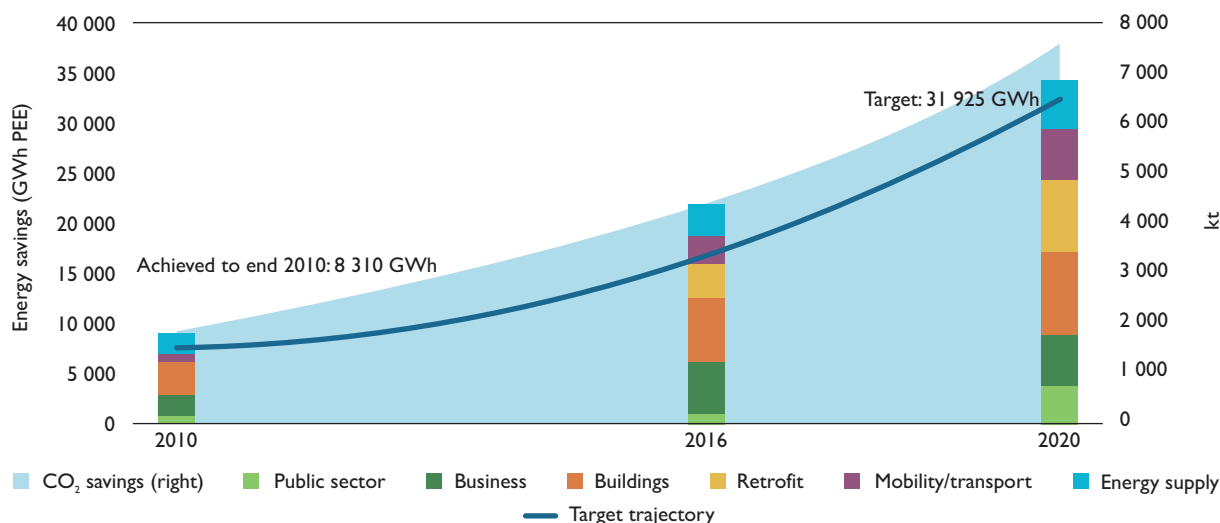
Energy efficiency market activity

Market supply: Potential for avoided energy use

In line with European Union (EU) policy, Ireland has set a 20% national energy savings target by 2020, equivalent to 31 925 gigawatt hours (GWh) or 114 930 terajoules (TJ), and a 9% target by 2016. To reach these targets, Ireland is implementing a range of measures that have the potential to reduce energy spending across all sectors by EUR 2.4 billion.

Energy efficiency improvements in Ireland in the 1990s were mainly driven by increased efficiency in the industry sector. Recently however, improvement has been driven more by the residential sector. Ireland has identified existing residential buildings and the public sector as the largest markets for energy efficiency improvements from now to 2020 (Figure 10.5).

Figure 10.5 Energy and carbon dioxide savings and target trajectory to Ireland's 20% energy savings target for 2020



Note: CO₂ = carbon dioxide; kt = kilotonne; PEE = primary energy equivalent.

Source: DCENR (2012), *Ireland's second National Energy Efficiency Action Plan to 2020*, DCENR, Dublin, www.dcenr.gov.ie/NR/rdonlyres/B18E125F-66B1-4715-9B72-70F0284AEE42/0/2013_0206_NEEAP_PublishedversionforWeb.pdf.

Ireland's third National Energy Efficiency Action Plan (NEEAP) estimated that energy savings achieved were 12 337 GWh by the end of 2012. Projected savings to 2020 of 31 995 GWh are expected to exceed the 2020 national energy savings target of 31 925 GWh (DCENR, 2014a).

Market driver: Energy efficiency policies and programmes

Energy efficiency policies and programmes are set out in the NEEAP and fall within the context of energy policy more broadly, as set out in the Sustainable Energy White Paper of 2007, the *National Climate Change Strategy 2007-2012*, and the *National Development Plan 2007-2013*. A new Green Paper on energy policy was published in 2014 (DCENR, 2014b). There are also a range of national programmes and measures that specifically target energy efficiency at country level, the most important of which are discussed in the next section.

As with other member states, European Union (EU) policies and programmes are also a key driver of the energy efficiency market in Ireland. For instance, Ireland has a successful scheme of energy performance certificates in line with the Energy Performance of Buildings Directive (EPBD) (Box 10.1), and is currently implementing an Energy Efficiency Obligation scheme under the Energy Efficiency Directive.

Box 10.1 Energy Performance Certificates in Ireland

Ireland's Energy Performance Certificates scheme came into effect in stages between 2007 and 2009. The certificates are called Building Energy Ratings (BERs) in Ireland. By mid-2014, the number of dwellings with a valid BER was over 460 000, or about 25% of the total. From 2013, a BER must be displayed in all advertising and marketing materials when buildings are offered for sale or rent. This key requirement of the EPBD is intended to make sure that energy efficiency plays a role in decision making in the market.

The effect of a one-letter improvement in energy efficiency has been estimated at 2.8% in the sales market and 1.4% in the rental market (Bio Intelligence Service, Lyons and IEEP, 2013). The effect in the sales market fell between 2009 and 2011, but was as large in 2012 as it had been in 2009.

Current energy efficiency market activity

Energy efficiency market activity in Ireland is currently concentrated in the buildings, industry, and public and commercial sectors. Each of these market segments is described below and in Table 10.1. In 2013, the Department for Communications, Energy and Natural Resources (DCENR) estimated that five years of EUR 250 million annual public investment in energy efficiency programmes had leveraged additional spending in the economy of more than EUR 250 million.

Grants for energy efficiency in homes and buildings

Ireland has a number of grant schemes for homeowners to improve their energy efficiency, which come under the umbrella of the Better Energy Programme, including the Better Energy Homes scheme, the Better Energy Warmer Homes scheme, and the Better Energy Communities scheme.

Better Energy Homes provides a financial incentive to private homeowners who wish to improve the energy performance of their homes.¹ Better Energy Homes is a demand-led programme. Since commencing in March 2009 the scheme has delivered energy efficiency measures to 158 963 homes, supported by grants of over EUR 166 million. The scheme has delivered over EUR 461 million of investment in the residential sector. A typical grant represents about 20% of the total investment undertaken by the homeowner. In 2014, EUR 12.5 million has been allocated, which should enable 10 000 homes to be upgraded, providing 50 GWh in energy savings and corresponding to EUR 3.4 million in avoided energy costs.

Better Energy Warmer Homes delivers a range of energy efficiency measures to low-income households that meet the defined eligibility criteria and that are vulnerable to energy poverty. Recipients of the scheme have measures installed free of charge. Since the scheme commenced in 2000, 106 296 households have received energy efficiency measures, and EUR 119.3 million has been spent. EUR 20 million was allocated in 2014, which will support the delivery of energy efficiency measures to about 12 000 homes and result in energy savings of 25.2 GWh and EUR 1.7 million of avoided energy costs.

The Better Energy Communities scheme supports the improvement of the thermal and electrical efficiency of the buildings and facilities in communities, encouraging the implementation of deeper and more technical and economically challenging measures. The scheme helps to support innovative partnership approaches to delivering these projects at scale, using local resources and leveraging additional financial support from other sources. It is a competitive call. Typical partners in projects are obligated

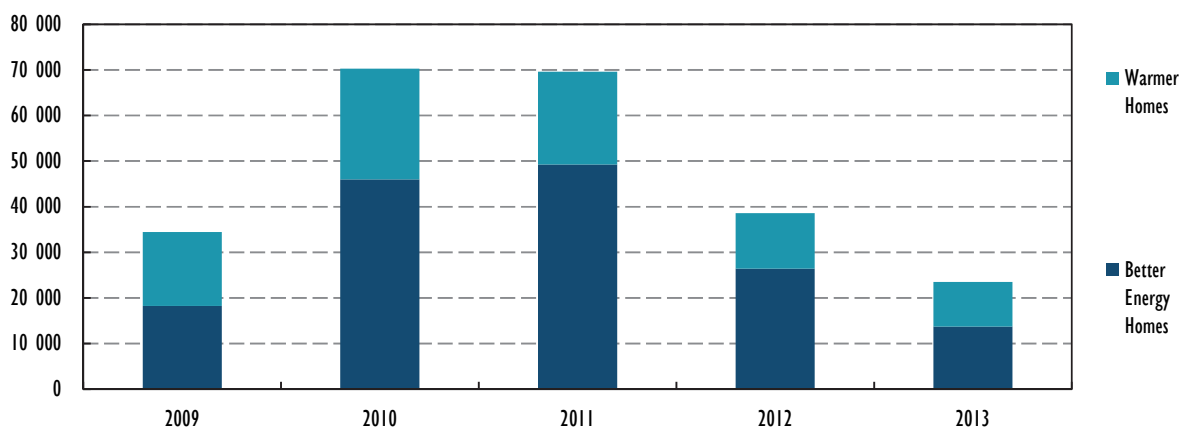
¹ See www.seai.ie/Grants/Better_energy_homes/.

energy suppliers, community-based organisations, private companies, public bodies, ESCOs and local energy agencies. The scheme has a specific strand focusing on the energy-poor sector, supporting the Affordable Energy Strategy. The scheme has EUR 22.5 million in funding allocated for 2014. It is anticipated that it will generate energy savings of 97 GWh.

The Better Energy Programme as a whole has resulted in annual average investment of EUR 230 million in energy efficiency-related construction over the period 2009-13 (SEAI, 2012). Within a broadly similar budget, the Better Energy Programme has evolved such that it now includes demand-led schemes (Better Energy Homes); Affordable Energy Strategy-led Better Energy Warmer Homes; and the partnership and locally focused scheme, Better Energy Communities.

The number of homes enhanced under Better Energy Homes reached 49 000 in 2011 before falling back to 14 000 in 2013. The number of homes improved under Warmer Homes peaked at 24 000 in 2010, but fell to 10 000 in 2013 (Figure 10.6).

Figure 10.6 Number of homes receiving energy efficiency measures by scheme, 2009-13



Note: excludes the contribution of upgrades delivered by the Better Energy Communities scheme.

Source: Houses of the Oireachtas (2014), Dáil Eireann Debate, 13 March 2014, Dublin, <http://oireachtasdebates.oireachtas.ie/debates%20authoring/debateswebpack.nsf/takes/dail2014031300060>.

Energy efficiency in the industry sector

The Sustainable Energy Authority of Ireland (SEAI) Large Industry Energy Network (LIEN) currently has 173 active members whose total energy use accounts for 70% of industrial energy use in Ireland, equivalent to EUR 900 million per year (DJEI, 2013). Regular workshops, seminars and site visits enable LIEN members to learn from energy experts and other specialists, and to share knowledge and experiences with other energy managers. Of the network's members, 73 have achieved or are working towards ISO 50001 certification. An average savings of 10% has been achieved to date.

The international energy management standard ISO 50001 was based on an Irish standard, which was one of the first of its type in the world. As a result, Ireland now has one of the highest rates of uptake of energy management standards in the world, giving a competitive advantage to Irish-based companies. SEAI is currently working on an Irish standard for Energy Efficient Design, building on Ireland's leadership in developing ISO 50001. The new standard puts forward an advanced methodology for industry-focused energy cost reduction. Among the early adopters of the standard are Allergan, Diageo and Glanbia.

Small and medium-sized enterprises (SMEs) are a vital sector in terms of potential for energy efficiency. Between 2007 and 2011, the SME Programme of the SEAI supported more than 1 470 companies employing the equivalent of approximately 130 000 staff, with advice, mentoring and training (Scheer and Motherway, 2011). In 2012, over 200 SMEs with 2 000 employees and a total annual energy bill of EUR 19.7 million were supported to achieve savings of EUR 2 million.

Box 10.2 The Green International Financial Services Centre

The International Financial Services Centre (IFSC) in the Dublin Docklands area encompasses more than 500 firms and directly employs more than 33 000 people. Established more than 25 years ago, the IFSC is today emerging as a centre for green finance and green asset management, with some USD 30 billion in green funds managed, or serviced from Ireland.

The Green IFSC initiative is a public-private partnership to position Ireland as a global centre of excellence for green finance and green asset management. The objective is to grow green assets in Ireland to USD 200 billion by 2020 and to make sure that Ireland has the optimum business environment to sustain and accelerate that growth.

Further strengthening Ireland's credentials in the area of green finance is the Greening the IFSC project. The Green IFSC, in partnership with SEAI and Dublin City Council, has created this project in a bid to ensure Ireland has one of the most resource-efficient financial centres in the world. This first-of-a-kind project has also been designed to help companies measure their carbon footprint and come up with a plan to reduce resource consumption (waste, water and energy) and cut costs. Eight companies, with a collective energy bill of over EUR 5 million and 7 620 employees, have come together in a pilot project to reduce their energy consumption and company costs. As the project grows, it is expected that half of the IFSC workforce, or 16 500 people, will become involved.

The Better Energy Workplaces scheme provided support for sustainable energy upgrades to buildings, services and facilities in 2011 and 2012. Similarly, the Accelerated Capital Allowance (ACA) scheme, introduced in 2008, enables companies to write off 100% of the purchase value of qualifying energy-efficient equipment against their profit in the year of purchase. Qualifying products from the defined ACA equipment categories are listed on the ACA Specified List, which is updated on a regular basis.²

Energy efficiency is growing into a major exporting sector in its own right. Exports of energy efficiency-related products from Ireland increased from around EUR 100 million in 2010 to over EUR 170 million in 2012 (66% increase). This growth is focused on thermal insulation products and energy-efficient lighting.

National Energy Services Framework

Ireland has taken a three-pronged approach to scaling up energy efficiency activity in the public and commercial sectors. The first is the Energy Efficiency Fund, launched in 2014, which establishes financing for the non-residential sector, with EUR 35 million from the government and an additional EUR 35 million sought in matching funds from the private sector. The fund seeks to provide transparent financing for EPCs. The second is an EPC policy framework that brings suppliers and buyers together under an agreed set of protocols and provides standard reference material on procurement, model contracts and technical support. This framework seeks to overcome barriers to deploying EPCs. The third is a technical support programme that aims to deliver a number of exemplar projects with tested methodologies and investment-ready status.

² See www.seai.ie/Your_Business/Accelerated_Capital_Allowance/.

Central to the success of both the overall framework and the fund in particular will be Ireland's ability to identify and build a pipeline of investment-grade projects. Undoubtedly this will take time but, once up and running, should provide a steady stream of activity that will lead to jobs and economic growth in the retrofit and energy services markets. The first tranche of 21 projects was launched in June 2013. Collectively, these projects will see investment of up to EUR 55 million in energy-saving measures, resulting in annual savings of EUR 7 million. A series of workshops have been organised to monitor progress, and EUR 550 000 in technical assistance has so far been committed.

Table 10.1 Overview of key government-led energy efficiency investments, 2014

Name	Policy type	Sector	Direct spending (EUR million)	Leverage (EUR million)
Better Energy Homes	Grants	Residential	12.5	50
Warmer Homes	Direct investment	Residential	20	..
Better Energy Communities	Grants	Residential	13.5	27
VAT rebate	Tax rebate	Residential
National Energy Services Framework	Framework	Non-residential	0.5	..
Energy Efficiency Fund	..	Non-residential	35	35-300
Exemplar projects	Direct investment	Non-residential	55	30
Energy Efficiency Obligation scheme	Regulation	All	< 1	..

Note: .. = data not available.

Prospective energy efficiency market activity

Policy developments will continue to be a key driver of market activity in Ireland. The Better Energy Programme is set to gradually evolve into a **Better Energy Financing** (BEF) scheme that can promote a higher level of private sector activity with less government outlay. In November 2012, representatives from the financial community, energy suppliers and the retrofit sector were tasked with designing this national residential retrofit scheme. Proposals are currently under consideration within DCENR, with a number of pilot projects planned for 2014 and 2015.

As for the National Energy Services Framework, Ireland's focus in 2014 is on managing the **exemplar projects** already underway while bringing a further tranche through the development phase. Governance structures will need to be put in place to review and monitor progress against the Action Plan for Jobs commitments and to address any policy issues that arise.³

Challenges

Ireland suffered a major economic downturn after 2007. Because this was in large part due to the bursting of a property bubble, the construction sector was particularly hard hit. With a large abandoned building stock, the construction sector remains somewhat fragile. As the economy returns to growth, there may be a risk that progress in reducing energy intensity could slow down.

Uptake of the various residential sector grant programmes is an ongoing challenge that demands vigilance.⁴ A further consideration is the significant potential for rebound with schemes such as the Better Energy Warmer Homes scheme that retrofit low-income households.

³ Further detail on the National Energy Services Framework is available at www.seai.ie/Your_Business/National_Energy_Services_Framework.

⁴ Climatic conditions may play a role. Particularly cold winters are often followed by increased uptake of retrofit measures the following spring. SEAI ran an extensive winter advertising campaign that promoted the availability of grants in 2013 and a further marketing exercise is underway in 2014 to maximise uptake across all the schemes.

Conclusions

Even as the economy begins a modest recovery, energy demand in Ireland continues to decline, thanks in part to energy efficiency gains across all sectors. A holistic policy framework has been put in place, and Ireland is well placed to reap employment, economic activity and other benefits of greater efficiency. The market size of energy efficiency-related construction in Ireland over the period to 2020 is estimated at between EUR 1 billion and EUR 1.2 billion per year on average (SEAI, 2014), and Irish companies are well positioned to capture new business as a result of this investment. Ireland's very high level of fuel import dependency makes energy efficiency a particularly high priority.

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11. ITALY

In line with European Union (EU) directives, and in support of its National Energy Efficiency Action Plan (NEEAP), Italy has been steadily expanding its range of public energy efficiency programmes that have, along with some of the highest electricity prices in Europe, leveraged private investments and grown the energy efficiency market.

For example, the first phase of the Italian White Certificate Scheme (2005 to 2012) cost EUR 172 million and led to energy savings of approximately 35 gigawatt hours (GWh) per year. The overall cost of the programme was calculated to be EUR 0.005 for each kilowatt hour (kWh) saved.

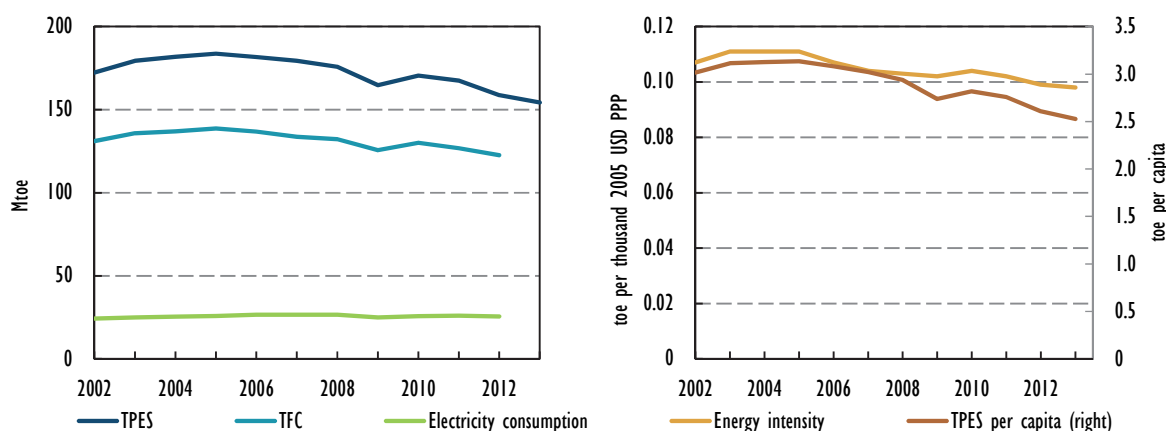
The Energy Efficiency Tax Rebate Programme was also effective at scaling up energy efficiency investments. Between 2007 and 2013, more than 1.8 million applications and EUR 23 billion of investments were made by households, at a cost of about EUR 13 billion in tax rebates.

Italy is looking to further expand the energy efficiency market in order to achieve the targets set out in its 2013 National Energy Strategy (NES). Energy efficiency measures in support of the NES are expected to reach EUR 25 billion in public support and stimulate between EUR 50 billion and EUR 60 billion of aggregate investment by 2020.

Energy profile and context

Italy's total primary energy supply (TPES) decreased by 16% from a peak of 184 million tonnes of oil-equivalent (Mtoe) in 2005 to 154 Mtoe in 2013. Total final consumption (TFC) dropped by 12% from a peak of 139 Mtoe in 2005 to 123 Mtoe in 2012, driven by combined ongoing impacts of the 2008 financial crisis and energy efficiency investments. Italy's energy intensity continues its long-term decline (Figure 11.1).

Figure 11.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13

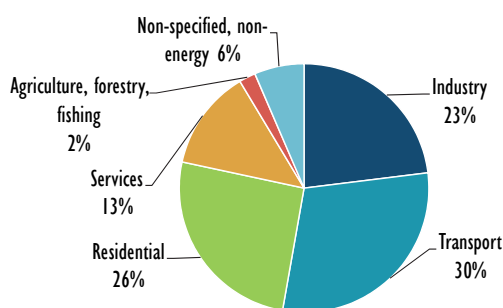


Note: PPP = purchasing power parity; toe = tonne of oil-equivalent.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

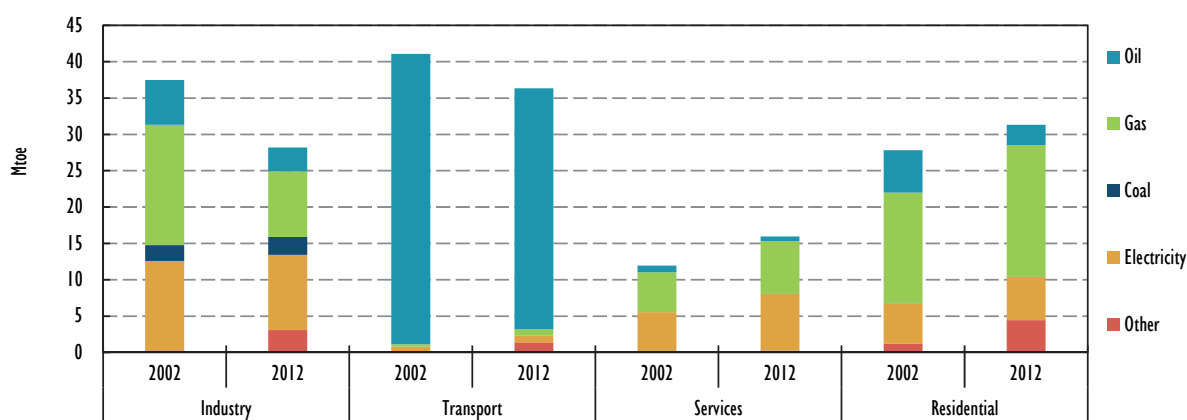
The residential sector accounts for a little over a quarter of Italy's TFC (Figure 11.2), and this share has remained relatively steady over the last decade. In 2012, transport comprised 30% of Italy's final energy consumption, while industry accounted for 23%.

Figure 11.2 TFC by sector, 2012



Since 2002, TFC in transport and industry has declined, as it has in the services sector. Only TFC in the residential sector has increased (Figure 11.3).

Figure 11.3 TFC by sector and by energy source, 2002 and 2012

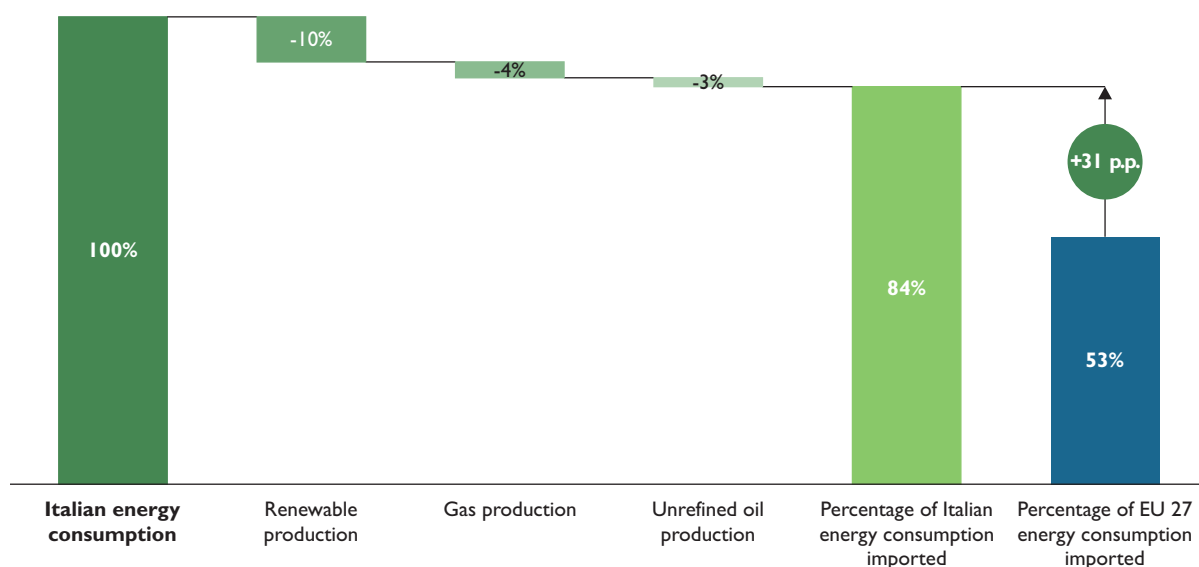


Natural gas dominates the residential sector, comprising 51% of TFC in 2012, on a par with 2002 levels. However, natural gas's share of TFC in industry has declined sharply, reflecting continued impacts of the economic crisis on the sector. By contrast, its use has increased in both the service and transport sectors, leading to continued reliance on natural gas imports (29% of TFC). Italy imports around 84% of its energy (Figure 11.4), which leaves it vulnerable to price shocks.

The average electricity price for households in Italy in the first quarter of 2014 was 35% higher than the OECD Europe average. At EUR 0.235 per kWh, the average cost of electricity for households in Italy is 51% higher than in nuclear power-dominated France (EUR 0.156).

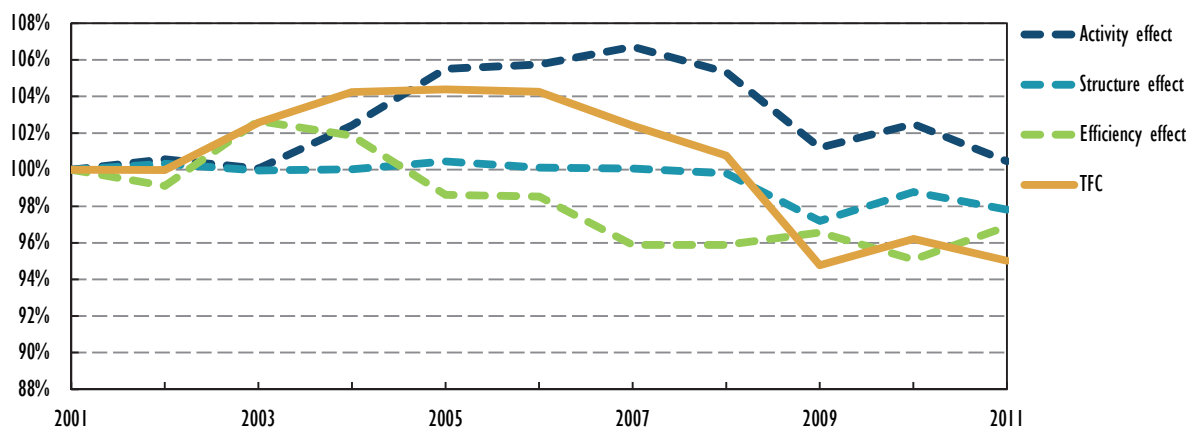
The decomposition of Italian energy consumption shows activity, structure, and efficiency effects were all serving to reduce TFC from 2001 levels (Figure 11.5). Total final consumption peaked in 2006, coinciding with efficiency effects driving reductions. Prior to 2006, efficiency did not have a significant energy-lowering impact on TFC. Since 2006, efficiency has had a larger role in helping to reduce energy consumption. Absolute reductions in energy consumption coincided with declining activity effects, a likely result of the 2008 recession. Activity levels were unchanged from 2001 levels by 2011, but energy consumption is down 5% over the same period, outlining the role that both structural change and efficiency improvements have had in improving Italy's energy intensity.

Figure 11.4 Imports as share of Italian energy consumption



Source: Italian Ministry of Economic Development (2013), *Italian National Energy Strategy: For a More Competitive and Sustainable Energy*, www.sviluppoeconomico.gov.it/images/stories/documenti/SEN_EN_marzo2013.pdf.

Figure 11.5 Decomposition of energy use in Italy



Note: All values are indexed to 2001 levels.

Energy efficiency market activity

Market driver: Energy efficiency policies, programmes and investments

With relatively high energy prices, Italy already has a powerful motivation for the development of energy efficiency markets. The government is expanding the market for energy efficiency with actions taken in support of its NEEAP. Initiatives introduced between 2005 and 2012 are estimated to have facilitated energy demand reductions of around 6.5 Mtoe per year in TFC, approaching the 2016 target of 10.9 Mtoe per year set by the government and worth approximately EUR 3.5 billion in fossil fuel import cost savings.¹ Based on official estimates (Table 11.1), the cost per kWh saved varies

¹ These results were calculated net of the reduction in energy consumption resulting from the economic crisis that has hit the country.

widely and ranges between EUR 0.005 per kWh saved (for measures under the White Certificates Scheme) to 0.083 for tax deductions for insulation and more efficient windows.²

Table 11.1 Italian energy efficiency policies and measures and their cost-effectiveness, 2005-12

Buildings	Cost (EUR million)	Annual cost (EUR million/year)	Life (years)	Achieved saving (GWh/year)	Performance (EUR/kWh)
White certificates	1 723	172	10	34 798	0.005
Deep renovation	296	14.8	20	433	0.034
Insulation of opaque envelope and replacement of windows	5 164	258.2	20	3 107	0.083
55% tax rebate					
Replacement of electric boilers with solar panels	759	37.9	20	1 164	0.033
Efficient heating systems	2 934	244.5	12	3 621	0.068
Multiple selection	769	38.5	20	574	0.067
Incentive for new cars and trucks	1 589	132.4	12	1 315	0.1
Average	x	109.4	16.3	x	0.056

Note: x = not applicable.

Source: ENEA (2014), *Energy Efficiency Annual Report*, ENEA, Rome.

The **White Certificate Scheme** is a trading incentive scheme that requires electricity and natural gas distribution system operators (DSOs) with more than 50 000 customers (“obliged parties”) to achieve yearly energy savings targets. They can do this either by implementing energy efficiency solutions themselves, or by buying certified savings from other (non-obliged) DSOs, energy service companies (ESCOs) and other entities that have an appointed energy manager or an ISO 50001-certified energy management system in place. Only savings achieved above the market average or above legislative requirements are taken in account (baseline).

The **Energy Efficiency Tax Rebate Programme** (55% tax reduction) provides credits to households for comprehensive or single retrofit energy efficiency measures (such as thermal insulation, installation of solar panels, and replacement of heating and air-conditioning systems or comprehensive refurbishments). Tax credits are applied over ten years, beginning with the completion of work. In order to apply for a tax credit, building owners must submit an application that contains a description of the work performed, confirmation documents to prove payment, and performance certificates (online or via post) within 90 days of the work’s completion.

Current energy efficiency market activity

This section focuses on energy efficiency market activity stimulated by the White Certificate Scheme, the Energy Efficiency Tax Rebate Programme, and the scheme known as the Heating and Cooling Account.

White Certificate Scheme

According to Italian government analysis, the White Certificate Scheme put in place in 2005 has been an effective way to expand the market for energy efficiency and achieve energy savings. The first phase of the programme, which ran from 2005 to 2012, cost EUR 172 million a year and led to energy

² A key challenge for any country operating multiple tax rebates, white certificates and grants, is discerning the impacts and overlaps across policies and ensuring free ridership is minimised, while still sending a cost-effective stimulus to the market. This challenge is particularly important when strong energy price signals exist.

savings of approximately 35 GWh per year. The cost of the programme was calculated to be EUR 0.005 for each kWh saved (Table 11.1). The average price of a certificate was EUR 96.53, and over 23 million certificates were issued.

Decree 28/12/2012, which entered into force in January 2013, launched the 2013-16 phase of the White Certificate Scheme. This new phase introduces rewards for large industrial and infrastructure projects capable of generating savings of at least 35 000 toe per year. ENEA, the Italian energy research and development agency, estimates that phase two of the White Certificate Scheme will lead to energy efficiency investments valued at more than EUR 20 billion to 2016, at a cost of EUR 3 billion (ENEA, 2014).

A programme evaluation conducted by ENEA found that the 55% tax deduction is an effective scheme for scaling up energy efficiency investments. Between 2007 and 2013, more than 1.8 million applications were approved, and about EUR 23 billion of investments were leveraged by households, at a cost of about EUR 13 billion in undiscounted foregone tax revenue (ENEA, 2014). In 2012 alone, more than 265 500 energy-efficient projects were implemented, which included 2.3 million square metres (m²) of window replacements and 1.2 million m² of rehabilitated solid surfaces. These measures led to primary energy savings of 1 260 GWh per year and 270 thousand tonnes per year of carbon dioxide (kt CO₂) avoided.

Of all the energy efficient tax deduction measures (apart from replacement of electric boilers with solar panels), the most cost-effective was found to be comprehensive renovation (e.g. implementation of a package of several measures including the building shell and the heating system).

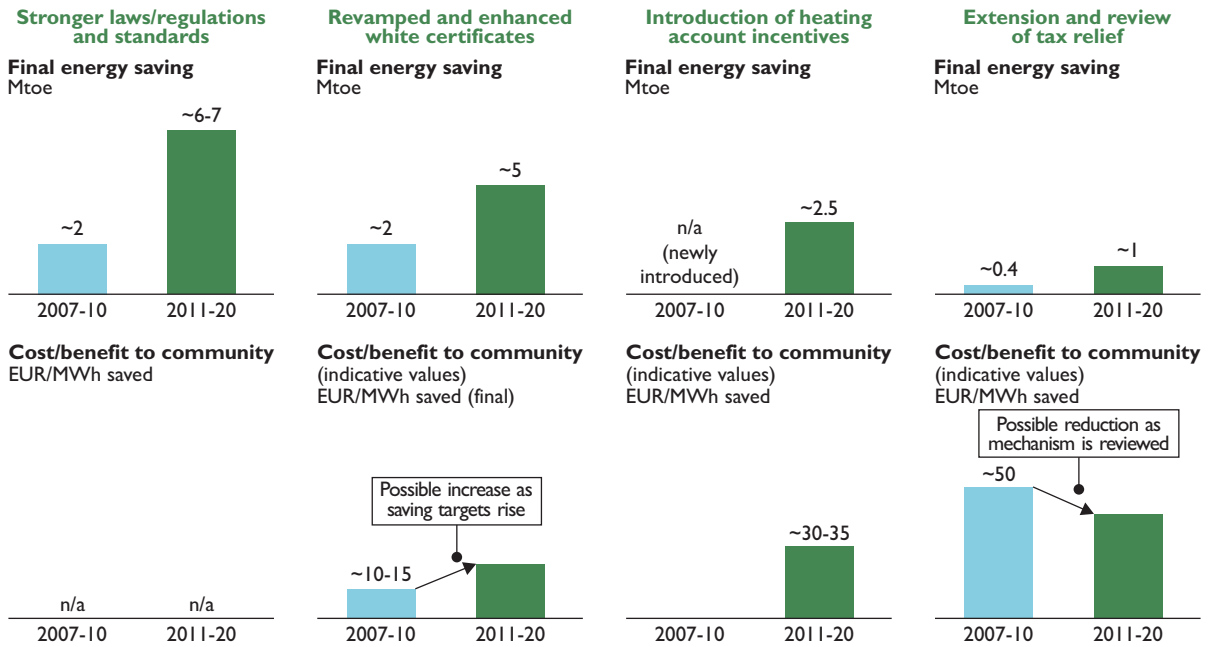
In 2013, through Law Decree 90/2013, Italy increased the tax rebate from 55% to 65% for investments made between June 2013 and December 2014. According to the 2014 NEEAP, between 2014 and 2020, the tax rebate is expected to stimulate total private investment of about EUR 20 billion, resulting in about 0.9 Mtoe per year of final energy savings.

Renewable Energy for Heating and Cooling Support Scheme (Heating and Cooling Account)

The Ministerial Decree of 28 December 2012 provides incentives of up to EUR 200 million per year for small-scale energy efficiency projects and production of thermal energy from renewables. Gestore dei Servizi Energetici-GSE S.P.A. is the body in charge of awarding incentives, implementing and managing the scheme. Public administrations and private individuals are eligible to receive incentives that can, among other things, go towards energy efficiency improvements in existing building envelopes (thermal insulation of walls, roofs and floors, replacement of doors, windows and shutters, installation of solar screens); replacement of existing systems for winter heating with more efficient ones (condensing boilers); and audits and energy certification associated with these projects. The scheme is expected to lead to EUR 5 billion in energy efficiency investments between now and 2020. The private sector will receive incentives of up to EUR 700 million per year, and may use ESCOs to implement measures, putting in place contracts for third-party financing.

Incentives paid in yearly instalments are intended to support part of investment costs (up to 40%) for a period ranging from two to five years, depending on the type of intervention realised (Italian Ministry of Economic Development, 2013).

Figure 11.6 Principal instruments and achieved/expected energy savings



Note: MWh = megawatt hour; n/a = not applicable.

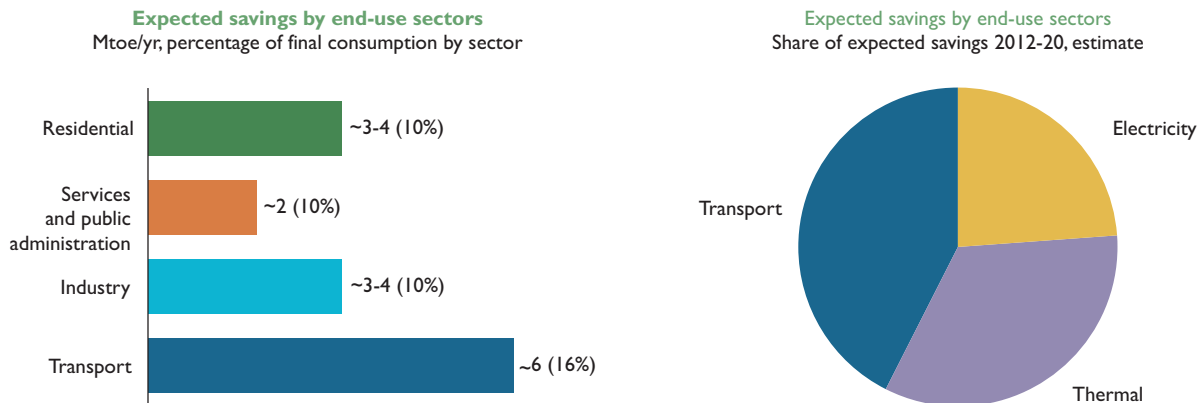
Source: Italian Ministry of Economic Development (2013), *Italian National Energy Strategy: For a More Competitive and Sustainable Energy*, www.sviluppoeconomico.gov.it/images/stories/documenti/SEN_EN_marzo2013.pdf.

Prospective energy efficiency market activity

In support of its 2013 NES and through the National Energy Efficiency Action Plan of 2014, Italy is rolling out further energy efficiency measures that seek to:

- save 20 Mtoe of primary energy a year, and 15.5 Mtoe of final energy, so that by 2020 Italy will reduce its TFC from 209 Mtoe to 158 Mtoe, about 24% less than in a reference scenario
- prevent the emission of about 55 million tonnes of CO₂ (MtCO₂) annually, making energy efficiency the main driver in lowering national CO₂ emissions
- save an estimated EUR 9 billion on national electricity and gas bills.

Figure 11.7 Expected savings by end-use sector



Source: Italian Ministry of Economic Development (2013), *Italian National Energy Strategy: For a More Competitive and Sustainable Energy*, www.sviluppoeconomico.gov.it/images/stories/documenti/SEN_EN_marzo2013.pdf.

The results expected from the energy efficiency measures are significant (Figure 11.7). Importantly, the new initiatives target industry and transport (which account for over 60% of the expected energy demand reductions). Moreover, consistent with the principles of the European Union Energy Efficiency Directive (EU EED), the public sector will be a role model for energy savings, with an efficiency improvement target of at least 20% by 2020.

Taken as a whole, these measures are estimated to reach EUR 25 billion (including the amounts already committed) in public sector funding by 2020. This could stimulate between EUR 50 billion and EUR 60 billion in aggregate investment, particularly in the industrial sector (Italian Ministry of Economic Development, 2013).

Challenges

While Italy's programmes have been comprehensive and impressive in their uptake, incentive programmes with large rebates or grants can prove costly for governments as their appeal increases. This is particularly likely as high energy prices in Italy will continue to be an effective incentive for efficiency improvements. A challenge will be to provide sufficient government fiscal support for efficiency to build and maintain a robust energy efficiency industry that can gradually sustain itself. This would allow for phasing out of direct government spending towards a viable self-sustaining market while continuing to improve energy efficiency outcomes.

Globally, very few national government initiatives, beyond EU requirements, are being planned or implemented to expand the transport energy efficiency market. The transport sector in Italy accounts for 30% of TFC and demands increased attention as oil is imported. Potential policies to enhance the transport efficiency market are diverse, and could include road tolls and congestion charging, scaled-up investments in public infrastructure and tax incentives to encourage the purchase of more efficient vehicles and technologies.

Conclusions

Developing an effective policy mix that limits free riders while stimulating market transformation requires careful analysis and dynamic policy implementation. The Italian energy efficiency market will continue to grow as the government puts in place the energy efficiency activities described in this chapter, as well as a range of enabling measures.

Enabling measures that the government has committed to include enhancing the ESCO model by introducing classification criteria; developing and disseminating innovative contract models for financing via third parties; and setting up dedicated guarantee funds or special revolving funds for larger projects, with possible participation of public financial institutions. The government also plans to step up inspection procedures and introduce heavier penalties to ensure compliance with the regulatory provisions and standards. Improving energy efficiency awareness has been identified as an important area for action, and the government is launching an extensive communication campaign in close collaboration with regional governments and business associations. Finally, promoting energy audits for the service and industrial sectors (particularly for small and medium-sized enterprises) and introducing energy efficiency training courses to strengthen the collaboration between ENEA and companies will likely go a long way towards expanding the energy efficiency market in Italy in the years to come.

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12. JAPAN

Japan imported 100.3% of its total primary energy supply (TPES) in 2013, a jump from 85.7% in 2010. By comparison, energy imports as a share of TPES for member countries of the International Energy Agency (IEA) as a whole were 59.3% in 2012. In the aftermath of the March 2011 natural disasters, Japan has been prioritising energy efficiency even more than before, having already been a front-runner since the 1970s.

The *Energy Efficiency Market Report 2013* included a chapter on Japan that touched upon a variety of energy efficiency policies and market activity with focus primarily on the Top Runner programme. This year, the market report focuses on the rapidly developing market for light-emitting diode (LED) lamps.

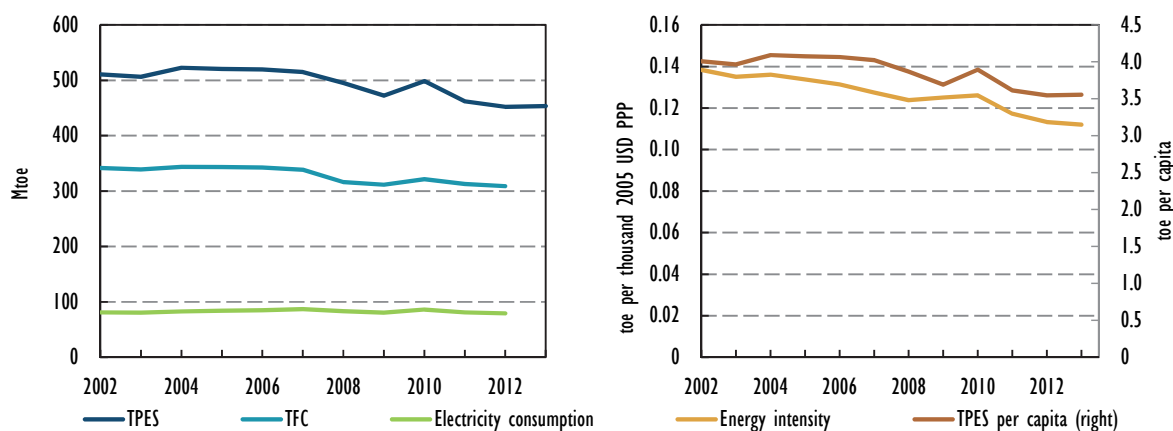
The market for energy-efficient lighting in particular has grown at a remarkable rate, largely driven by government policy. Sales of LED lamps have shot up to over 30% of all bulbs sold in Japan in 2013; LEDs comprise 8% of the Japanese lighting fixtures market, worth USD 5.18 billion per year.

* TPES takes into account production, imports and exports, international marine and aviation and bunkers, and stock changes – thus explaining how imports could be more than 100%.

Energy profile and context

TPES was 453 million tonnes of oil-equivalent (Mtoe) in 2013. Total final consumption (TFC) was 309 Mtoe in 2012. Both have been decreasing since 2004 (Figure 12.1). Japan's energy supply remains dominated by fossil fuels, notably oil (45%), followed by coal and natural gas, which together made up another 50% of TPES in 2013. In that year, Japan's energy production amounted to 27.2 Mtoe (down from 99.3 Mtoe in 2010), while net imports were at 437 Mtoe.

Figure 12.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13



Note: PPP = purchasing power parity; toe = tonnes of oil-equivalent.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

Industry and transport together account for just over half of Japan's TFC (Figure 12.2). Energy consumption in both sectors has decreased since ten years ago, by approximately 12% for industry and 14% for transport. Meanwhile, energy use in the service and residential sectors has decreased by only 4% and 5% respectively (Figure 12.3).

Figure 12.2 TFC by sector, 2012

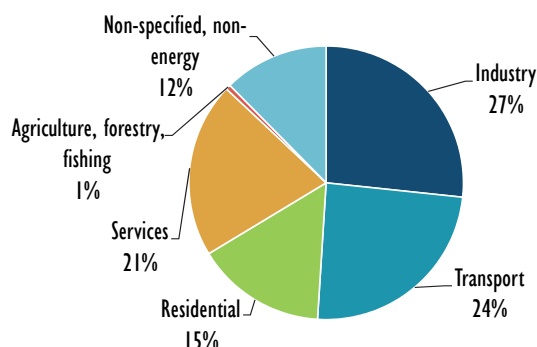
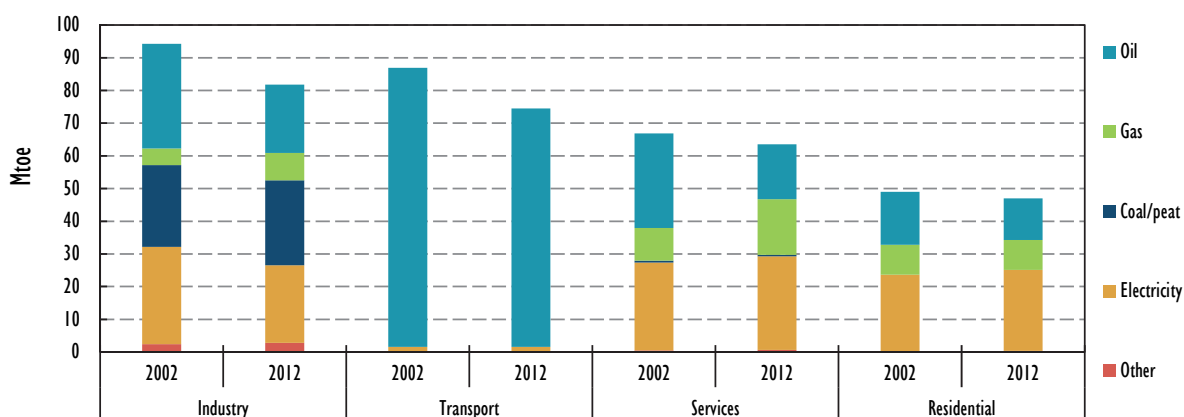


Figure 12.3 TFC by sector and by energy source, 2002 and 2012



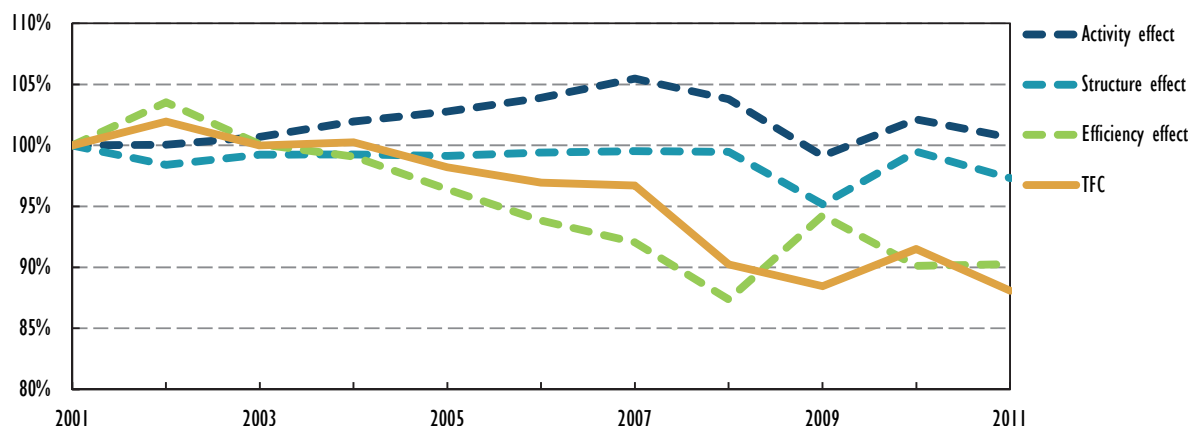
Between 1987 and 2011, nuclear generation accounted for an average of 30% of Japan's total electricity. As a result of the nuclear outages post-March 2011, the share of nuclear fell to 1% while the share of fossil fuels rose to 86%, with 8% from hydro and the rest from other renewables. Japan's total electricity output in 2013 was 1 052 terawatt hours (TWh).

Japan's use of fossil fuels for electricity generation was up by 17% in 2011 compared to 2010. Consumption of natural gas to produce electricity was up by 25% that year. Japan's use of fossil-fuelled generation rose by 21% in 2012, compared to 2011.

By the end of 2013, fuel import cost increases resulted in an estimated USD 30 billion in losses from Japan's top ten utility companies (USEIA, 2013). Japan's total spending on fuel imports in 2012 was USD 250 billion, accounting for about 33% of total imports (USEIA, 2013). The high share of imported oil and growing reliance on gas imports in Japan's energy supply mix makes it particularly vulnerable to increases in the prices of those fuels.

Energy efficiency has played an ongoing role in reducing energy demand in Japan. During the period of economic growth between 2001 and 2007, energy efficiency increased by over 4% and helped reduce TFC by 3%. Subsequent losses in efficiency were reported during the recession when output shrank. This was mitigated by a swing in the activity effect, highlighting the importance of total economic output to energy consumption (Figure 12.4).

Figure 12.4 Decomposition of energy demand in Japan



Energy efficiency market activity

To increase the country's energy security, Japanese policy has emphasised energy conservation and efficiency and lower dependency on oil imports. Energy efficiency programmes and high levels of investment in research and development (R&D) since the 1970s have substantially increased energy efficiency. Despite already having one of the lowest energy intensities of IEA member countries, energy efficiency measures are being scaled up in the aftermath of the March 2011 earthquake and tsunami. A key characteristic of Japanese energy efficiency policy is that it is closely linked to technology development and deployment on domestic and export markets.

Japan's approach to promoting the development of energy-efficient technologies and market uptake can be illustrated by the case of LED lighting. Japan has systematically promoted LED lighting technology development over a number of decades and accelerated the development of the market for LED lighting.

Market supply: Potential for energy savings

Lighting accounts for approximately 16% of Japan's electricity consumption. If all lighting in Japan were switched to LEDs,¹ Japan's electricity consumption could be reduced by 92.2 TWh per year, or 9% of electricity demand. This corresponds to the electricity produced by 13 nuclear power plants or 88 gigawatts of photovoltaic power (Suehiro and Shibata, 2011).

The total number of lamps² used in Japan in 2011 was 1.6 billion, of which 0.87 billion were in the residential sector, 0.58 billion in the public and commercial sector, and 0.16 billion in the industrial sector. Fluorescent lamps were the most common technology, accounting for 64% of the market, followed by incandescent lamps (20%) and compact fluorescent lamps (CFLs) (13%) (Suehiro and Shibata, 2011).

The largest energy savings potentials in the area of lighting are in the commercial and public sector, where annual savings of around 54.5 TWh could be achieved by replacing existing lighting with LED lighting.

The greatest savings could be achieved by switching straight tube fluorescent lamps to LED equivalents, while switching incandescent lamps to LED equivalents offers the shortest payback period (one year and five months) (Table 12.3).

¹ Based on 2010 lighting electricity consumption and 2010 LED penetration.

² Lamp is the term used to refer to the complete light source package, including the inner parts as well as the outer bulb or tube.

Table 12.1 Number of lamps used in Japan by technology, sector and related electricity consumption (billion), 2011

	Residential	Public and commercial	Industry	Total
Fluorescent lamps	0.46	0.42	0.15	1.03
CFLs	0.15	0.06	x	0.21
Incandescent lamps	0.25	0.08	x	0.34
High-intensity discharge lamps	x	0.01	0.01	0.02
Total	0.87	0.58	0.16	1.6
Electricity consumption (TWh)	38.2	89.1	23.3	150

Notes: x = not applicable. LED lighting was excluded from this overview because of its low energy consumption and limited market share at that time.

Source: Suehiro, S. and Y. Shibata (2011), "Electricity saving potential and cost and benefit of LED lighting in Japan", *IEEJ Energy Journal*, Vol. 6, No. 3, Institute of Energy Economics, Japan.

Table 12.2 Electricity savings potential in the lighting sector

	Number of lamps (billion)	Annual electricity consumption (TWh)	Annual electricity consumption if only LEDs were used (TWh)	Annual savings (TWh)
Residential	0.87	38.2	14.1	24.1
Public and commercial	0.58	89.1	34.6	54.5
Industry	0.16	23.3	58.4	13.6
Total	1.6	150.6	107.1	92.2

Source: Suehiro, S. and Y. Shibata (2011), "Electricity saving potential and cost and benefit of LED lighting in Japan", *IEEJ Energy Journal*, Vol. 6, No. 3, Institute of Energy Economics, Japan.

Table 12.3 Cost and payback periods for replacing different lamp types with LED lamps

	Total number of lamps (million)	Price per replacement LED lamp (USD)*	Total initial cost (USD billion)	Payback period (months)	Electricity savings (TWh/year)
Incandescent lamps	340	19-29	8.1	17	27.3
Fluorescent lamps (straight tube)	690	96-240	92.4	119	49.7
Fluorescent lamps (circular)	350	67-144	33.2	222	6.8
High-intensity discharge lamps	20	962	16.9	131	8.4
CFLs	210	x	x	x	x
Total excluding CFLs	1 400	x	150.6	x	92.2

Notes: x = not applicable. JPY/USD exchange rate used is 104.

* Replacement costs include possible infrastructure and labour costs required to make the changes; replacement of CFLs by LED lamps is excluded, as electricity savings are marginal.

Source: Suehiro, S. and Y. Shibata (2011), "Electricity saving potential and cost and benefit of LED lighting in Japan", *IEEJ Energy Journal*, Vol. 6, No. 3, Institute of Energy Economics, Japan.

Market driver: Energy efficiency policies and programmes

Several interconnected factors have been driving the LED lamp market in Japan. In 1998, the Japanese government provided strong support to LED research through its project "21st Century Light Plan". From 1998 to 2002, the Japanese government invested USD 48 million in the development of white LED lighting and new semiconductor materials.

To stimulate market demand for LED lighting, in December 2005 Japan introduced a tax instrument for businesses and organisations that replaced incandescent lighting with LED lighting – either a faster depreciation rate for investments or a 7% tax rate reduction. In 2008, the government asked manufacturers to stop producing incandescent bulbs by 2012.

Japan's Eco-Point Program quickly contributed to increasing the market share for LED lamps and boosting Japan's LED manufacturing sector. In April 2009, Japan announced a large economic stimulus package that included the USD 10.9 billion Eco-Point Program to encourage consumer purchases of energy-efficient products. In December 2009, the government added LED lamps to the list of redeemable products. From April 2010 onward, consumers were allowed to exchange their eco-points³ for LED lamps at twice their value. The LED component of the programme demonstrated that significant energy savings and rapid market transformation could be achieved by significantly lowering the initial cost of products in a way that appealed to the public's values. In May 2011, a total of 450 000 consumer applications had been processed to redeem eco-points for LED lamps (batteries were also included in this category), worth a total of USD 46 million.

From 2012, LED lighting has also been included in the Top Runner programme. In the summer of 2012, the Japanese government encouraged major electronics retailers and home appliance makers to voluntarily halt production and sales of incandescent bulbs. Japan has announced a target of 100% energy-efficient lighting sales by 2020, and by 2030 Japan intends its entire stock to be composed of energy-efficient lighting.

While government policies have accelerated the adoption of energy-efficient lighting, businesses played an important role in spurring the LED market towards rapid expansion. Japan has the world's most complete value chain for the production of LED products. The country has several major LED manufacturers, and Japanese companies are active at all stages of the value stream – providing such essential materials as phosphor, silicon lenses and sapphire ingots. Japanese firms also control many of the key patents and production techniques in the LED supply chain. This competitive industrial structure also allowed Japanese firms to take advantage of rapid technological advancements, which has opened up new market segments.

Market activity

The demand for power-saving lighting devices has increased at a rapid rate in Japan. In 2007, LED lighting accounted for less than 1% of the Japanese general-purpose lighting market. The share of LED lighting doubled by 2008 and reached 5% in 2009. In 2010, the share again doubled to more than 10% and reached 25% in 2011. By 2012 the share of LED lighting exceeded 40%.

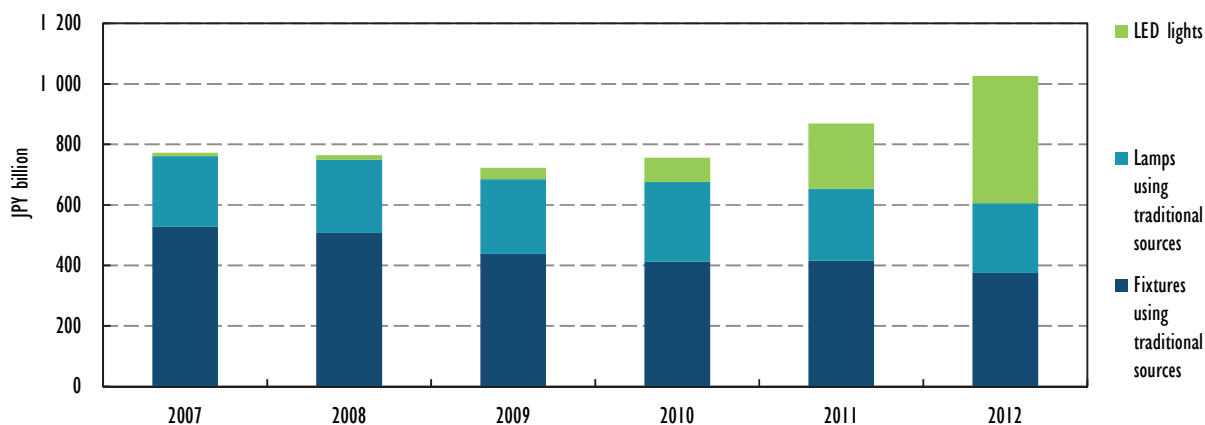
The Eco-Point programme resulted in a shift towards LED lamps and additional cost reductions due to economies of scale. Between December 2009 (when LEDs were included in Eco-Point) and June 2010, consumer sales of LED lamps surged to 19% of total light-bulb sales by volume and 60% by total value. At the same time, the average cost of LED lamps fell by about 25% (Jessup, 2011).

Sales of LED luminaires⁴ increased by 308% in 2010 compared to 2009. In 2011, sales increased by a further 268%, and in 2012 by 185% (JLA and JELMA, 2012). Sales of LEDs accounted for over 30% of all Japanese bulbs sold in 2013 (The Economist, 2013), reaching a value of USD 5.18 billion (Yanagi, 2013).

³ "Eco-points" equal one point for every JPY 1 spent and are given to people that build green homes or undertake energy-efficient re-modelling. Although each eco-point is equivalent to JPY 1, it cannot be redeemed for cash and must be exchanged for eco-friendly products or gift certificates or used for additional renovations. These points can also be exchanged for eco-friendly gift vouchers and public transport passes, and can be used for donations to environmental organisations.

⁴ A luminaire is a complete lighting unit consisting of a lamp (or lamps), ballast (or ballasts) and the parts designed to distribute the light, position and protect the lamps and connect them to the power supply. A luminaire is often referred to as a fixture.

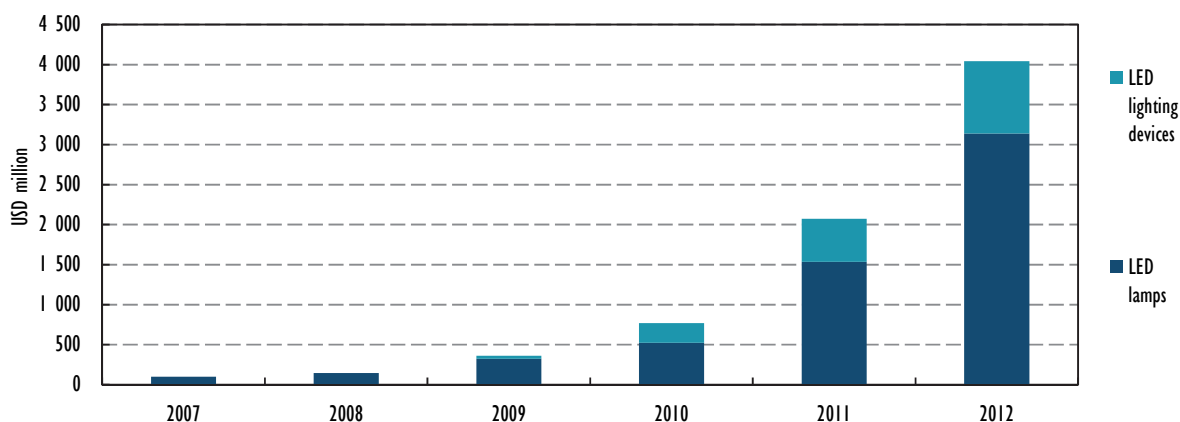
Figure 12.5 Lighting fixtures market in Japan, 2007-12



Notes: based on shipment values supplied by manufacturers. Includes incandescent, fluorescent, high-pressure discharge lamps and LEDs in buildings and on streets for general lighting purposes. Does not include vehicle lights or industrial and machinery lights.

Source: Yano Research Institute (2013), *Lighting Fixtures Market in Japan: Key Research Findings 2013*, Yano Research Institute, Tokyo.

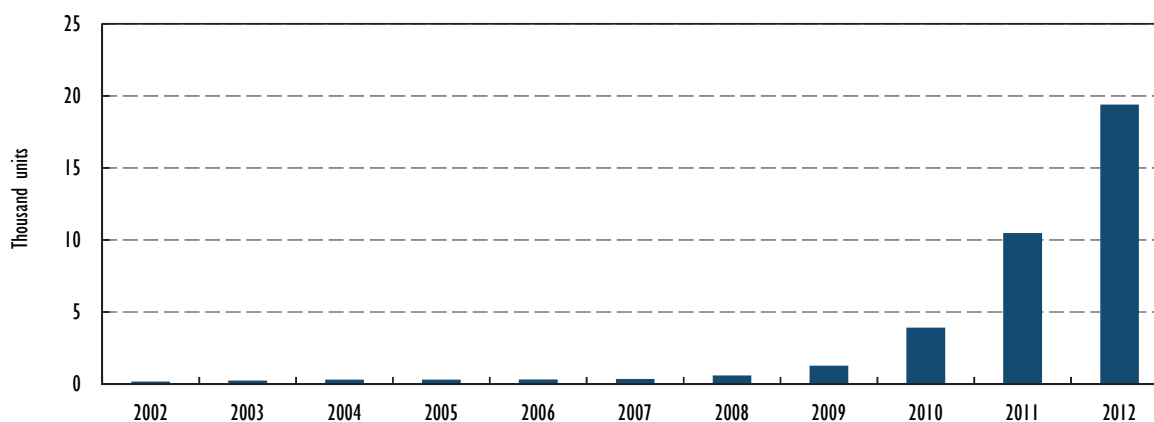
Figure 12.6 Size of LED lighting fixtures market



Notes: based on shipment values supplied by manufacturers. Includes general-purpose LED lamps and lighting devices used in buildings and streets.

Source: Yano Research Institute (2013), *Lighting Fixtures Market in Japan: Key Research Findings 2013*, Yano Research Institute, Tokyo.

Figure 12.7 Quantity of LED luminaires sold



Source: JLA and JELMA (2012), "Recent Topic in Japan", presentation 9 October 2012.

Prospects for efficient lighting

A steady decline in average selling price, owing to shrinking manufacturing costs, will play an important role in future market penetration and growth of LED lighting. LED chip prices are falling steadily, resulting in close to 30% annual reductions in LED bulb pricing. Demand for all LED lighting types, including LED spotlights, streetlights, luminaires, residential use light bulbs, and LED replacements for fluorescent tubes, is set to increase in the next few years. Penetration of LED lighting is expected to be fastest in the outdoor and commercial lighting segments.

Prospects in other areas

In the near future, rapid growth is expected in other Japanese energy efficiency markets beyond LED lighting. Energy efficiency plays a key role in the new Japanese energy strategy. The draft of Japan's new Basic Energy Plan, made public in February 2014 and adopted in April, outlines a series of ambitious targets and more stringent policy measures. These include continued expansion of the Top Runner programme (in 2013 building components were added and electrical motors will be added effective 2015), strengthening of buildings energy auditing, certification and labelling of buildings, successively more stringent energy performance requirements for new buildings and scaled-up efforts to improve the efficiency of the existing building stock. Plans are underway to develop 40 000 public net zero-energy buildings. By 2020 it is planned that all new public buildings will be zero-energy buildings, a requirement that is to be expanded to all new buildings by 2030. Transport energy efficiency will be improved through infrastructure development and planning to optimise traffic flow, including implementation of intelligent transport systems (ITS), modal shift and voluntary initiatives to optimise freight transport.

It is expected that energy efficiency markets relating to building components, technologies and services for low-energy buildings will grow rapidly over the coming years in Japan. Ambitious vehicle targets coupled with the strategic “Next-Generation Vehicle and Fuel Initiative”, which brings together the automotive industry, oil industry and the Ministry of Economy, Trade and Industry, will result in technologies and markets for more efficient vehicles and increased investment in the development of energy-efficient transport infrastructure. The government aims for 70% of light-duty vehicle sales to be “next generation” vehicles by 2020.

In the industrial sector, Japan’s energy service company (ESCO) market had revenues of USD 374 million in 2011 (Murakoshi, 2013), but has not achieved its full potential. Measures to stimulate the ESCO market could include ensuring access to longer-term debt financing for energy efficiency projects. Another area that could warrant additional attention is electric motors. In the industrial sector, polyphase motor-driven equipment consumes about 360 TWh, accounting for about 75% of the total electricity used by industry. While the Top Runner programme will have an impact on certain types of new motors (6.8 million new motors are shipped annually), there is an existing stock of approximately 100 million motors (Chun Chun, 2013). Some of these have lifetimes of up to 40 years, so substantial improvements would require additional efforts such as dedicated motor replacement programmes.

Challenges

The post-Fukushima *Setsuden* (energy saving) strategy, which aimed to encourage people and companies to save energy, has led to increased and sustained consumer interest in energy efficiency and demand for energy-efficient products. While a notable rebound has not yet occurred, international experience indicates that energy-efficient behaviour and demand for energy efficiency tends to reduce when urgent

energy supply constraints are resolved (IEA, 2011). Possible reduced pressure on society and businesses to conserve energy in light of mitigated energy supply constraints, as some of the nuclear reactors are restarted in 2015, may have a negative impact on the development of energy efficiency markets.

Meanwhile in some areas, Japan may be facing the challenge of diminishing returns where incremental improvements in energy efficiency will be more expensive or impractical compared to other countries. However, clear energy efficiency market opportunities exist, not least in the area of developing new technologies and solutions.

Conclusions

Government policies aimed at phasing out inefficient lighting technologies are a strong growth driver for LED adoption; however, high initial costs are still a barrier for LED uptake. The systematic approach taken by the Japanese government shows that market development can be accelerated by measures aimed at reducing the initial investment required from consumers, particularly when coupled with consumer awareness campaigns and the provision of guidance and information. The approach of the government, coupling support to research and market development, has effectively created the preconditions needed to achieve a rapid deployment of efficient technologies.

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13. KOREA

Korea has laid out an ambitious policy framework to improve energy efficiency, in light of its strong growth in energy consumption and limited domestic energy resources. Korean policy is sending signals across all major energy-using sectors, and advanced information and communications technology (ICT) is an essential part of its strategy to achieve energy efficiency.

According to the recently released *Korea Energy Master Plan Outlook and Policies to 2035*, the Korean government will implement measures to promote the market for smart appliances, energy storage and energy management systems (EMS) using cutting-edge ICT.

The IEA *Energy Efficiency Market Report 2013 (EEMR 2013)* highlighted several measures to scale up energy efficiency in Korea, including those to promote markets for smart appliances. This year's *EEMR* focuses on measures to develop the market for EMS, particularly using ICT, in Korean industry and buildings.

Energy profile and context

Korea is the world's eighth-largest energy-consuming economy and the ninth-largest oil-consuming nation. In 2012, energy expenditure in Korea amounted to USD 184.8 billion, comprising mainly crude oil (USD 108.3 billion), liquefied natural gas (LNG) (USD 27.4 billion) and coal (USD 16.0 billion). Energy accounted for 36% of total Korean imports in 2012. It is expected that energy will continue to account for a large proportion of imports as Korea strives for increased economic growth, as laid out in its three-year Economic Innovation Plan released in February 2014.

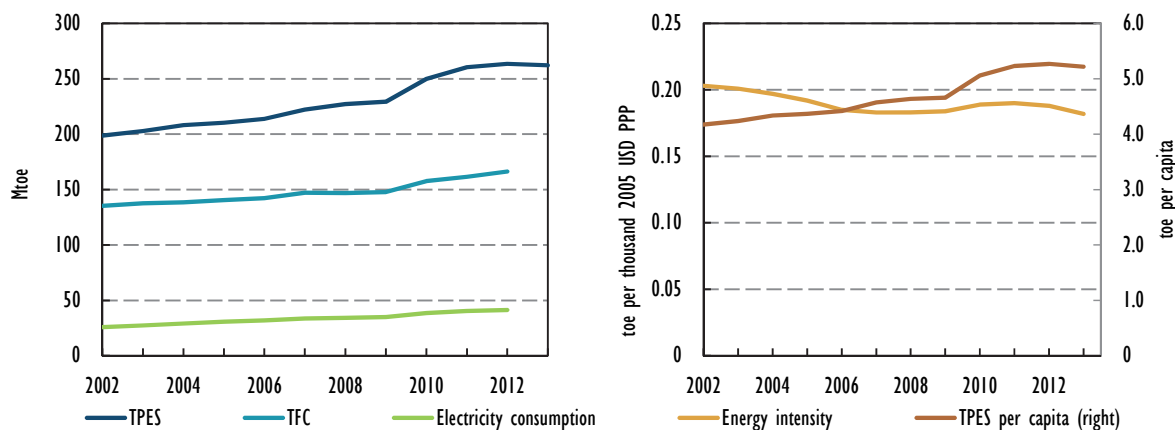
Korea's total final consumption of energy (TFC) increased by 23% between 2002 and 2012 and was the fastest-growing TFC among IEA member countries (Figure 13.1). TFC in the residential sector increased by 15% and industrial TFC increased by 21% between 2002 and 2012. Korea is one of the least energy self-sufficient IEA member countries, producing only 17% of its required energy.

Heavy, energy-intensive industries have played a large role in Korea's rapid economic growth. Industry accounted for 29% of Korea's TFC in 2012 (Figure 13.2), which is higher than in most IEA member countries, e.g. Japan (26%) and the United States (17%).

The buildings sector accounts for a smaller share of TFC in Korea, but it is a sector with high energy savings potential. Energy consumption for air conditioning and heating has increased rapidly since 2007 and accounts for 60% of energy consumption in buildings. Electricity is the major energy source for cooling systems (KEMCO, 2014).

TFC for transport has not materially increased since 2002. This is likely to be the result of transport fuel prices in Korea: gasoline prices are higher in Korea than in any other IEA member country. Both passenger and freight sectors appear to be responding to high prices with reduced transport activity. The average efficiency of new vehicles sold in Korea improved by 10% between 2005 and 2011. Tested efficiency of new Korean passenger light-duty vehicles was, on average, 6.9 litres of gasoline equivalent (lge) per 100 kilometres (km) in 2011, compared with the OECD average of 7.0 lge/100 km and the European Union (EU) average of 5.9 lge/100 km (GFEI, 2014).

Figure 13.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13



Note: Mtoe = million tonnes of oil-equivalent; PPP = purchasing power parity; TPES = total primary energy supply.

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

Figure 13.2 TFC by sector, 2012

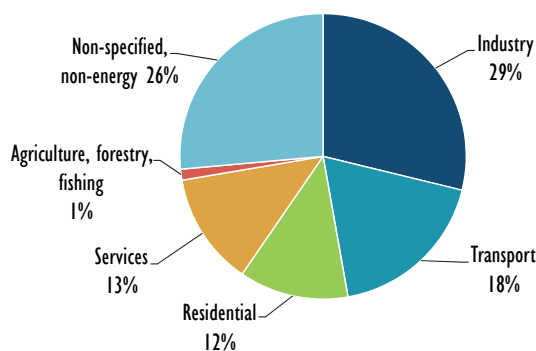
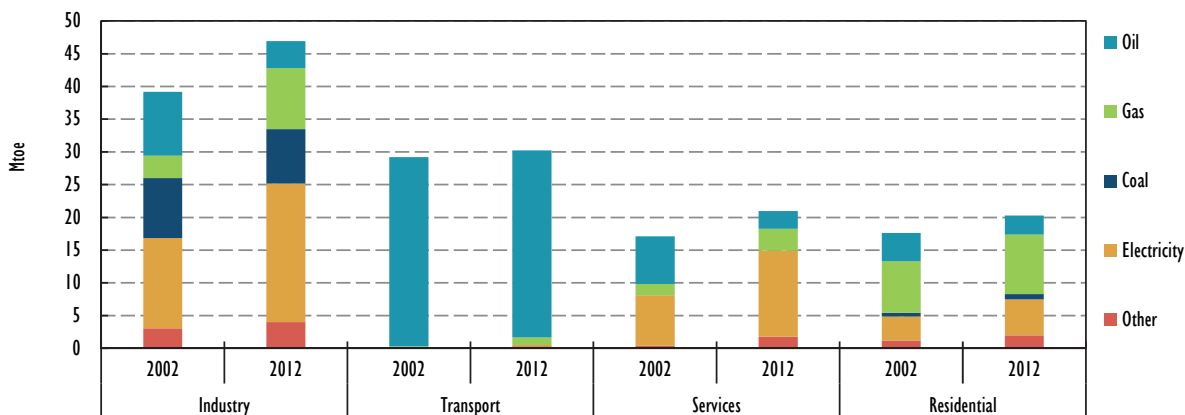


Figure 13.3 TFC by sector and by energy source, 2002 and 2012



Energy efficiency market activity

Market supply: Potential for avoided energy use

Korea announced its Energy Master Plan in mid-January 2014. This energy policy framework covers the period from 2014 to 2035. According to the plan, TFC is projected to increase by 0.9% per year to 2035 (Table 13.1). Among secondary energy sources, electricity will increase most rapidly, by 2.5% per year and by 80% in 2035 compared to 2011.

Table 13.1 Demand projection of TFC, 2011 to 2035 (Mtoe)

	Electricity	Oil	Coal	Gas	Thermal	Renewables	Total
2011	39.1	102.0	33.5	23.7	1.7	5.8	205.9
(share)	(19.0%)	(49.5%)	(16.3%)	(11.5%)	(0.8%)	(2.8%)	(100%)
2035	70.2	99.3	38.6	35.3	3.3	7.4	254.1
(share)	(27.6%)	(39.1%)	(15.2%)	(13.9%)	(1.3%)	(2.9%)	(100%)

Source: MOTIE (2014a), "The 2nd Energy Master Plan", press release, Ministry of Trade, Industry and Energy, Seoul.

The Energy Master Plan features a shift in energy policy from conventional "supply control" to a focus on demand-side measures. Korea aims to improve energy intensity by 30% by 2030 (from 2011 levels), i.e. an annual intensity improvement of 1.4%. Korea is also seeking to reduce TFC by 13% in 2035 from 2011 levels. Energy consumption in industry should decrease by 6.3%, the largest reduction of any sector, followed by transport (4.8%) and buildings, appliances and lighting (2.2%).

Market driver: Energy efficiency policies and programmes

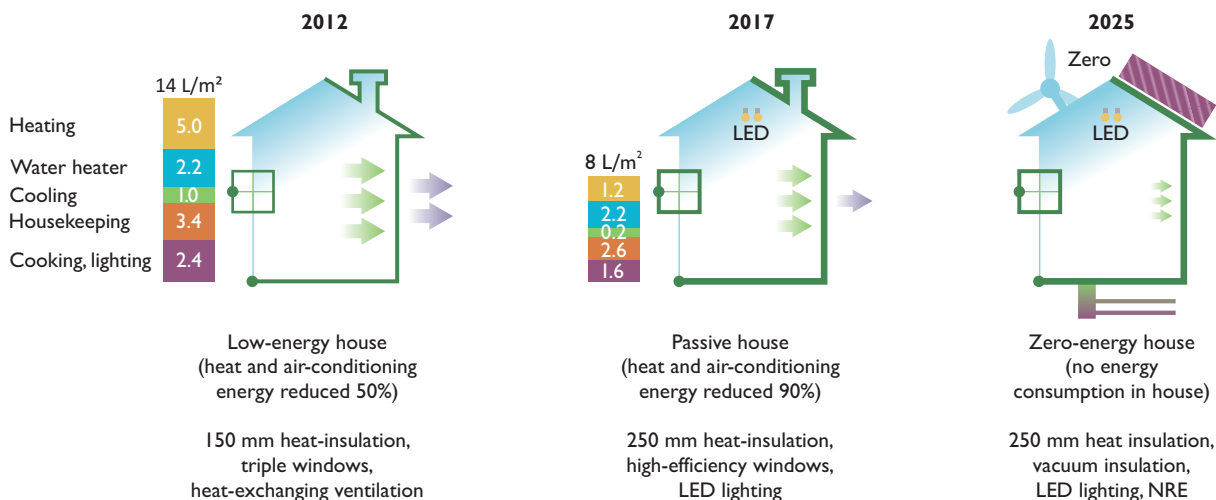
In support of the objectives and targets outlined in the Energy Master Plan, Korea's Ministry of Trade, Industry and Energy (MOTIE) announced the "Plan for Demand-Side Energy Management Based on ICT to Create a New Market". The action plan includes the development of energy storage systems, EMS and smart appliances. EMS activities are described in more detail in the next section.

In addition to EMS activities, the Korean government has developed and implemented diverse energy efficiency measures to exploit energy savings potential in the industrial sector. The representative energy efficiency programmes that Korea is implementing include the following:

- **Compulsory energy auditing.** Companies that consume more than 2 000 tonnes of oil-equivalent (toe) annually should undergo energy audits every five years in compliance with the Energy Use Rationalisation Act.
- **Reporting annual energy consumption.** Companies that consume more than 2 000 toe annually should report energy consumption, energy savings performance and energy efficiency improvements to facilities and production of high-efficiency products.
- **Consultation for energy use plan.** A private or public superintendent of a project that plans to set up a new business or a facility over a certain size is obliged to establish and implement an energy use plan and consult with MOTIE.
- **Large company/small and medium-sized enterprise (SME) partnership.** The Korean Energy Management Corporation (KEMCO) arranges partnerships between large companies and SMEs to exchange technical energy efficiency advice.
- **Financial support for SME energy audits.** The government provides grants up to USD 1.8 million annually for SME energy audits.
- **Energy supporter programme.** The government provides energy managers for SMEs that use between 500 toe and 2 000 toe annually.

In the buildings sector, the Korean government has reinforced energy efficiency building codes to ensure all new buildings are zero-energy by 2025. Energy efficiency measures for buildings are differentiated according to the age of buildings. Of Korea's total building stock of 6.85 million units, 1.58 million buildings over 15 to 25 years old will be the main target of Green Remodelling and energy efficiency retrofits. Buildings over 25 years old will be subject to new building codes through the maintenance process, and the adoption of energy-saving actions will be promoted to owners of buildings less than 15 years old (Figure 13.4).

Figure 13.4 Energy demand and targets, 2010-35



Source: KEMCO (2014), *Briefing session for energy and climate change Policies in 2014*, Korea Energy Management Corporation, Yongin City.

KEMCO estimates that 74% of domestic buildings are more than 15 years old and need energy performance improvement. The representative energy efficiency programmes that Korea is implementing include the following:

- **Building energy labels and certificates.** KEMCO rates new buildings according to whether they are designed for energy efficiency and whether they have adopted energy-saving technologies and have installed energy-saving materials.
- **Compulsory energy saving plan for new buildings.** Buildings are required to develop energy saving plans when seeking construction permission. KEMCO and other institutions review these plans.
- **Evaluation of eco-friendly homes.** Owners of newly constructed apartment buildings with more than 20 households should submit a written form of evaluation regarding a building's "eco-friendliness" (e.g. measures taken to reduce energy consumption and carbon dioxide [CO₂] emissions) and provide evidence.

Current energy efficiency market activity

This section focuses on the market for ICT-based EMS in Korea, which was estimated to reach USD 100 million in 2012. EMS activity is expected to grow to USD 700 million by 2017, by which time the sector is expected to have created 66 000 new jobs and save 100 000 kilowatts of peak load electricity. Korean EMS measures include (a) the Factory Energy Management System (FEMS) for industry, and (b) the Building Energy Management System (BEMS).

FEMS

The institutional framework for FEMS was established in 2006, but only 1.6% of domestic companies had adopted FEMS by 2011 and 2.9% by 2012. In order to expand the market adoption of FEMS, the Korean government committed USD 38 million from 2011 to 2014 for various programmes, including covering up to 50% of the installation costs of FEMS for SMEs.

Seven companies, including Daewoo Shipbuilding, Hyundai Samho Heavy Industries and Home Plus participated in FEMS pilot projects starting in 2012. Evaluations show annual energy savings of 15.8% and an average payback of 3.8 years. It is estimated that 569 Mtoe will be saved and 1 230 million tonnes of CO₂ of emissions will be avoided when 2 293 energy-intensive workplaces adopt FEMS.

BEMS

Since 2013, MOTIE has recommended BEMS for new public buildings with total floor areas greater than 10 000 square metres (m²) and for existing buildings with annual energy consumption over 2 000 toe. BEMS is not widely adopted, mostly due to low public awareness. However, it has been gradually applied to large buildings, like the Samsung office building in Seocho (2007), SK Chemical Research Center (2010) and Kangwon National University (2012). Samsung estimates that its office building in Seocho saves 11% of its annual energy consumption through application of this self-developed BEMS.

The Korean government performed three pilot projects in Shila University, BCCard Co. and the KT Seolleung Center in 2012, and the energy savings are shown in Table 13.2. Large conglomerates, including Samsung, LG, SK and POSCO, are actively developing BEMS projects.

Table 13.2 Energy savings in three BEMS pilot projects (toe)

	Average energy consumption (Q1 of 2011, 2012)	Energy consumption (Q1 of 2013)	Energy savings (%)
Shila University	850	746	12.2
BCCard Co.	553	511	7.6
KT Seolleung Center	214	199	7.0
Total	1 617	1 456	10.0

Source: KEMCO (2014), *Briefing session for energy and climate change Policies in 2014*, Korea Energy Management Corporation, Yongin City.

It is estimated that 3 712 gigawatt hours of energy will be saved and 7 300 jobs created when 2 300 buildings that are larger than 3 000 m² adopt BEMS in Korea. Government analysis shows that USD 934 million of investment will be needed to achieve this result.

Challenges

Many barriers exist to scaling up EMS in Korea, including the fact that ICT-based energy efficiency technologies (such as FEMS and BEMS) are not well understood or widely available. KEMCO has found that EMS hardware is largely developed but that there is a shortage of experts and investment, which impedes the development of large-scale operation and management software. Another challenge facing EMS is a lack of standardisation. Each EMS has a different process of data collection, processing and controlling, and these are often incompatible, which makes comparing projects using different EMS projects difficult. Despite these challenges, Korea remains committed to building up EMS expertise and the related job market.

Conclusions

In light of its strong growth in energy consumption and limited domestic energy resources, Korea has laid out an ambitious policy framework to improve energy efficiency. The policies and measures implemented in support of this framework are helping to mobilise energy efficiency investments across sectors. Energy management systems for buildings (BEMs) and industry (FEMs) is an area of particular focus for the Korean government and is expected to grow significantly over the next decade. Further work to standardise EMS in Korea could enable comparability and enhance learning across projects.

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14. THE NETHERLANDS

The Netherlands has in place a number of stimulus funds and economic instruments for sustainable energy. Combined with cost-reflective pricing for wholesale energy markets,¹ energy efficiency investors have a strong motivation to act.

The energy-saving technology manufacturing and service sectors in the Netherlands have been growing by 9% a year since 1995, with their combined goods and services valued at EUR 4.13 billion in 2012 (ING, 2013).

Investment in building insulation in the Netherlands has also been growing rapidly at a rate of 10% per year, reaching a value of EUR 680 million in 2012.

With the government supplementing its European Union (EU) obligations with additional financial commitments, and setting a clear target to reduce total final energy consumption (TFC) by a cumulative 100 petajoules (PJ) by 2020 (equivalent to a reduction in energy demand of 1.5% per year to 2020), there is a strong expectation that the energy efficiency market will continue to grow rapidly in the Netherlands.

Energy profile and context

The Netherlands is a densely populated country located at the delta of the rivers Maas, Waal, Rhine and IJssel, on the North Sea. This strategic location makes it an important transit and trade hub for natural gas, coal, oil and electricity. The Netherlands has significant natural gas production and a large oil-refining and chemical industry. In 2010, the Dutch energy sector reached almost EUR 55 billion or 10.9% of Dutch gross domestic product (GDP), and generated around EUR 15 billion worth of exports and a net value-added of EUR 26.74 billion (IEA, 2014).

The energy intensity of the Dutch economy was 0.13 toe per USD 1 000 GDP at purchasing power parity (PPP) in 2013 (Figure 14.1). This is similar to the IEA member country average of 0.14 toe. Compared to its neighbours, the energy intensity of the Netherlands is higher than Germany's and lower than Belgium's. Over the decade to 2013, energy intensity in the Netherlands improved by 11%, as total primary energy supply (TPES) grew at a slower rate than GDP. In comparison, the IEA member country average energy intensity improved by 16% over the same period.

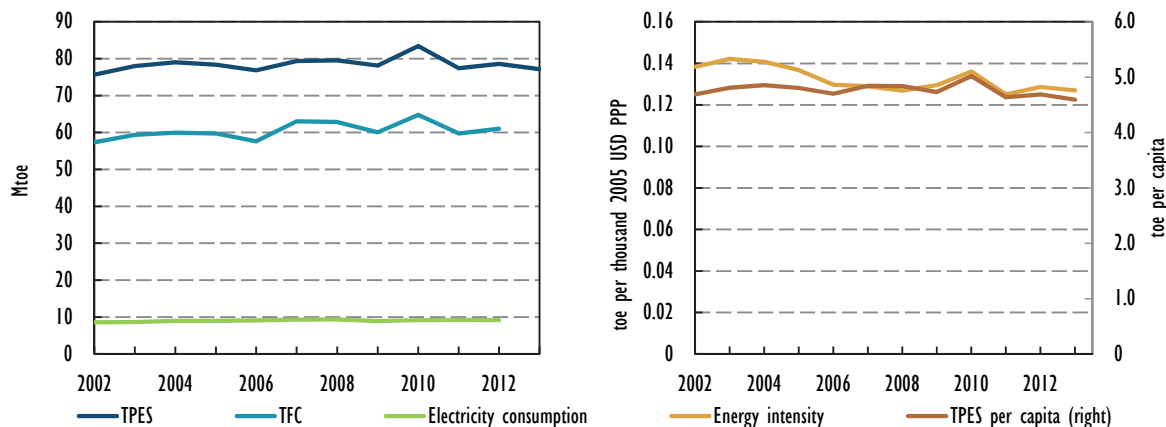
TPES per capita was 4.6 toe in 2013, lower than at any time in the last decade, whereas the IEA member country average dropped from 4.9 toe in 2002 to 4.5 toe in 2013. Electricity consumption per capita increased slightly in the Netherlands from 2002 to 2012. TFC also increased gradually, by 6.4% between 2002 and 2012, following an upward trend since the early 1990s.

Industry was the largest consumer of energy in 2012,¹ representing 21% of TFC (and more than 45% of TFC if petrochemicals and other non-energy-related industries are included) (Figure 14.2). The three sub-sectors that consume the most energy in the industrial sector are the chemical industry and the food industry. Natural gas is the largest source of fuel for industry, followed by oil and closely by electricity. TFC in industry has improved since 2002 thanks to a combination of structural effect and improvements

¹24% of TFC went to non-energy uses such as petrochemicals.

in the steel and chemicals sectors (Odyssey, 2012). The Netherlands is a major exporter and importer of energy; since the country has a large energy-intensive industry, the competitiveness of Dutch industry overall depends on affordable and secure energy supplies.

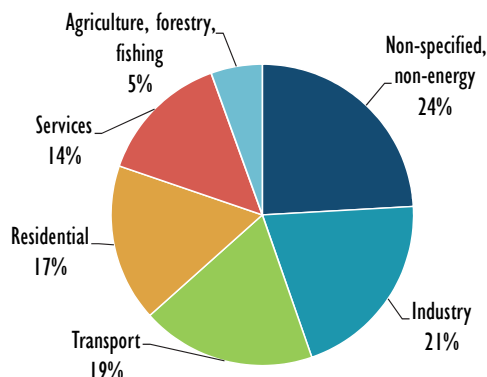
Figure 14.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-13



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

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

Figure 14.2 TFC by sector, 2012

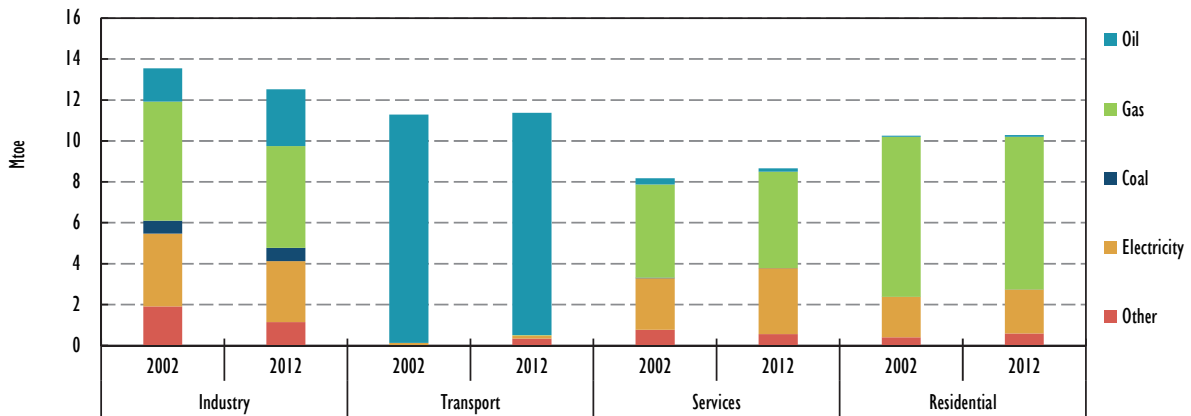


Notes: Non-specified energy use in the Netherlands is high because the Netherlands is home to a large petrochemical industry, which uses oil as a feedstock. Petrochemicals comprise 17% of manufacturing GDP in the Netherlands, which is a higher share than the United States, Canada, Germany and Japan.

Energy consumption in transport has increased at 0.1% per year since 2002, and accounted for 19% of TFC in 2012. The transport sector is mainly fuelled by oil products (95.6%) and to a smaller extent by biofuels and waste, electricity and natural gas. The transport sector has seen a growing use of electricity and biofuels and waste since 2002, while the use of oil products has declined.

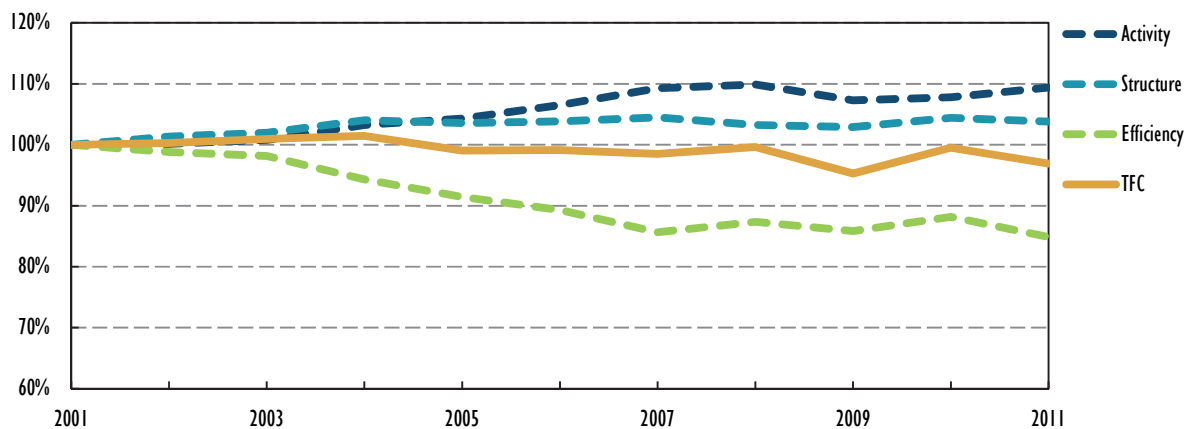
In 2012, the residential and service sectors represented 17% and 14% of TFC, respectively. Natural gas is the main source of energy in both sectors (almost all households and commercial buildings use gas for heating), followed by electricity and heat (Figure 14.3). Despite an overall decrease in population growth, the number of households and single-person homes is increasing in the Netherlands, which results in higher infrastructure and housing needs. Residential energy consumption has increased marginally since 2002.

Figure 14.3 TFC by sector and by energy source, 2002 and 2012



Over the past ten years, efficiency has been the key driver of Dutch energy savings. Flattened energy demand for a decade is a result of subdued economic growth as well as continued efficiency improvements over the period. Efficiency improvements have counter-balanced both increased activity levels and a structural shift towards more energy-intensive industry, particularly as general manufacturing has declined and refining has increased in share. Efficiency gains were greatest in the residential sector, with energy intensity declining by 20% since 2001 (Figure 14.4).

Figure 14.4 Decomposition of Dutch energy consumption



Market variable: End-use energy prices

The Netherlands has some of the highest transport fuel prices in Europe as a result of high fuel taxes. Gasoline prices in the Netherlands were 17% higher in 2012 than the IEA average. High prices have resulted in expenditure on energy accounting for a high share of household income. Based on IEA estimates, on average energy accounted for 10% of household expenditure in 2012. This was higher than the 7.5% average for Organisation for Economic Co-operation and Development (OECD) member countries reviewed.

High energy prices mean that the Dutch population spends a relatively high share of income on both electricity and gas for their homes and on transport fuel for their vehicles. As a result, households have a financial incentive to improve their energy efficiency. Retrofits of the existing building stock are

expected to continue to be a good opportunity to lower the impact of energy prices on household budgets. Housing associations play a key role in this respect, since they own one-third of Dutch houses and target low-income households that are vulnerable to rising energy prices.

Energy efficiency market activity

Market supply: Potential for energy savings

In its 2013 Energy Agreement for Sustainable Growth (known as the Energy Agreement), the Netherlands has committed to reducing TFC by 100 PJ by 2020, with a reduction in TFC of 1.5% per year. This target is in line with the EU-wide goal of reducing TPES by 20% by 2020, as required by the European Union Energy Efficiency Directive (EU EED). The Energy Agreement sets out a range of measures in support of the 100 PJ energy savings target. The estimated savings sought by 2020 are outlined in Table 14.1.

Table 14.1 Estimated energy savings from Energy Agreement measures

Sectors of the economy	Total energy savings (final PJ) in 2020 compared to 2013	Savings per sector (PJ)
Total agreed specific measures	22-60	50% of the EED
Buildings	13-43	Private property housing: 3 Rental housing: 7-12 Service sector: 3-28
Industry, agriculture	9-17	Industry in ETS: 0.5 Industry in non-ETS: 0.3 Other industry: 1-8 Energy investment allowances: 5 Indoor horticulture: 3

Note: ETS = EU Emissions Trading Scheme.

Source: Londo, C., K. Schoots and P. Boot (2013), presentation to the IEA on the Dutch National Energy Agreement, October, PBL Netherlands Environmental Assessment Agency and ECN Energy Research Centre of the Netherlands.

The greatest improvements in efficiency were in the residential and industrial sectors. Household efficiency improvements were driven by space heating improvements (Odyssee, 2012). These were, in turn, driven by the steady adoption of condensing boilers, which can have duty-cycle efficiencies of over 90%. The proportion of dwellings with condensing boilers increased from 30% in 2000 to over 70% in 2010 (Odyssee, 2014), with sales reaching 387 000 units in 2006 (Weiss et al., 2009), comprising 95% of all heating system sales in the Netherlands (Statista, 2014).

Market driver: Energy efficiency policies and programmes

To expand the market for energy efficiency, the Netherlands is implementing a portfolio of energy efficiency policies and measures in line with EU directives and regulations (see chapter on the European Union) and domestic energy efficiency acts and agreements (Table 14.2). The overarching energy efficiency policy frameworks in the Netherlands include the Environmental Management Act (*Wet milieubeheer*), the Second National Energy Efficiency Action Plan (NEEAP-II) of June 2011, and the 2013 Energy Agreement mentioned in the previous section.

To support the objectives outlined in the overarching policy frameworks, the Netherlands has a long tradition of voluntary agreements called *meerjarenafspraak* (MJA). The most recent MJA consists of the MJA3 for non-Emissions Trading Scheme and *meerjarenafspraken energie-efficiëntie* (MEE) for

Emissions Trading Scheme sectors. Under this agreement, companies commit to undertake energy efficiency improvements in return for tax incentives or compensation under the EU-ETS.

A number of voluntary agreements are aimed at stimulating large-scale investments in energy efficiency in existing buildings, including the More with Less Covenant (*Meer met Minder*) that is currently being reworked under the Energy Agreement. The Voluntary Energy Saving Agreement for the Rental Sector (*Convenant Energiebesparing Huursector*) has also been established and is described later in this chapter.

In addition, energy performance requirements in building codes have been and are being strengthened, which is leading to rapid growth in the residential energy efficiency market. Codes for new buildings were strengthened by 25% in 2011, and will improve by 50% in 2015 compared with 2007. In line with EU policy, the Netherlands aims for all new buildings to be energy neutral by 2020.

Finally, fiscal incentives for the purchase of efficient, low-emission cars, combined with the highest automotive fuel taxation in the European Union (EEA, 2013), have increased the share of fuel-efficient cars in recent years, although many of these incentives are currently being phased out.

Current energy efficiency market activity

The design and manufacture of energy-saving technologies is an industry that has been growing by 9% a year since 1995, with a value of produced goods and services of at EUR 4.13 billion in 2012. Investments in building insulation in the Netherlands have been growing at 10% per year, reaching a value of USD 680 million in 2012. Total direct employment in energy efficiency industries is estimated at 22 000. The new Energy Agreement for Sustainable Growth (*Energieakkoord voor duurzame groei*) estimates an additional 15 000 person-years of employment for energy efficiency.

Table 14.2 Summary of government-led investments in energy efficiency market (EUR million)

Programme	Funding	Leveraged funding
Top-sector energy programme	23.8	
Energy-innovation programmes	31.7	
“Green Deal” projects	25	
Market introduction of energy Innovations	13.7	
Investment scheme for energy efficiency	2.3	
Energy transition platform for building sector	150 (revolving fund)	450 (private sector)
EIA (energy transition platform)	160	
MIA (environmental investment rebate)		
VAMIL		
“More with Less” programme, 2014-17	400 (grants)	
Beter Benutten, traffic congestion alleviation	794 (2011-14)	

The public transport programme, Better Utilisation (*Beter Benutten*), allocated a total of EUR 794 million in the period 2011-14. Better Utilisation aims to reduce congestion by approximately 20% on specific congested corridors and facilitate the increased use of public transport. Initial evaluations of the programme are expected at the end of 2014.

The government and the regions will be jointly investing EUR 600 million up to 2017 to further reduce rush hour congestion and decrease door-to-door journey times in the busiest areas by 10% (*Beter Benutten*, 2014).

The Block-by-Block programme (*Blok-voor-Blok*) was started in 2012 to promote energy savings in existing social housing stock. A total of 14 projects, each upgrading between 1 600 and 2 500 homes, have been completed and as of June 2014, 15 000 houses have undergone energy efficiency improvements. The government spent between EUR 350 000 and EUR 500 000 on each of the 14 projects for a total contribution of EUR 5.75 million (Rijksoverheid, 2014).

In addition to voluntary agreements and energy performance requirements, the Netherlands has put in place a variety of tax incentives, including the Energy Investment Allowance (EIA), which offers Dutch companies a deduction of up to 44% on their taxable profit for investments in energy-saving equipment and the generation of renewable energy. In 2013, the programme had a maximum annual budget ceiling of EUR 160 million.

Table 14.3 Key figures and developments in the EIA

Year	Total allocated investment (EUR million)	Number of applications	Reserved budget (EUR million)	Loss of tax revenue (EUR million)	Effective rate deduction (in combination with marginal tax rate)	Average investment size (EUR)
2006	2 007	10 402	139	261	13.0%	356 700
2007	1 530	13 366	139	161	10.5%	151 100
2008	1 105	13 496	139	116	10.5%	106 600
2009	671	11 150	145	70	10.4%	78 100
2010	826	14 255	150	87	10.5%	83 600
2011	1 091	15 884	151	109	10.0%	91 600

Source: Ecorys, Vrije Universiteit Amsterdam and Van Zutphen Economisch Advies (2012), *Evaluatie Energie Investeringsaftrek: Ex post evaluatie 2006-2011*, for Ministerie van Economische Zaken, Landbouw en Innovatie, Rotterdam.

The Dutch government also supports energy efficiency investment and finance through the VAMIL and MIA schemes. VAMIL offers a tax advantage to “green” saving and investment projects, while MIA offers companies a 36% deduction of the investment costs of energy-efficient equipment from taxable profits. From 2005 to 2010, over 57 000 applications were filed under the MIA/VAMIL joint scheme. The programme benefits small and medium-sized enterprises (SMEs) in particular, with an average investment size of EUR 150 000 for both MIA and VAMIL. Projects were focused on the agricultural sector (68%), with further investment in industrial projects (8%) and other sectors (25%), particularly transport. In 2013, a budget of EUR 101 million was available for MIA projects and a further EUR 24 million available for VAMIL projects.

The government also facilitates the Green Funds Scheme in close co-operation with the financial sector. Under the scheme, qualifying financial institutions have a “green bank” or “green fund”, which attracts funding from investors at a lower than market interest rate, which is compensated through a tax incentive. The green banks and green funds are able to pass on the benefit of this lower cost funding in loans to finance activities which are designated “green projects” by the government. Many energy efficiency investments qualify as green projects. As of 2013, the combined fundraising of the green banks and green funds in the Netherlands amounted to EUR 4.5 billion, of which EUR 3.4 billion has been lent to “green projects”.

Prospective energy efficiency market activity

To achieve the objectives set out in the Energy Agreement, the Netherlands has committed to:

- a EUR 600 million revolving fund to scale up the market for energy efficiency in the residential sector (EUR 150 million is provided by the government and the remainder is leveraged by the private sector);
- EUR 400 million in grants between 2014 and 2017 for energy efficiency improvements in rental houses;
- funding to regional and local governments to support the implementation of energy efficiency policies and measures.

The market for energy efficiency in rented housing is being expanded through the new Voluntary Energy Saving Agreement for the Rental Sector (Convenant Energiebesparing Huursector). This scheme provides grants to owners who seek to make energy efficiency improvements to their rental properties, with the goal of achieving at least a label B (for corporation-owned buildings) and label C (for private landowners). The national government is providing EUR 400 million between 2014 and 2017 in support of this programme, which is seeking to retrofit 1 million homes by 2020 and achieve energy savings of 21 PJ.

Energiesprong is a market development programme for energy efficiency in buildings. In 2013, the government selected contractors to refurbish 111 000 social housing units, paid for by energy cost savings. The refurbishment of each home is to be done within one week and comes with a 30-year energy performance guarantee. Pilots have already been finished and the programme is starting with 11 000 homes and ten organisations.

Energiesprong has the potential to lift market barriers, create attractive financing conditions, mobilise demand and, by creating scale, challenge the construction sector to deliver better refurbishment (defined as lower cost, shorter intervention time, better aesthetics and provision of an energy performance guarantee). On the financing side, the programme works with financiers and regulators to find optimum financing conditions, possibly directly backed with government (or European Investment Bank) loans. The next step being considered would be to expand the programme beyond the Netherlands to the United Kingdom and France by partnering with large financiers of social housing in those countries.

Energy provider-delivered energy efficiency. The 2012 EU EED requires the implementation of a 1.5% annual energy saving obligation on energy providers or alternative policies with equivalent impact. The Netherlands' Energy Agreement calls for stronger engagement of energy providers in the delivery of end-use energy efficiency. Proposed measures include energy conservation measures to be financed through energy bills. Through a consultation process, a scheme is being developed that would allow end users to avoid the need to find funding to cover upfront costs, but instead pay investment costs in instalments, out of savings from implemented energy efficiency measures.

Challenges

Energy policy in the Netherlands took an important step forward in 2013 when, facilitated by the Social and Economic Council of the Netherlands (SER), more than 40 organisations – including central, regional and local government, employers and unions, nature conservation and environmental organisations, and other civil society organisations and financial institutions – endorsed an Energy Agreement for Sustainable Growth. The core feature of the agreement is a set of broadly supported provisions regarding energy saving, clean technology and climate policy. Implementing these provisions is intended to result in an affordable and clean energy supply, jobs and opportunities for the Netherlands in the market for clean technologies. The agreement depends heavily on onshore and offshore wind energy

and concerns have been expressed that the costs of ambitious plans for offshore wind project developments may put at risk the full implementation of the agreement in other areas, such as energy efficiency.

In the buildings sector, one challenge with new investments is that past energy efficiency market activity has focused on rapidly implementing measures with short payback periods. Achieving a deep renovation of the Dutch building stock will require financial instruments and investments, perhaps from the large Dutch banking sector, pension funds and insurance companies, which are based on long-term savings of future energy consumption.

Conclusions

With the government adding financial pledges to EU commitments, and supporting a clear target to reduce TFC by 100 PJ in 2020 (equivalent to a reduction in energy demand of 1.5% per year to 2020), the strong expectation is that demand for energy efficiency will grow rapidly in the Netherlands. A number of stimulus funds and economic instruments for sustainable energy are in place, and when combined with the cost-reflective pricing for wholesale energy markets in the Netherlands,² energy efficiency investors have a strong motivation to act.

Energy efficiency improvements in the industrial sector are higher than the EU average. This is the result, in part, of long-term agreements between government and industry. Dutch industrial efficiency programmes and policies, as described in the previous section, place large emphasis on co-operation between industry and government. The government sets annual efficiency targets 1.5%³ per year out to 2020) and participating companies are obliged to develop their own plans to achieve these improvements and to report on results. The achievement of targets is non-binding; however, this co-operative approach tends to foster greater awareness and knowledge sharing between government and industry and across industry. It will be important to strengthen compliance by implementing stronger surveillance and enforcement mechanisms and to strongly consider implementing mandatory energy savings targets.

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² The liberalisation of the consumer electricity market has yet to be completed.

³ Annual efficiency targets are set in line with the Energy Efficiency Directive.

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15. THAILAND

Thailand's rapidly expanding economy has led to increased energy demand over the past two decades. This growth is expected to continue, with energy efficiency playing an increasingly important role in mitigating Thai dependence on energy imports.

To date, policy frameworks and financing mechanisms put in place to promote energy efficiency in Thailand have not reduced overall energy demand, largely because of the increasing share of energy-intensive industry in the economy. They have, however, generated private-sector energy efficiency investments of up to ten times the invested government funding.

The state-owned energy utility, Electricity Generating Authority of Thailand (EGAT), has played a groundbreaking role in developing and implementing approaches to creating markets for more efficient products.

Thailand is now in the process of ramping up its energy efficiency activities as part of the Energy Efficiency Development Plan released in 2011, which sets out an ambitious course to reduce energy demand by 20% by 2030. The government has pledged USD 0.9 billion during the first five years of implementation to programmes in support of this target. The plan is expected to result in cumulative energy savings with an average of 14.5 Mtoe per year, which is, at current prices, worth USD 8.4 billion per year. If implemented as intended, the plan is expected to leverage considerable private sector investment in energy efficiency and drive the demand for energy-efficient products and services.

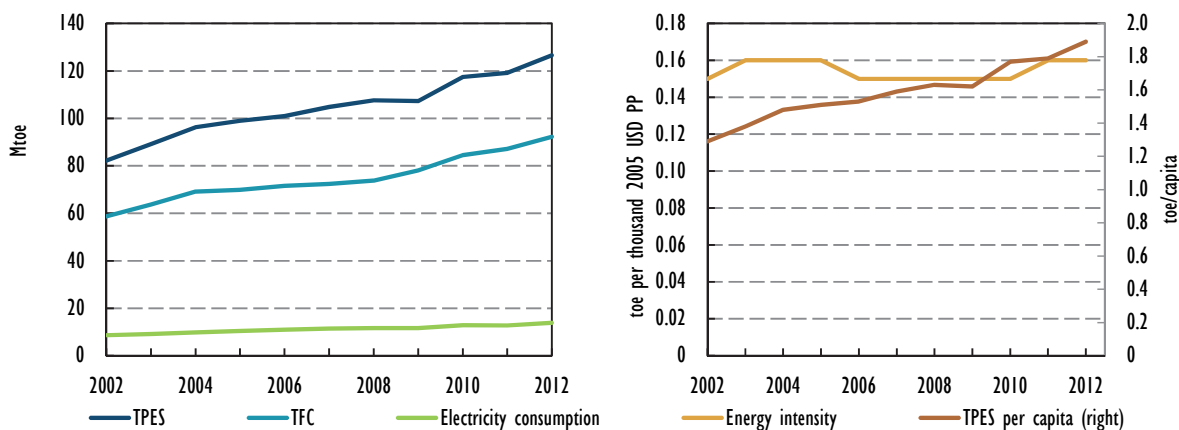
Energy profile and context

Total primary energy supply (TPES) equalled 127 Mtoe in 2012, while total final consumption (TFC) reached 92 Mtoe. Both have been increasing steadily since 2002 (Figure 15.1). Between 1990 and 2010, Thailand's gross domestic product (GDP) grew at an average rate of 4.5% annually. Energy demand kept a similar pace, growing at an average of 4.4% per year and is predicted to grow at a higher rate over the next decade (EPPO, 2013). TPES in 2012 was three times the amount it was in 1990.

In the next 20 years, TFC under a business-as-usual scenario is expected to reach 151 Mtoe, an annual average growth rate of 3.9%, under the assumption that GDP will grow at an annual average rate of 4.2% (EPPO, 2013). GDP growth is forecast to average 5.1% per year between 2013 and 2017 (OECD, 2013).

This rapid growth in energy demand is leading to increased energy security concerns. Thailand has limited domestic oil production and reserves, and imports make up 80% of the country's oil consumption. Thailand relies on imports for about 55% of its overall energy demand.

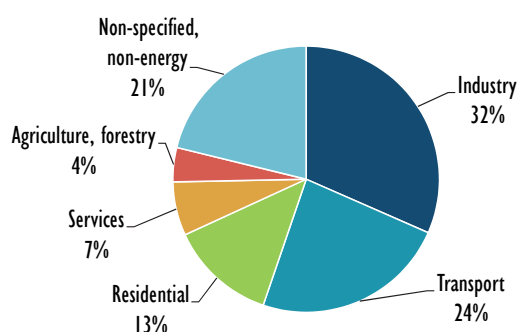
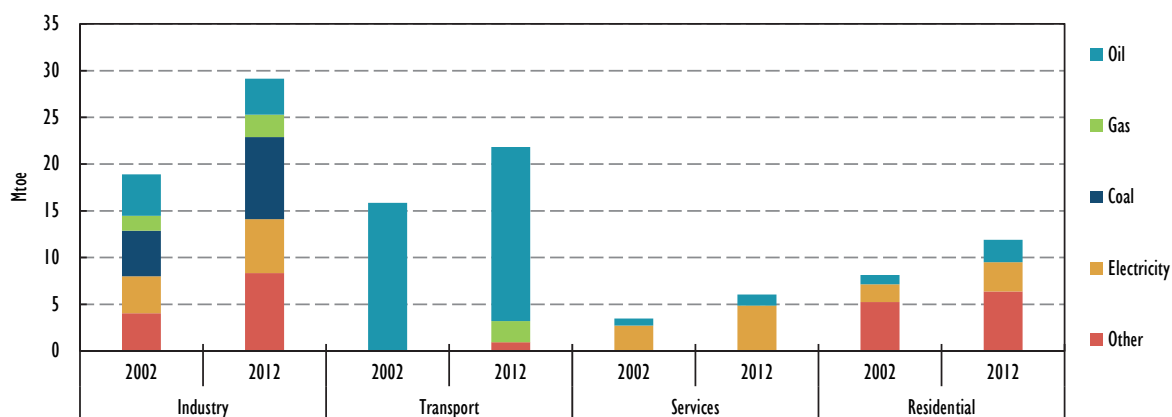
Energy consumption growth rates in the manufacturing and commercial sectors are much higher than the GDP growth rate, with increases of 3.0 and 3.7 times respectively compared with consumption in 1990 (EPPO, 2013). The rising energy demand of industry is primarily driven by the increasing share of manufacturing in the economy and use of inefficient industrial plants. The high transport sector energy demand is mainly due to the country's heavy reliance on road transport and lack of fuel economy standards.

Figure 15.1 TPES, TFC, electricity consumption, energy intensity and energy use per capita, 2002-12

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

Source: Unless otherwise indicated, all tables and figures in this chapter derive from IEA data and analysis.

15.2 TFC by sector, 2012

**Figure 15.3** TFC by sector and by energy source, 2002 and 2012

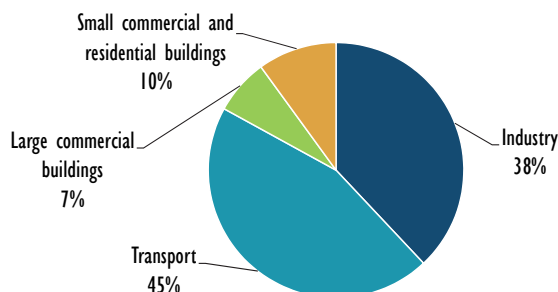
Thailand's rapid economic expansion over the past two decades has spurred the need for generation capacity to keep pace with higher electricity demand. Growth in power consumption has averaged approximately 5% a year over the past decade.

Energy efficiency market activity

Market supply: Potential for energy savings

Significant energy efficiency potential exists across all sectors; the transport and industrial sectors have the greatest energy savings potential (Figure 15.4).

Figure 15.4 Share of energy savings potential by sector to 2030



Source: EPP0 (2011), *20-Year Energy Efficiency Action Plan (2011-2030)*, Energy Policy and Planning Office, Ministry of Energy, Bangkok, www.eppo.go.th/encon/ee-20yrs/EEDP_Eng.pdf.

Market driver: Energy efficiency policies and programmes

In Thailand, the government has introduced various energy conservation measures since the Energy Conservation Promotion (ENCON) Act, B.E. 2535, entered into force in 1992. A key instrument is the ENCON Fund based on a small levy on fuels. This levy provides annual inflows of approximately USD 200 million. This fund is used for research, development, demonstration, incentives (grants and soft loans) and capacity building. Programmes financed by the ENCON Fund include the following:

- Introduced in 2002, the Energy Efficiency Revolving Fund (EERF) provided credit lines to 11 participating Thai banks at a zero interest rate in the range of USD 2.5 million to USD 10 million to finance energy efficiency projects. Among the requirements stipulated by the revolving fund was that the interest rate charged to borrowers was to be no more than 4% (compared to the 2002 market rate of 9%). Local banks were able to provide low-interest loans, which covered up to 100% of project costs but were limited to USD 1.4 million per project. In cases where a project required finance of over USD 1.4 million, the commercial banks could provide their own funds to cover the remaining amount. As the financing volume grew, banks began to co-finance projects and the interest rate on government financing was subsequently reset to 0.5% to cover administrative costs. Loan repayment flowed back to the ENCON Fund and not to the EERF. Local banks were required to repay the principal and interest back to the EERF within 10 years. The initial allocation to the revolving fund was USD 60 million (CCAP, 2012). The EERF was phased out in 2011, since as it was assessed that the banks could continue without government support (CCAP, 2012).
- Demand-side management (DSM) Bidding, introduced in 2008, provides subsidies through a bidding mechanism to encourage business operators to invest in higher energy efficiency machines/equipment to achieve energy savings. Subsidies are provided based on actual units of energy savings achieved in a year. With the bidding mechanism, companies requesting the lowest weighted subsidy rate are subsidised first. Allocated programme funding amounted to USD 11.6 million. Upon completion of the 8th bidding round on 1 June 2010, a total of 271 proposals had been submitted. Of these, 260 proposals were approved for implementation, involving investment in energy efficiency improvement by the companies of more than THB 4 billion (USD 124 million), with the total amount of subsidies required from the ENCON Fund standing at about THB 540 million (USD 17 million), which was only 52% of the budget. The expected total energy saving is 126.68 ktoe per year, amounting to 170% of the target.

- Established in 2008, the ESCO Fund aims to invest jointly with private operators, including energy service companies (ESCOs), in energy efficiency and renewable energy projects. The scheme was specifically created to target small and medium-sized enterprises (SMEs) and small renewable energy and energy efficiency projects that have a good potential in energy saving but cannot access financing for investment. The ESCO Fund provides a variety of financial mechanisms to help project developers and/or ESCOs access and leverage capital. The ESCO Fund includes six funding assistance instruments: equity; venture capital; equipment leasing; partial credit guarantees; carbon credit trading; and technical assistance (CCAP, 2012).

In addition, the Board of Investment (BOI) grants duty-free import of energy-efficient equipment and an eight-year corporate income tax holiday to enterprises engaged in energy conservation, production of renewable energy and production of environmentally friendly products. The tax preferences include a 50% reduction in corporate income tax on net profit for five years after the expiry of the tax holiday. Another tax incentive scheme is in the form of a 25% tax deduction on the purchase of energy-efficient equipment.

Ramping up energy efficiency activity

The 20-year Energy Efficiency Development Plan (2011 to 2030) aims to reduce TFC by 20% by 2030, equivalent to a reduction of 30 Mtoe. In 2012 this target was increased to 38.2 Mtoe. The plan focuses on maintaining and expanding existing programmes and approaches that have proven to be successful, and complements these with new programmes and elements based on best international practice (Table 15.1). The initial phase of the programme (first five years) is driven by government funding totalling USD 900 million. The cost of energy conservation for the government is assessed to be around USD 60 to USD 185 per toe.

Table 15.1 Planned distribution of funding per type of activity

	Funding (USD million)	Percentage of total
Direct funding for energy savings achieved	61.5	68%
Management and public relations	9	10%
Infrastructure development for standards and labelling	4.6	5%
Funding for research, development and demonstration	10	12%
Human resources and institutional capacity building	4.6	5%

Source: EPP0 (2013), *20-Year Energy Efficiency Development Plan (2011-2030)*, Energy Policy and Planning Office, Ministry of Energy, Bangkok, www.eppo.go.th/encon/ee-20yrs/EEDP_Eng.pdf.

Table 15.2 Planned distribution of funding per sector (based on the indicated share of primary energy savings target)

	Funding (USD million)
Industrial	34
Transport	29
Large commercial buildings	12
Small commercial buildings and residential	15

Source: EPP0 (2013), *20-Year Energy Efficiency Development Plan (2011-2030)*, Energy Policy and Planning Office, Ministry of Energy, Bangkok, www.eppo.go.th/encon/ee-20yrs/EEDP_Eng.pdf.

Market activity

Energy efficiency policies and measures have to date effectively leveraged private sector finance and had clear impacts on creating markets for certain energy-efficient product categories.

EERF leverages private investments

By the close of the EERF programme, the total investment leveraged was USD 521 million, which consisted of USD 236 million from the EERF and USD 285 million in debt financing from local banks. It is estimated that the achieved energy savings were worth USD 154 million per year, and projects had an average payback period of approximately three years (CCAP, 2012). The initial ratio for lending under the programme was initially 1:1 between the government and the banks; the private sector finance ratio steadily increased over time. While government funding for this programme has ended, commercial banks are continuing to provide loans for energy efficiency.

The DSM Bidding mechanism leverages eight times the invested government funding

The DSM Bidding mechanism resulted in the implementation of 170 projects with a total investment value of more than USD 93 million. The subsidies amounted to 12.5% of the total value mechanism (UNIDO, 2011).

ESCO Fund leverages ten times the invested government funding

Phase 1 of the ESCO Fund project ran from October 2008 to September 2010, with a total ESCO Fund budget of USD 16 million. Phase 2 of the project ran initially from October 2010 to September 2012, with a total budget of USD 16 million, and was recently extended to end in 2013 with an expanded budget of USD 116 million. Phase 3 of the programme started in 2013 with a budget of USD 15 million (CCAP, 2012). At the close of Phase 1 in 2010, a total of USD 10.8 million had been deployed by the ESCO Fund, and resulted in a total investment of USD 109 million. By the end of Phase 2 (2012), the energy efficiency and renewable energy projects were projected to create energy savings of 23.97 ktoe per year and financial savings of USD 29 million per year (CCAP, 2012).

Energy utility leads groundbreaking activity in market creation

The state-owned public EGAT has, since 1991, been actively engaged in DSM and the promotion of end-use energy efficiency. EGAT achieved 15 700 gigawatt hours (GWh) of energy savings by 2012, exceeding its own energy savings targets.

The Thailand Promotion of Electricity Energy Efficiency (TPEEE) Project took place from 1993 to 2000. It was co-financed by a Global Environmental Facility (GEF) grant of USD 9.5 million, USD 5.4 million from the Government of Australia, a loan of up to USD 25 million from the Overseas Economic Cooperation Fund of Japan and the Japanese Bank for International Cooperation, and funds from EGAT.

In the context of the project, four specific initiatives have been particularly successful in stimulating the market for more efficient products: voluntary agreements on efficient fluorescent tubes, bulk purchases of compact fluorescent lamps (CFLs) to reduce retail prices, consumer labels for refrigerators and consumer labels for air conditioners.

- **Fluorescent tubes:** While thin T-8 tubes are more energy efficient and are cheaper to manufacture than thick T-12 tubes, manufacturers were reluctant to sell them due to the consumer perception that a thick tube gives more light than a thin one. As part of the DSM programme, EGAT negotiated a voluntary agreement with all five Thai manufacturers of T-12 tubes, as well as the one importer of T-12 tubes. The manufacturers and importer agreed to switch from T-12 tubes to the more efficient T-8 tubes. In return, EGAT supported the manufacturers with an USD 8 million consumer information campaign, which explained that thin tubes provide more light for the same energy cost. This agreement effectively and completely eliminated the less efficient T-12 tubes from the Thai market, estimated at 20 million tubes per year. In 1994, when the programme began, efficient T-8 tubes had a 40% market share. By the end of 1995, the efficient T-8 tubes had achieved a 100% market share (Birner and Martinot, 2003).
- **CFLs:** EGAT purchased CFLs in bulk and re-sold them through a distribution network of convenience stores. EGAT tested and labelled lamps to ensure consistent quality and covered for advertising costs. Bulk distribution and partnership with franchised retail outlets allowed substantial reduction in transaction costs. Over 900 000 CFLs were sold as of early 2000, at 40% below the prevailing market price (Birner and Martinot, 2003).
- **Consumer labelling:** EGAT negotiated with manufacturers a voluntary labelling scheme that awarded refrigerators a label designating efficiency from level 1 to level 5 (level 5 being most efficient). EGAT also sponsored an advertising campaign to promote the label, and partnered with a Thai technical standards institute to test domestically available refrigerators. A few years later, the label scheme was made mandatory, and EGAT reached agreement with the manufacturers to increase by 20% the efficiency requirements for each label level. In 1994, only one single-door model and 2% of double-door models qualified as level 5. By 2000, all single-door and 60% of two-door models met the level 5 requirements. It is estimated that the programme contributed to a 21% reduction in overall refrigerator energy consumption (Birner and Martinot, 2003).

In response, sales of high-efficiency (level 5) lamps, refrigerators, and air-conditioning units are estimated to have risen substantially in the period to 2004, with sales reaching 85 million T8 fluorescent tubes, 5 million CFLs and 12.4 million refrigerators (World Bank, 2006).

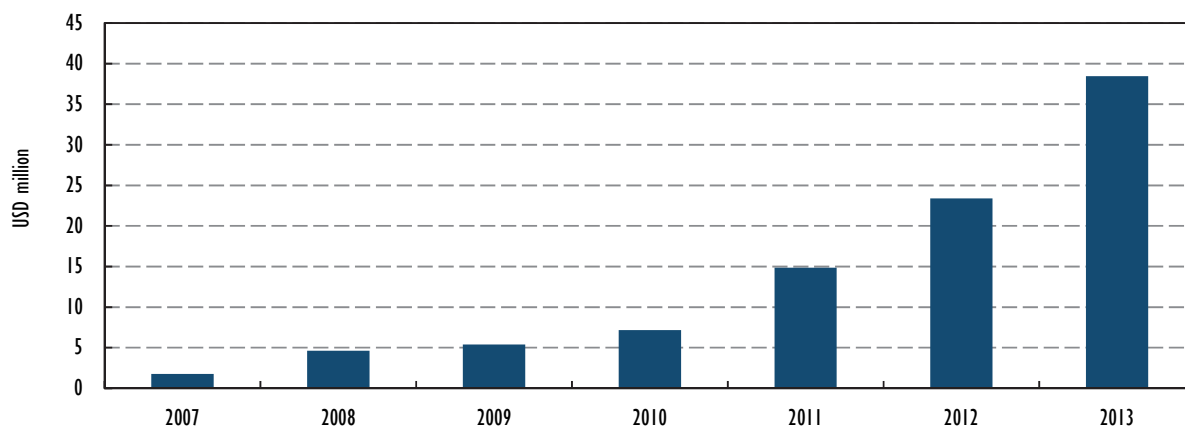
When the TPEEE Project ended, Demand-Side Management Office (DSMO) funding from a dedicated tariff was removed, but EGAT continued funding at equivalent or higher levels through its own revenue base (World Bank, 2006). CFL prices have continued to drop, with a 20% lower price in 2011 compared to 2006 (Phumaraphand, 2013).

EGAT has continued, with the support of ENCON, to promote the use of more efficient light tubes between 2009 and 2014, resulting in a switch from T8 (36 watt) tubes to the 30% more efficient T5 (28 watt) tubes, with the aim of replacing 18.5 million lamps in commercial, industrial and residential sectors (Phumaraphand, 2013).

LED lighting market share growing exponentially

The Thai light-emitting diode (LED) lighting market has grown rapidly in recent years, with sales reaching almost USD 15 million in 2011 and growing to USD 38 million in 2013 (Figure 15.5). By 2011, LED lighting achieved an 8% share of the total lighting market, assessed to be worth USD 184 million in 2011, and its share has now exceeded 12%.

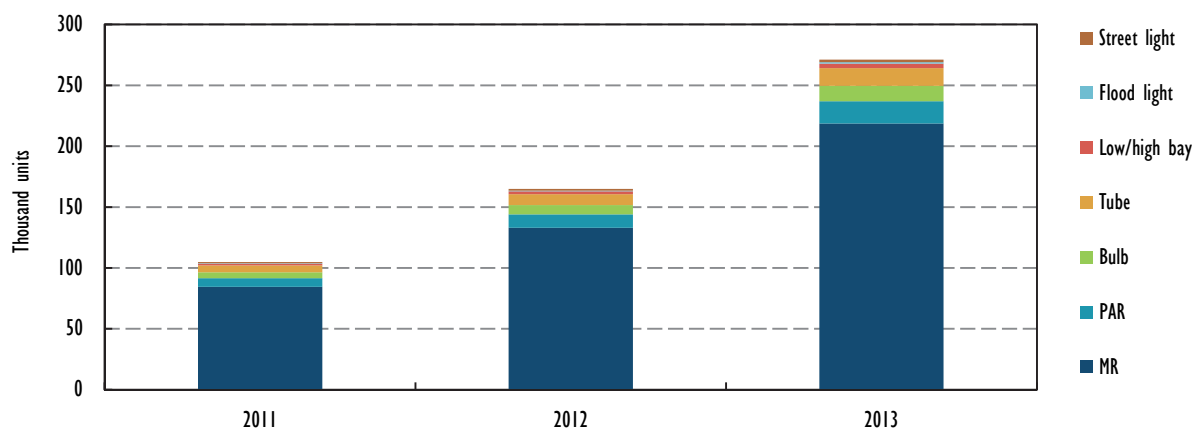
Figure 15.5 LED sales in Thailand



Notes: An exchange rate of THB 32.5 to USD 1 is used. 2013 is projected.

Source: Asawutmangkul (2012), "Energy Efficiency Standard and Labeling Program for LED in Thailand", presentation at APEC workshop on LED Lighting Technology with Energy Savings Issues, Taipei, 22 October.

Figure 15.6 Lighting sales in Thailand



Notes: PAR = parabolic aluminised reflector lamp, a type of lamp that is widely used in commercial, residential, and transport illumination; usage includes locomotive headlamps, aircraft landing lights, and residential and commercial recessed lights; MR = multifaceted reflector, used in residential lighting and retail lighting contexts. An exchange rate of THB 32.5 to USD 1 is used. 2013 is projected.

Source: Asawutmangkul (2012), "Energy Efficiency Standard and Labeling Program for LED in Thailand", presentation at APEC workshop on LED Lighting Technology with Energy Savings Issues, Taipei, 22 October.

Prospective energy efficiency market activity

The 20-year Energy Efficiency Development Plan (2011 to 2030) is expected to drive the development of the market for energy-efficient products and services across all sectors:

- The strong focus on the transport sector and foreseen fuel efficiency standards, energy labelling and tax measures will stimulate demand for more efficient vehicles and vehicle components. Investments are also expected in the development and deployment of intelligent transport systems and in expanding public transport systems.
- Increased focus on industrial energy efficiency will create demand for industrial equipment, such as efficient motors, chillers, boilers, cooling facilities, as well as for energy service providers that provide energy audits and energy management and process optimisation services.

- Financial assistance via the Standard Offer Program (SOP), i.e. provision of funding according to the amount of energy saving that can be proven or assessed, is expected to increase the uptake of energy-efficient equipment and implementation of energy efficiency projects.
- Plans to improve efficiency in the building sector, including through mandatory labels, will contribute to stimulating the market for efficient buildings, building components, appliances and equipment, as well as creating market demand for energy services such as auditing, validating energy savings, and energy management.
- Mandatory energy efficiency resource standards (EERS) for large-scale energy companies are expected to drive up the demand for more efficient products, as well as energy services. These require them to implement ENCON measures to encourage their customers to reduce energy use by a specified minimum standard.
- Expansion of the standards and labelling programme for equipment and appliances, coupled with consumer awareness campaigns and incentive programmes, will strengthen the demand for more efficient products. In particular, the LED lighting market is expected to grow at a dramatic rate. The compound annual growth rate of LED products is more than 60%, while the total lighting market is growing at a rate of 5% per year (Asawutmangkul, 2012). Market share is expected to reach between 45% and 50% in 2015 (Thailand LED EXPO, 2013). LED automotive lighting constitutes an important future market for Thailand. The number of cars with LED headlights are expected grow from 1.5 million in 2013 to 5 million by 2015, with the value of LED components growing from USD 130 million to USD 300 million. Plans by the Provincial Electricity Authority (PEA) to replace one million streetlights with LED bulbs will contribute to strong growth in this segment. Planned infrastructure projects (schools, hospitals, sports stadiums etc.) are further expected to contribute to the demand for LED products.

Challenges

A number of factors may constrain the development of energy efficiency markets in Thailand; lack of co-ordination between government agencies could have an impact on the effectiveness of policies and programmes, as could deficits of energy efficiency finance, particularly for SMEs. Other challenges include the need to further efforts in the development of measurement, reporting and verification (MRV) systems, particularly as the ESCO market relies on access to and use of measurement and verification (M&V) standards and protocols. Finally, while energy providers have taken an active role in demand-side energy efficiency, sustaining and expanding this role requires a system that would make reducing energy demand, and capturing the other benefits of energy efficiency, a viable business opportunity.

Conclusions

The ENCON Fund is one of very few examples in Asia Pacific where governments directly collect taxes on petroleum products and allocate the revenues specifically to stimulate private investment in energy efficiency. Both the EERF and the ESCO Fund have been successful in increasing participation from commercial banks and the private sector in energy efficiency. EGAT has played a groundbreaking role by developing and implementing approaches to create markets for more efficient products.

The new plan is ambitious and comprehensive and, if implemented as planned, is expected to leverage considerable private sector investment in energy efficiency and drive the demand for energy-efficient products and services.

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PART 3
**ANNEX AND
LIST OF ACRONYMS**

ANNEX: ENERGY USE AND INTENSITY DATA

Table A.1 Total primary energy supply (TPES) by country (Mtoe)

	2002	2004	2006	2008	2010	2012	2013
Australia	109.5	112.7	114.9	122.5	122.5	128.3	129.3
Austria	30.4	32.7	33.8	33.6	34.1	33.1	33.3
Belgium	56.4	58.9	58.2	58.8	60.5	56.0	56.1
Canada	248.4	267.6	272.1	264.4	251.3	251.1	251.4
Chile	25.6	27.5	29.5	30.3	30.8	37.2	38.3
Czech Republic	42.5	45.5	46.0	45.0	44.5	42.6	41.4
Denmark	19.0	19.4	20.3	19.2	19.5	17.3	17.5
Estonia	4.7	5.3	5.1	5.5	5.6	5.5	5.9
Finland	34.9	37.2	37.4	35.3	36.5	33.3	32.3
France	261.2	269.8	266.8	264.8	261.2	252.3	252.3
Germany	338.7	339.3	346.2	331.3	327.5	312.5	312.4
Greece	28.3	29.7	30.2	30.4	27.6	26.6	23.9
Hungary	25.6	26.1	27.3	26.5	25.7	23.5	22.9
Iceland	3.3	3.4	4.2	5.4	5.4	5.7	5.4
Ireland	14.5	14.5	14.5	14.8	14.3	13.2	13.4
Israel*	18.8	19.2	20.4	22.9	23.2	24.3	24.8
Italy	172.4	181.9	181.7	175.8	170.5	158.8	154.3
Japan	510.4	522.5	519.7	495.3	498.8	452.3	453.3
Korea	198.7	208.3	213.7	227.1	250.0	263.4	262.2
Luxembourg	3.6	4.3	4.3	4.2	4.2	4.1	4.0
Mexico	149.2	160.8	170.9	180.8	176.3	188.4	182.5
Netherlands	75.7	79.1	76.8	79.6	83.4	78.6	77.2
New Zealand	17.1	17.3	16.9	17.4	18.3	19.0	18.6
Norway	24.9	26.4	27.1	29.7	32.4	29.2	32.9
Poland	88.9	91.3	97.1	98.0	100.6	97.9	97.1
Portugal	25.8	25.8	25.2	24.7	23.5	21.4	22.1
Slovak Republic	18.7	18.4	18.6	18.3	17.8	16.7	16.9
Slovenia	6.8	7.1	7.3	7.7	7.2	7.0	6.6
Spain	128.8	139.0	141.8	139.1	127.6	125.0	116.6
Sweden	51.8	52.6	50.2	49.6	50.9	50.2	48.0
Switzerland	25.9	26.1	27.1	26.8	26.2	25.6	26.7
Turkey	74.2	80.7	93.2	98.7	105.3	116.9	116.0
United Kingdom	218.3	221.6	219.0	207.1	201.4	192.2	190.2
United States	2 255.9	2 307.8	2 296.8	2 277.1	2 215.4	2 140.6	2 186.7
China	1 253.8	1 639.9	1 938.9	2 120.8	2 526.4	2 746.9	2 894.3
India	478.0	517.9	569.7	632.3	722.5	751.8	788.1
Indonesia	165.2	176.6	184.0	186.8	209.4	205.3	213.6
Thailand	82.3	96.3	101.0	107.6	117.4	119.1	126.6
IEA	5 105.3	5 261.7	5 282.1	5 220.5	5 157.1	4 987.1	5 014.8
World	10 359.3	11 223.6	11 836.9	12 283.5	12 890.8	13 371.0	..
EU-28	1 728.2	1 782.5	1 793.7	1 755.3	1 720.7	1 659.7	..

Notes: .. = data not available. Values for 2013 are estimates.

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Source: Unless otherwise noted, all tables and figures in this chapter derive from IEA data and analysis.

Table A.2 Total final consumption (TFC) by country (Mtoe)

	2002	2004	2006	2008	2010	2011	2012
Australia	69.75	72.55	72.99	76.19	76.40	77.95	79.36
Austria	25.10	26.94	27.64	27.46	28.18	27.19	27.25
Belgium	40.30	41.99	40.91	42.58	43.06	42.81	41.89
Canada	187.76	199.03	199.69	206.07	200.05	206.66	207.84
Chile	20.66	21.66	22.89	22.57	23.84	25.05	24.95
Czech Republic	25.80	27.95	28.02	27.24	27.03	26.05	25.71
Denmark	14.36	14.84	15.09	14.89	15.05	14.29	13.79
Estonia	2.73	2.99	3.06	3.23	2.96	2.87	2.93
Finland	25.59	26.25	26.58	25.75	26.42	25.01	25.13
France	164.89	169.80	167.53	165.43	162.71	151.60	154.95
Germany	231.78	233.00	234.61	226.83	229.60	218.85	220.98
Greece	19.50	20.39	21.38	21.19	19.43	19.02	17.09
Hungary	18.04	18.64	19.67	18.58	18.12	17.70	16.31
Iceland	2.25	2.26	2.39	2.92	2.92	2.95	2.69
Ireland	11.06	11.44	12.64	12.54	11.34	10.44	10.31
Israel*	11.53	12.66	12.47	13.86	14.83	14.08	14.73
Italy	131.08	136.96	136.87	132.28	130.06	126.79	122.65
Japan	341.76	343.56	342.38	316.42	321.55	312.86	308.77
Korea	135.39	138.46	142.11	146.88	157.66	161.50	166.38
Luxembourg	3.38	4.01	4.05	3.98	3.94	3.94	3.85
Mexico	97.91	102.88	109.93	115.07	113.61	116.12	117.01
Netherlands	57.39	59.95	57.66	62.87	64.77	59.77	61.05
New Zealand	13.49	13.21	12.66	12.67	12.81	12.70	12.88
Norway	19.98	20.49	20.41	20.96	21.35	20.43	20.32
Poland	56.78	60.77	64.42	65.66	69.93	67.46	66.64
Portugal	19.95	20.41	19.70	19.51	18.95	18.14	16.51
Slovak Republic	11.92	11.29	11.39	11.82	11.44	10.97	10.23
Slovenia	4.75	5.08	5.24	5.50	5.13	5.08	4.96
Spain	90.92	99.37	99.31	97.96	92.19	88.82	84.64
Sweden	35.53	34.76	34.23	33.26	34.86	33.02	32.94
Switzerland	19.65	20.40	20.55	20.62	21.04	19.45	20.12
Turkey	57.24	63.16	72.47	74.40	77.75	81.67	87.33
United Kingdom	147.38	149.93	145.73	139.44	136.51	125.08	127.57
United States	1 522.54	1 565.68	1 555.51	1 525.26	1 500.77	1 487.41	1 432.73
China	854.71	1 070.50	1 244.17	1 369.32	1 527.97	1 635.13	1 701.87
India	329.20	348.83	383.45	415.37	473.40	494.65	511.54
Indonesia	124.19	133.33	139.72	139.83	149.69	151.86	159.66
Thailand	58.72	69.14	71.60	73.83	84.51	87.14	92.28
IEA	3 500.98	3 608.22	3 609.21	3 551.97	3 535.91	3 470.42	3 418.15
World	7 213.31	7 744.00	8 121.44	8 408.80	8 740.50	8 885.74	8 978.86
EU-28	1 187.61	1 229.97	1 231.44	1 214.61	1 202.72	1 146.77	1 139.25

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Table A.3 TPES/GDP PPP by country (toe per thousand 2005 USD)

	2002	2004	2006	2008	2010	2012	2013
Australia	0.169	0.161	0.154	0.156	0.149	0.147	0.145
Austria	0.117	0.121	0.118	0.111	0.116	0.108	0.108
Belgium	0.177	0.178	0.168	0.163	0.169	0.154	0.154
Canada	0.232	0.238	0.228	0.215	0.203	0.194	0.191
Chile	0.146	0.142	0.135	0.128	0.124	0.135	0.133
Czech Republic	0.227	0.223	0.197	0.177	0.179	0.17	0.167
Denmark	0.111	0.111	0.109	0.103	0.109	0.096	0.097
Estonia	0.264	0.259	0.207	0.217	0.253	0.218	0.231
Finland	0.237	0.237	0.222	0.199	0.217	0.195	0.191
France	0.148	0.148	0.14	0.136	0.136	0.129	0.129
Germany	0.134	0.133	0.13	0.119	0.119	0.11	0.109
Greece	0.118	0.112	0.106	0.103	0.102	0.113	0.106
Hungary	0.169	0.158	0.154	0.147	0.152	0.139	0.134
Iceland	0.376	0.349	0.384	0.461	0.515	0.525	0.482
Ireland	0.103	0.095	0.086	0.085	0.088	0.08	0.081
Israel*	0.125	0.12	0.115	0.115	0.109	0.106	0.105
Italy	0.107	0.111	0.107	0.103	0.104	0.099	0.098
Japan	0.138	0.136	0.131	0.124	0.126	0.113	0.112
Korea	0.203	0.197	0.185	0.183	0.189	0.188	0.182
Luxembourg	0.128	0.142	0.13	0.119	0.123	0.117	0.112
Mexico	0.123	0.125	0.123	0.124	0.121	0.12	0.115
Netherlands	0.138	0.141	0.13	0.127	0.136	0.129	0.127
New Zealand	0.182	0.17	0.156	0.159	0.165	0.163	0.156
Norway	0.122	0.123	0.12	0.129	0.142	0.122	0.137
Poland	0.192	0.18	0.174	0.156	0.152	0.139	0.135
Portugal	0.116	0.115	0.11	0.105	0.101	0.097	0.101
Slovak Republic	0.252	0.225	0.197	0.166	0.163	0.145	0.146
Slovenia	0.163	0.158	0.147	0.141	0.141	0.139	0.132
Spain	0.119	0.121	0.115	0.108	0.103	0.102	0.097
Sweden	0.193	0.184	0.163	0.157	0.159	0.151	0.142
Switzerland	0.099	0.097	0.095	0.088	0.086	0.082	0.083
Turkey	0.119	0.112	0.112	0.112	0.115	0.115	0.11
United Kingdom	0.12	0.114	0.106	0.098	0.099	0.093	0.09
United States	0.19	0.182	0.171	0.167	0.163	0.15	0.151
China	0.26	0.28	0.27	0.23	0.23	0.22	..
India	0.18	0.17	0.16	0.15	0.14	0.14	..
Indonesia	0.15	0.14	0.13	0.12	0.12	0.11	..
Thailand	0.15	0.16	0.15	0.15	0.15	0.16	..
IEA	0.162	0.158	0.15	0.144	0.144	0.135	0.134
World	0.19	0.18	0.18	0.17	0.17	0.16	..
EU-28	0.14	0.14	0.13	0.12	0.12	0.12	..

Note: .. = data not available.

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Table A.4 TPES/population by country (toe per capita)

	2002	2004	2006	2008	2010	2012	2013
Australia	5.54	5.56	5.51	5.64	5.46	5.55	5.52
Austria	3.77	4.00	4.09	4.04	4.08	3.93	3.93
Belgium	5.46	5.66	5.52	5.49	5.56	5.06	5.06
Canada	7.92	8.38	8.35	7.94	7.36	7.20	7.14
Chile	1.62	1.71	1.80	1.81	1.80	2.14	2.18
Czech Republic	4.17	4.46	4.48	4.31	4.23	4.06	3.94
Denmark	3.54	3.60	3.73	3.50	3.51	3.10	3.13
Estonia	3.46	3.93	3.78	4.09	4.20	4.12	4.40
Finland	6.70	7.11	7.09	6.65	6.81	6.15	5.93
France	4.24	4.32	4.21	4.13	4.03	3.86	3.84
Germany	4.11	4.11	4.20	4.04	4.01	3.82	3.81
Greece	2.58	2.69	2.72	2.72	2.48	2.39	2.15
Hungary	2.52	2.58	2.71	2.64	2.57	2.37	2.31
Iceland	11.41	11.50	13.68	16.79	16.89	17.74	16.67
Ireland	3.69	3.55	3.41	3.29	3.13	2.89	2.90
Israel*	2.86	2.82	2.88	3.11	3.04	3.07	3.08
Italy	3.02	3.13	3.08	2.94	2.82	2.61	2.53
Japan	4.01	4.09	4.07	3.87	3.90	3.55	3.56
Korea	4.17	4.34	4.42	4.64	5.06	5.27	5.22
Luxembourg	8.16	9.33	9.15	8.60	8.31	7.69	7.31
Mexico	1.44	1.52	1.58	1.63	1.54	1.61	1.54
Netherlands	4.69	4.86	4.70	4.84	5.02	4.69	4.60
New Zealand	4.31	4.22	4.03	4.06	4.18	4.27	4.14
Norway	5.49	5.76	5.82	6.24	6.62	5.82	6.49
Poland	2.32	2.39	2.55	2.57	2.61	2.54	2.52
Portugal	2.49	2.46	2.38	2.32	2.21	2.02	2.11
Slovak Republic	3.48	3.41	3.46	3.39	3.28	3.08	3.13
Slovenia	3.42	3.57	3.65	3.83	3.53	3.40	3.19
Spain	3.12	3.26	3.22	3.05	2.77	2.71	2.54
Sweden	5.80	5.85	5.53	5.38	5.43	5.27	5.00
Switzerland	3.53	3.50	3.58	3.47	3.37	3.23	3.33
Turkey	1.12	1.19	1.34	1.39	1.44	1.56	1.53
United Kingdom	3.68	3.70	3.61	3.37	3.24	3.02	2.97
United States	7.83	7.87	7.69	7.48	7.15	6.81	6.90
China	0.98	1.27	1.48	1.60	1.89	2.14	..
India	0.44	0.47	0.50	0.54	0.60	0.64	..
Indonesia	0.77	0.80	0.81	0.80	0.87	0.87	..
Thailand	1.29	1.48	1.53	1.63	1.77	1.89	..
IEA	4.90	4.98	4.94	4.81	4.70	4.50	4.50
World	1.66	1.75	1.80	1.83	1.87	1.90	..
EU-28	3.53	3.61	3.60	3.50	3.41	3.24	..

Note: .. = data not available.

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Table A.5 Electricity consumption by country (Mtoe)

	2002	2004	2006	2008	2010	2011	2012
Australia	16.44	16.28	16.57	17.40	17.98	18.14	18.00
Austria	4.63	4.88	5.24	5.27	5.35	5.35	5.42
Belgium	6.75	6.93	7.10	7.11	7.17	6.89	6.99
Canada	42.08	43.58	44.23	46.84	43.51	44.44	43.17
Chile	3.52	4.05	4.37	4.60	4.71	4.98	5.35
Czech Republic	4.37	4.63	4.90	4.99	4.92	4.88	4.87
Denmark	2.80	2.84	2.91	2.85	2.78	2.75	2.70
Estonia	0.46	0.51	0.56	0.60	0.59	0.57	0.60
Finland	6.85	7.15	7.40	7.10	7.18	6.89	6.95
France	33.84	36.13	36.72	37.22	38.19	35.91	37.33
Germany	43.73	44.83	45.41	45.37	45.79	45.20	45.22
Greece	4.01	4.28	4.52	4.87	4.57	4.45	4.47
Hungary	2.71	2.74	2.86	2.95	2.94	2.97	2.82
Iceland	0.65	0.67	0.77	1.31	1.35	1.38	1.41
Ireland	1.87	1.98	2.23	2.29	2.19	2.14	2.08
Israel*	3.31	3.53	3.78	4.11	4.19	4.21	4.46
Italy	24.32	25.42	26.56	26.60	25.74	25.96	25.52
Japan	81.09	82.78	84.68	82.94	85.98	80.79	79.35
Korea	25.87	29.06	31.94	34.37	38.64	40.47	41.40
Luxembourg	0.51	0.55	0.57	0.57	0.57	0.56	0.54
Mexico	14.41	15.41	16.50	17.40	17.88	19.43	19.76
Netherlands	8.57	9.01	9.12	9.39	9.19	9.24	9.16
New Zealand	3.06	3.22	3.35	3.29	3.36	3.37	3.32
Norway	9.38	9.28	9.24	9.63	9.76	9.24	9.36
Poland	8.39	9.00	9.55	10.12	10.24	10.49	10.55
Portugal	3.57	3.84	4.11	4.16	4.29	4.16	3.98
Slovak Republic	1.96	2.07	2.03	2.13	2.08	2.13	2.06
Slovenia	1.01	1.08	1.13	1.10	1.03	1.08	1.08
Spain	17.67	19.84	21.17	21.94	21.05	20.94	20.66
Sweden	11.26	11.21	11.25	11.06	11.29	10.72	10.95
Switzerland	4.65	4.83	4.97	5.05	5.14	5.04	5.07
Turkey	8.73	10.29	12.16	13.73	14.62	15.82	16.59
United Kingdom	28.67	29.15	29.69	29.40	28.28	27.34	27.31
United States	305.79	312.70	322.38	329.35	325.65	324.82	320.51
China	107.76	147.87	199.33	244.67	296.77	332.18	355.02
India	34.88	39.83	46.72	53.21	62.53	69.05	74.71
Indonesia	7.49	8.61	9.75	11.08	12.73	13.75	15.08
Thailand	8.62	9.89	10.99	11.65	12.84	12.79	13.91
IEA	714.02	739.00	763.38	778.58	779.04	771.66	766.94
World	1 145.85	1 244.07	1 358.24	1 450.91	1 539.54	1 587.30	1 626.41
EU-28	225.59	236.31	243.91	246.44	244.48	239.92	240.51

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LIST OF ACRONYMS

2DS	IEA <i>Energy Technology Perspectives 2°C Scenario</i>
4DS	IEA <i>Energy Technology Perspectives 4°C Scenario</i>
ACEEE	American Council for an Energy-Efficient Economy
ADB	Asian Development Bank
AFD	Agence Française du Développement (France)
AfDB	African Development Bank
AGF	Advisory Group on Climate Change Financing
AISA	PT Tiga Pila Sejahtera Food (Indonesia)
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
ATRI	American Transportation Research Institute
AUD	Australian dollar
BC	British Columbia (Canada)
BEE	Bureau of Energy Efficiency (India)
BEF	Better Energy Financing (Ireland)
BEMS	Building Energy Management System
BERs	Building Energy Ratings (Ireland)
BEV	battery electric vehicle
BLY	Bachat Lamp Yojana (India)
BMWFW	Federal Ministry of Science, Research and Economics (Austria)
BMWi	Federal Ministry of Economic Affairs and Energy (Germany)
BOI	Board of Investment (Thailand)
BREEAM	Building Research Establishment Environmental Assessment Method
BRT	bus rapid transit
BSN	National Standardization Agency of Indonesia
CAB	Climate Awareness Bond
CAD	Canadian dollar
CAFÉ	corporate average fuel efficiency
CBI	Climate Bonds Initiative
CCAP	Centre for Clean Air Policy
CDC	Caisse des Dépôts et Consignations (France)
CDM	Clean Development Mechanism
CDP	Carbon Disclosure Project
CEB	Council of Europe Development Bank
CEEF	Commercialising Energy Efficiency Finance
CEFIA	Clean Energy Finance and Investment Authority (United States)
CERS	Certified Emissions Reductions
CESAR	Canadian Energy Systems Analysis Research
CFLs	compact fluorescent lamps
CHEEF	China Energy Efficiency Financing Programme
CHUEE	China Utility-Based Energy Efficiency Programme

CICERO	Centre for International Climate and Environmental Research – Oslo (Norway)
CIFs	Climate Investment Funds
CO ₂	carbon dioxide
COSIA	Canada's Oil Sands Innovation Alliance
CPI	Climate Policy Initiative
CTF	Clean Technology Fund
DALY	disability-adjusted life-year
DCENR	Department of Communications, Energy and Natural Resources (Ireland)
DECC	Department of Energy and Climate Change (United Kingdom)
DEEP	Debt for Energy Efficiency Projects (EIB)
DELP	Demand-side management Efficient Lighting Program
DG CLIMA	DG Climate Action (European Commission)
DG ENER	DG Energy (European Commission)
DSM	demand-side management
DSO	distribution system operator
EBRD	European Bank for Reconstruction and Development
ECBC	Energy Conservation Building Code (India)
eceee	European Council for an Energy Efficient Economy
ECO Canada	Environmental Careers Organization
EDC	Energy Data Centre (IEA)
EDT	Energy Demand Technology Unit (IEA)
EE	energy efficiency
EEA	European Environment Agency
EED	Energy Efficiency and Environment Division (IEA)
EED	Energy Efficiency Directive
EEEF	European Energy Efficiency Fund
EEFIG	Energy Efficiency Financial Institutions Group
<i>EEMR</i>	<i>Energy Efficiency Market Report</i>
<i>EEMR 2013</i>	<i>Energy Efficiency Market Report 2013</i>
<i>EEMR 2014</i>	<i>Energy Efficiency Market Report 2014</i>
EEO	Energy Efficiency Obligation
EERF	Energy Efficiency Revolving Fund
EERS	Energy efficiency resource standards
EESL	Energy Efficiency Services Limited
EEU	Energy Efficiency Unit (IEA)
EGAT	Electricity Generating Authority of Thailand
US EIA	Energy Information Administration (United States)
EIA	Energy Investment Allowance (Netherlands)
EIB	European Investment Bank
EJ	exajoule
ELENA	European Local Energy Assistance
EMCA	Energy Management Company Association
EMS	Energy Management Systems
ENCON	Energy Conservation Promotion (Thailand)

ENEA	National Agency for New Technologies, Energy and Sustainable Economic Development (Italy)
US EPA	Environmental Protection Agency (United States)
EPBD	Energy Performance of Buildings Directive
EPC	energy performance contracting
EPPO	Energy Policy and Planning Office (Thailand)
EPTS	energy performance testing standards
ERDF	European Regional Development Fund
ESA	energy service agreement
ESCO	energy service compagnie
ESIF	European Structural and Investment Funds
ETP	Energy Technology Perspectives
EU-ETS	EU Emissions Trading Scheme
EUR	euro
EV	electric vehicle
EVI	Electric Vehicles Initiative
FEMS	Factory Energy Management System
FMO	Dutch Entrepreneurial Development Banks (Netherlands)
FYP	Five-Year Plan (China)
GBP	Green Bond Principle
GCF	Green Climate Fund
GDP	gross domestic product
GEEREF	Global Energy Efficiency and Renewable Energy Fund
GFEI	Global Fuel Economy Initiative
GGGI	Global Green Growth Institute
GIB	Green Investment Bank
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (Germany)
GJ	gigajoule
GWh	gigawatt hour
HDV	heavy-duty vehicle
HSR	high-speed rail
HT	high tension (India)
ICCT	International Council on Clean Transportation
ICE	internal combustion engine
ICL	incandescent lamp
ICP	Investor Confidence Project
ICT	information and communications technology
IDB	Inter-American Development Bank
IDFC	International Development Finance Club
IDR	In-Depth Energy Review (IEA)
IEA	International Energy Agency
IEE	Intelligent Energy Europe
IFC	International Finance Corporation

IFIs	international financial institutions
IFSC	International Financial Services Centre
IIP	Institute for Industrial Productivity
INR	Indian rupee
IPEEC	International Partnership for Energy Efficiency Cooperation
ISO	International Standards Organization
ITF	International Transport Forum
ITS	intelligent transport systems
JBIC	Japan Bank for International Cooperation
JCM	Joint Credit Mechanism
JI	Joint Implementation
KEMCO	Korean Energy Management Corporation
KM	kilometre
kWh	kilowatt hour
LDVs	light-duty vehicles
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design
lge	litres of gasoline-equivalent
LIEF	Long-term Industrial Energy Forecast
LIEN	Large Industry Energy Network (Ireland)
LMDI	Log Mean Divisia Index
LNG	liquefied natural gas
LT	low tension (India)
LTEP	Long-Term Energy Plan (Canada)
M&V	monitoring and verification
MDBs	multilateral development banks
MEE	<i>meerjarenaafspraken energie-efficiëntie</i> (Netherlands)
MEPS	minimum energy performance standards
METI	Ministry of Economy, Trade and Industry (Japan)
MIA	Green Projects Scheme (Netherlands)
MJ	megajoule
MJA	<i>meerjarenaafpraak</i> (Netherlands)
MOF	Ministry of Finance (China)
MOTIE	Ministry of Trade, Industry and Energy (Korea)
MRV	measurement, reporting and verification
Mtoe	million tonnes of oil-equivalent
NAS	The National Academies Press
NDRC	National Development Reform Commission (China)
NEEAP	National Energy Efficiency Action Plan
NEEAP-I	National Energy Efficiency Action Plan I
NEEAP-II	National Energy Efficiency Action Plan II

NHB	National Housing Bank (Germany)
NMEEE	National Mission for Enhanced Energy Efficiency (India)
NRCan	Natural Resources Canada
NYSERDA	New York State Energy Research and Development Authority (United States)
OECD	Organisation for Economic Co-operation and Development
PACE	Property Assessed Clean Energy
PAT	Perform, Achieve and Trade
PDA	Project Development Assistance
PEA	Provincial Electricity Authority (Thailand)
PF4EE	Private Finance for Energy Efficiency
PFE	Swedish programme for improving energy efficiency in energy-intensive industries
PJ	petajoule
pkm	passenger-kilometre
PLDV	passenger light-duty vehicle
PoAs	Programmes of Activities
PPP	purchasing power parity
R&D	research and development
REIT	Real Estate Investment Trust
RES	renewable energy sources
Rio+20	United Nations Conference on Sustainable Development
RMI	Rocky Mountain Institute
RVO	Netherlands Enterprise Agency
SDCL	Sustainable Development Capital Limited
SE4All	Sustainable Energy for All (UN)
SEAI	Sustainable Energy Authority of Ireland
SEE Action	State and Local Energy Efficiency Action Network
SEFF	Sustainable Energy Financing Facility
SER	Social and Economic Council of the Netherlands (Netherlands)
SIDBI	Small Industries Development Bank of India
SMEs	small and medium-sized enterprises
SNI	Indonesian National Standard
SOP	Standard Offer Program
SPDB	Shanghai Pudong Development Bank
SUV	sports utility vehicle
TFC	total final consumption
TOD	transit-oriented development (Indonesia)
TPEEE	Thailand Promotion of Electricity Energy Efficiency
TPES	total primary energy supply
UKGIB	United Kingdom Green Investment Bank
UN	United Nations

UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP FI	UNEP Financial Initiative
UNFCCC	United Nations Convention on Climate Change
UNPD	United Nations Population Division
USD	United States dollar
VAMIL	Green Funds tax advantage Scheme (Netherlands)
VFE	vehicle fuel economy
ZAR	South African rand
ZICSC	Zhongnengshitong Investment Consulting Service Center (China)



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ENERGY EFFICIENCY Market Report 2014

The evidence is clear: energy efficiency has played, and continues to play, a large and valuable role in the sustainable development of the global economy. The energy demand that is avoided as a result of steady improvements in the efficiency of energy-using stock such as buildings, cars and appliances is larger than the total final consumption from coal, oil or gas in IEA member countries.

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This year's report includes an in-depth look at energy efficiency developments in the transport sector and in finance. Huge new waves of demand for mobility are emerging in OECD non-member economies, bringing with them the challenges of pollution and congestion already faced in OECD countries. Fuel-economy standards and other policies are expected to help shape the market for more energy-efficient vehicles in the years to come. In financial markets, energy efficiency is becoming an important segment in its own right, aided by a growing range of financial products. We document the growing scale and diversity of energy efficiency products and actors.

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