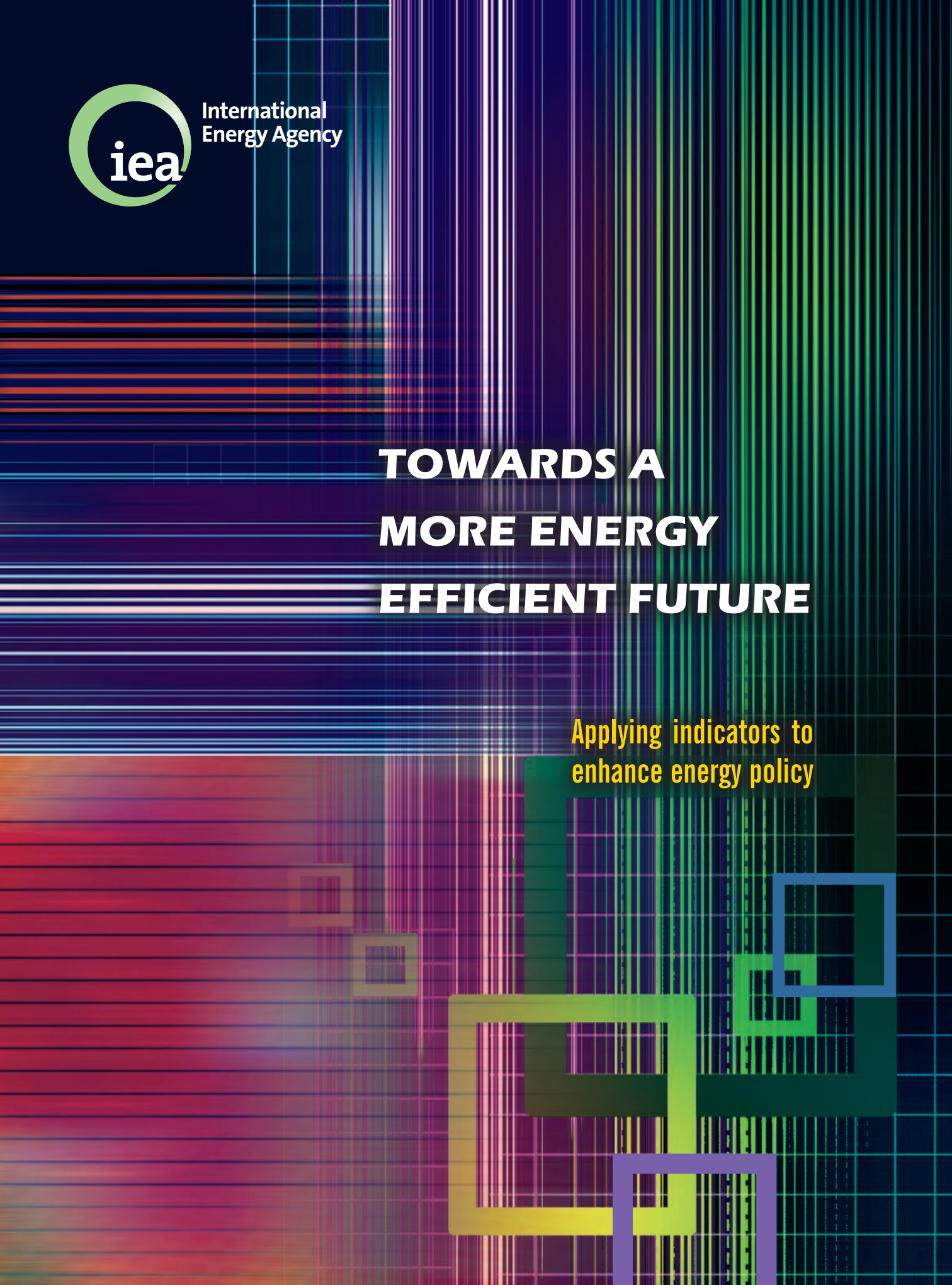
International
Energy Agency
iea
TOWARDS A
MORE ENERGY
EFFICIENT FUTURE
Applying indicators to
enhance energy policy

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-eight of the thirty OECD member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on international oil markets.
- To provide data on other aspects of international energy markets.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To promote international collaboration on energy technology.
- To assist in the integration of environmental and energy policies, including relating to climate change.

IEA member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea (Republic of)
Luxembourg
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

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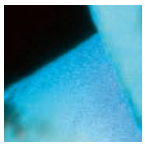




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The analysis contained in this brochure would not have been possible without the substantial support the IEA received from governments, organisations, companies and industry associations, all of which were involved in collecting and validating the underlying data. The IEA is grateful for the close collaboration of statisticians and analysts in IEA member countries, including experts from the European Union-sponsored ODYSSEE network.

This publication was prepared by the Directorate of Sustainable Energy Policy and Technology (SPT) in co-operation with the Energy Statistics Division (ESD). Nathalie Trudeau had overall responsibility for authoring the report. Peter Taylor, Head of the Energy Technology Policy Division and Jean-Yves Garnier, Head of ESD, provided invaluable leadership and inspiration throughout the project. Other main contributors include Davide D'Ambrosio, Michel Francoeur, Olivier Lavagne d'Ortigue, Bertrand Sadin, Marilyn Smith and Cecilia Tam. Many other IEA colleagues contributed to the analysis. Particular thanks go to the IEA Communication and Information Office (CIO) for their work in designing the layout and producing this publication.

INTRODUCTION

Energy supports a vast array of human activity and is a key driver of economic development. Yet recent analysis by the International Energy Agency reaffirms a vital message now being conveyed by multiple sources: despite some positive developments in how people use energy, current consumption patterns lead to an unsustainable energy future.

Towards a more energy efficient future…

Governments are uniquely positioned to establish, through policy implementation, the frameworks within which energy is both produced and consumed across many socio-economic levels. However, as governments around the world tackle the complex and intertwined challenges of improving energy security and reducing associated greenhouse gas emissions – while also supporting economic development objectives – two things are increasingly clear.

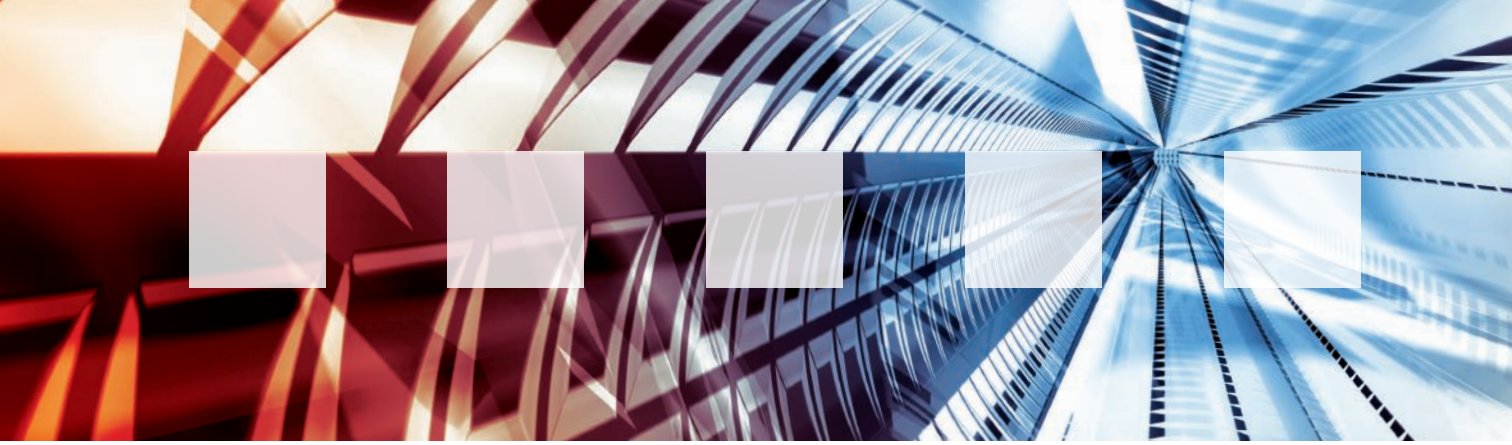
- Ensuring a better use of the world's energy resources will require policies that encompass a wide range of options. There is a growing recognition that improving energy efficiency is often the most economic, proven and readily available means of achieving this goal.
- Establishing and maintaining sound policy requires the availability of good quality, timely, comparable and detailed data that go well beyond those currently included in statistical energy balances, and reflect the distinct characteristics of economic activity and resources available in each country.

Recent work by the International Energy Agency seeks to fill existing knowledge gaps by improving data collection and analysis in six main energy-consuming sectors:

- ☒ Manufacturing
- ☒ Households
- ☒ Services
- ☒ Passenger transport
- ☒ Freight transport
- ☒ Electricity generation

The need for better data

This brochure reviews recent developments in energy consumption in six main energy-consuming sectors both globally and by region, comparing trends in the International Energy Agency (IEA) member and non-member countries. When possible, it incorporates detailed end-use data to overcome the limitations of the basic data contained in energy balances in order to highlight recent policy efforts that are already helping to create a more efficient energy future.



It also describes the IEA work to develop in-depth indicators of energy use, efficiency trends and CO_2 emissions, which will ultimately enable more informed decisions prior to policy making and more effective evaluation of policy impacts.

The overall aim of this publication is to demonstrate how more effective collection, interpretation and application of data and information can support strategic actions across all energy-consuming sectors.

Unravelling the complexity of energy consumption

For decades, countries around the world have used the data contained in statistical **energy balances** as a means of tracking energy consumption according to type of energy source and by major sector. For the overall economy, **aggregate indicators** such as total final energy consumption (TFC) per gross domestic product (GDP) or per capita are often used to construct a "big picture" of current patterns of energy use.

A key challenge in developing effective energy policies is that energy consumption is affected by many non-energy factors such as climate, geography, economy, travel distance, home size and the structure of the manufacturing sector. Thus, no single solution will be equally effective in all contexts.

Aggregate indicators have the advantage that they are often readily and widely available: thus, they can reveal high-level developments in energy use and can be constructed to facilitate basic cross-country comparisons. However, their usefulness is limited and inappropriate use can generate misleading results. For example, it would be incorrect to rank energy efficiency performance according to a country's TFC per GDP or per capita.

Thus, in order to develop estimates of overall energy efficiency, detailed data are required for the main end-use sectors. As each main sector is influenced by different underlying factors, different explanatory data will be needed depending on the sector analysed. Such data are not reported in energy balances and are currently available for only a few countries amongst both IEA members and non-members.

Experience shows that assessing the role of energy efficiency measures in reducing energy consumption is particularly challenging: in effect, it requires the calculation of the negative – how much energy was not consumed.

Collective effort to develop tools to improve data collection

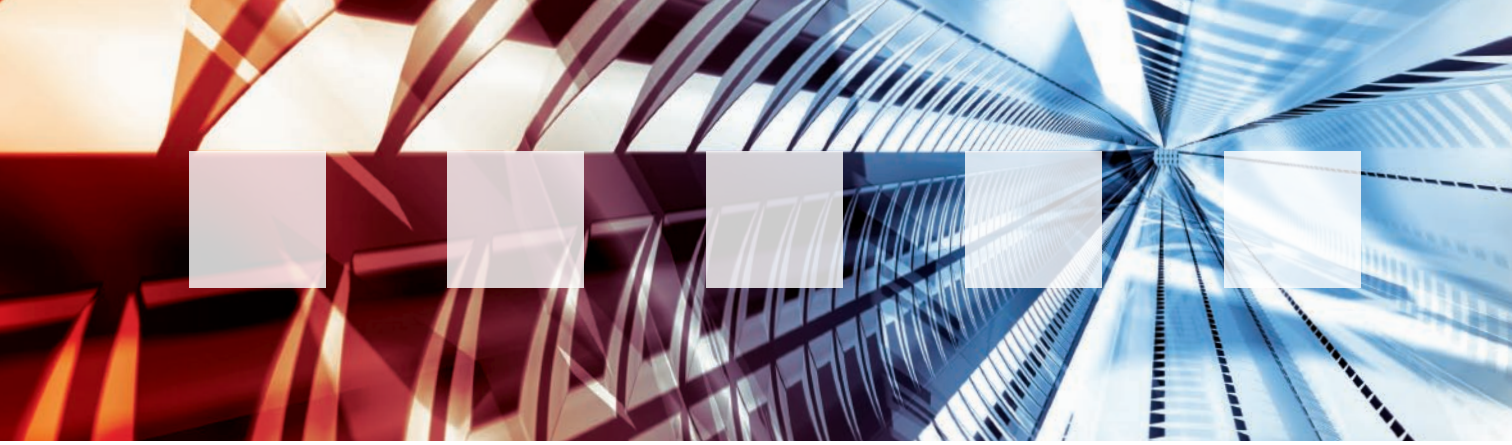
To facilitate the reporting of comparable data across all IEA member countries, the IEA has worked with the ODYSSEE Network (European Union) and the Asia-Pacific Economic Cooperation (APEC) to develop **a standard energy efficiency template**. The template (which is similar to – and builds on the success of – the IEA annual energy statistics questionnaires of fuels) establishes uniform system boundaries, data definitions and methodologies specific to energy consumption and related data.

Early use of this template by member countries has already allowed the IEA Secretariat to define a series of **disaggregate energy indicators** that aim to capture key data relevant to each major sector. Generally, these disaggregate indicators probe deeper than energy balances by focusing on:

☒ Activity levels	☒ Energy efficiency trends
☒ Structural effects	☒ Potential for future energy savings

Such indicators provide a much more effective means of tracking the evolution of energy use within a country and conducting comparative analyses. They can help to identify emerging trends in end-use sectors – including the factors behind increasing energy consumption and those that restrain it. They also help to uncover areas that hold the greatest potential for improving energy efficiency and the overall scope for further energy savings. Ultimately, indicators can thus be used to shape priorities for future actions and to monitor progress.

When endorsed by IEA member countries, the energy efficiency template will constitute a strong foundation for effective policy development.



Applying indicators to understand past trends, assess energy savings and enhance energy policy

Using data from energy balances, analysts can track overall growth in energy consumption over a period of time. However, it is not possible to single out the underlying factors determining growth rates – including the contribution of energy efficiency measures. Recent efforts by several IEA member countries to collect more detailed end-use data have helped to address these limitations in three different ways:

Understanding past trends

For example, energy balance data for a group of 11 IEA member countries show that energy consumption increased by 22% since 1973. More importantly, detailed end-use data available for these 11 countries demonstrate that without energy efficiency policies and measures put in place over the same period, energy consumption would have been 63% higher in 2006.

The energy savings from improved efficiency in these countries represent significant progress:

- 63 EJ (1 500 Mtoe) of energy saved in 2006, enough to meet the entire energy needs of Russia, India and Canada in 2006;
- USD 1.1 trillion of energy cost savings in 2006 alone (based on 2006 energy prices);
- 5 Gt of CO_2 emissions avoided, equivalent to global emissions from the industrial sector in 2006.

Assessing potential for energy savings

Detailed end-use data and indicators are equally essential for assessing the further contribution of energy efficiency. The IEA estimates show that large potentials remain across all sectors. For example,

- in **industry**, global application of best available technologies and best practices in the five most intensive sectors could lead to energy savings of 15 EJ per year while also reducing CO_2 emissions by 1.3 Gt per year;
- in public **power generation**, global adoption of current best practice levels of efficiency for fossil fuels would result in annual fuel savings of between 28 EJ (roughly the total primary energy supply [TPES] of Canada, Italy and the United Kingdom combined) and 35 EJ (the equivalent of TPES in Japan and Germany combined). Corresponding CO_2 savings would be about 2.3 Gt to 2.9 Gt.

Enhancing energy efficiency policies

This capacity to track trends and identify potential savings makes detailed end-use data and energy efficiency indicators key to launching and monitoring any energy efficiency policy. An analysis of the impacts to date of energy efficiency policies implemented by IEA member countries reveals that:

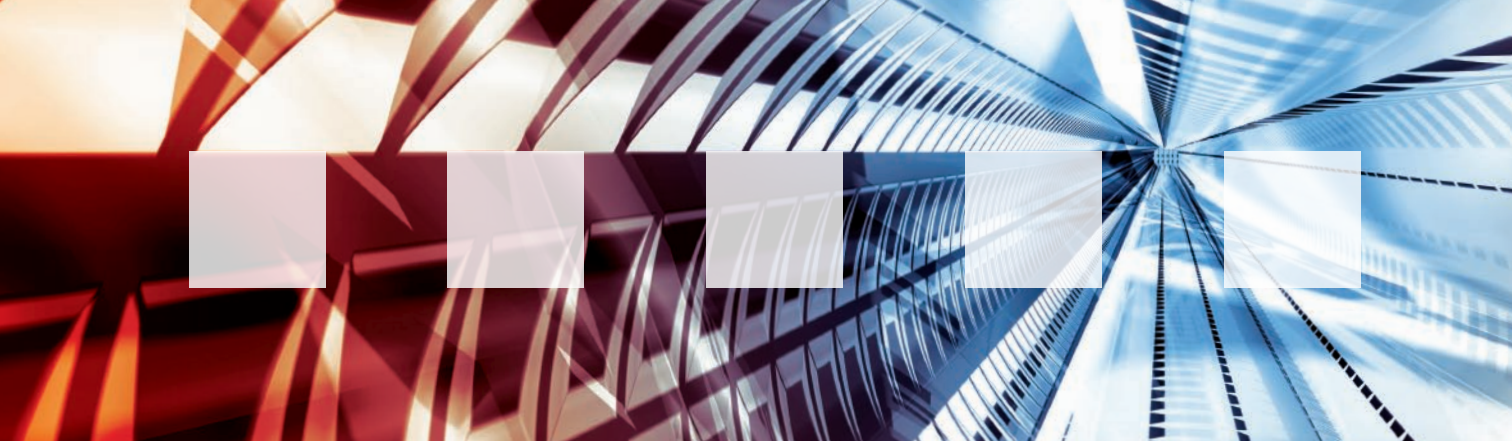
- Effective policies do make a difference. In each of the main energy-consuming sectors, there is evidence of improved efficiency, most of which result in reduced CO_2 emissions. In some cases, however, changes in consumption patterns within a given sector or sub-sector reduce the overall impact of efficiency gains.
- While it is clear that such measures work, the fact is that currently available energy data are a poor foundation for developing an in-depth understanding of how or why – or indeed, for analysing which measures are most effective and warrant broader implementation. This fact underlines the reality that existing data and information are too sparse to precisely analyse the impacts of specific measures.
- Clearly, more data – and different kinds of data – are needed to support the strategic development, implementation and evaluation of energy efficiency policies.

In 2008, the IEA presented a list of high-priority policy recommendations to help governments stimulate rapid improvement of energy efficiency in buildings, appliances, lighting, transport, industry, power utilities and cross-sectoral areas. The IEA estimates that if implemented globally without delay, this suite of actions could save around 96 EJ (2 300 Mtoe) of energy and 8.2 Gt of CO_2 per year by 2030 – equivalent to twice the European Union's yearly energy use and emissions (IEA, 2008).

This IEA indicator analysis shows that improvements in energy efficiency over the past years have played a key role in limiting global increases in energy use and CO_2 emissions. Of serious concern, however, is the rapid deceleration of the rate at which energy efficiency has improved since 1990. Recent rates have been about half of those experienced in the previous two decades, and will now need to increase substantially in order to achieve a more secure and sustainable energy future.

Used together and applied broadly, **energy indicators** and the **energy efficiency template** will enable energy stakeholders to more precisely analyse specific aspects of main energy-consuming sectors while fully accounting for the unique nature of each national context (for example, in relation to energy resources and sectors experiencing strong growth).

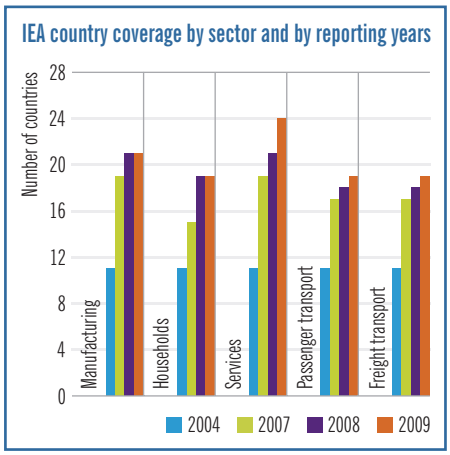
The data collected through the energy efficiency template could allow for a deeper quantitative assessment of the savings delivered by specific policies, complementing the qualitative evaluation of policy implementation conducted by the IEA in *Implementing Energy Efficiency Policies: Are IEA member countries on track?* (IEA, 2009e).



The way forward: collecting and applying timely, accurate and comparable data

Many IEA member countries have come to recognise the importance of a strong statistical foundation to support their energy indicator activities. Their efforts to collect and release more detailed and more accurate statistics have strengthened the work of the IEA. As a result, it is now possible to analyse data at the aggregate sector level for two or more sectors for 22 IEA member countries. This is a marked improvement from the 11 countries available in 2004.

The IEA has now taken steps to ensure that all member countries can participate fully in strengthening the data collection, and thereby realise the national and collective benefits of reduced energy consumption and lower CO_2 emissions. The IEA now urges member country governments to do their part in two ways.



Source: IEA indicators database.

First, they should substantially improve their data collecting efforts across all sectors, with a view to optimising energy efficiency policy making and evaluation. Broad-scale implementation of the proposed energy efficiency template constitutes a starting point in improving policy-relevant data reporting. Failure to optimise its application will limit the usefulness of indicators and undermine the ability of analysts and policy makers to develop, implement and monitor successful energy efficiency and other related policies.

Second, governments must use the new knowledge gained through indicator analysis to take strong action, in a timely manner. In order to enhance energy security and minimise the impacts of climate change, governments must act now to develop and implement the necessary mix of market and regulatory policies, including stringent norms and standards. This should be complemented by efforts to drive down the CO_2 intensity of electricity generation by moving towards a cleaner technology mix.

As governments move forward, the IEA will engage with member and non-member countries, regional and international organisations, companies and other stakeholders to continuously refine the energy indicators, improve the template, and develop transparent and consistent international databases and methodologies. The Agency's ultimate goal is to ensure that policy makers have access to the highest quality data and information – and can demonstrate to their publics a serious commitment to promoting energy efficiency and aggressively moving towards a more sustainable energy future.

WORLDWIDE AND REGIONAL TRENDS IN ENERGY CONSUMPTION

TRENDS 1990-2006:[1] energy consumption and CO_2 emissions

The IEA uses statistical **energy balances** to analyse energy consumption in all countries by major end-use sectors and energy sources. Recent analyses confirm that the current trends lead to an unsustainable energy future:

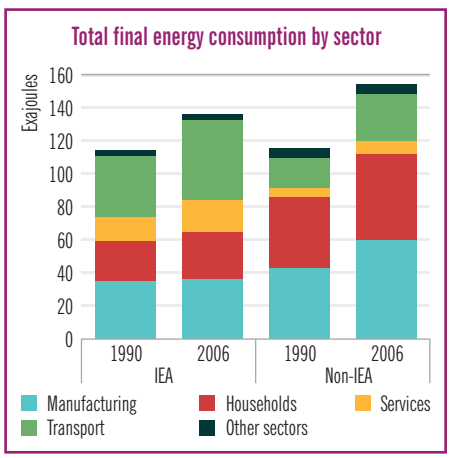
- global final energy consumption increased by 26%;
- associated CO_2 emissions rose by 31%.

On a more positive note, the same analyses clearly demonstrate that – armed with the right information – governments can influence these trends by implementing more effective energy policies. A first step in that direction is acquiring a clear understanding of current trends, and their associated challenges and opportunities.

Evolution of energy consumption by end-use sectors

Trends in energy consumption by end-use sectors vary significantly between countries and regions.

- **Globally**, energy consumption grew in all end-use sectors of the economy, with highest rates of growth in the transport (40%) and service (39%) sectors. Manufacturing remained the largest energy-consuming sector, accounting for 33% of total final energy consumption (TFC) in 2006.
- In **IEA member countries**, energy consumption increased by 19%. About 52% of this growth can be attributed to a significant increase in transport, the highest consuming sector. Growth in the service sector accounted for 22% of the increase.
- In **IEA non-member countries**, energy consumption patterns show a very different picture. As a result of rapid economic development, manufacturing (39%) and households (34%) dominate energy consumption. Despite having the highest growth between 1990 and 2006 (62%), the service sector still accounted for a small share (5%) of TFC.



Note: Other sectors includes construction, fishing and agriculture/forestry.
Sources: IEA, 2009a; IEA, 2009b; IEA estimates.

1. 2006 is the latest year for which detailed energy and related activity data are available. Aggregate energy consumption data are available from IEA energy balances up to 2007 and energy supply data are available up to 2008.

Evolution of energy consumption by energy sources

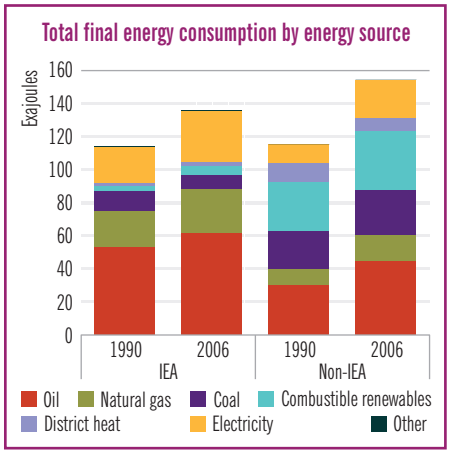
Although some similarities are evident, the final energy mix is quite different between IEA member and non-member countries.

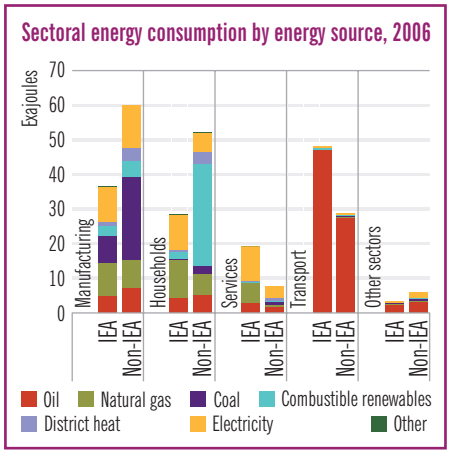
Globally, **oil products** continue to be the most important energy source in both IEA member and non-member countries, accounting for 37% of TFC in 2006. The increase in oil consumption between 1990 and 2006 (28%) is mostly attributable to the increase in the transport sector, which accounts for 70% of total oil consumption. Amongst IEA member countries, only those in the Pacific region have a large share of oil use in non-transport sectors. In IEA non-member countries, oil products are also important fuels in manufacturing and households.

Electricity consumption grew rapidly (60%) on the global scale and reached 18% of TFC in 2006. This increase was mostly driven by increased ownership of electricity-consuming appliances and equipment in the household and service sectors. In IEA non-member countries, rural electrification programmes in many developing countries also contributed to the increase.

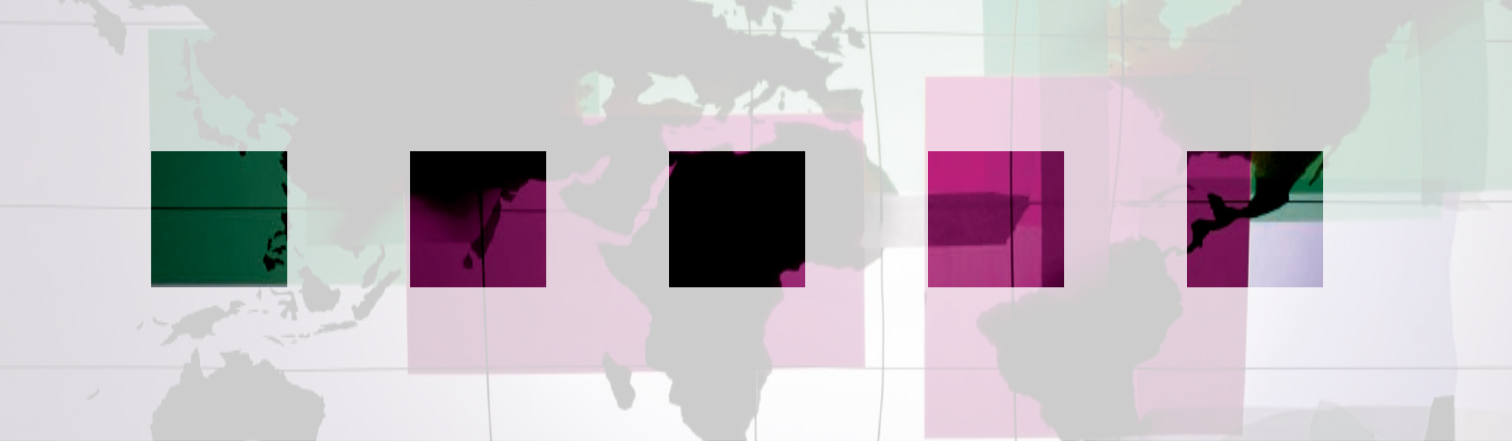
Global **coal** consumption declined in the 1990s, but the trend reversed in recent years. **China**, which accounted for 53% of global coal consumption in 2006, is the main driver of this increase. In IEA member countries, coal is not a major energy source for the end-use sectors; it represented only 6% of TFC in 2006, down from 11% in 1990.

Consumption of **combustible renewables** energy accounted for 14% of the world TFC in 2006. The vast majority (86%) of combustible renewables are used in IEA non-member countries, primarily for cooking and heating purposes in the household sector.





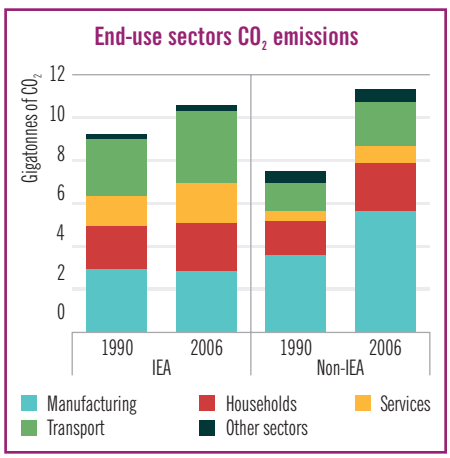
Notes: Other includes geothermal and solar. Other sectors includes construction, fishing and agriculture/forestry. Fuel use in electricity and heat production is excluded.
Sources: IEA, 2009a; IEA, 2009b; IEA estimates.



Evolution of CO_2 emissions

The total **CO_2 emissions** produced by each sectors depends on several factors including the sector's overall level of energy consumption and the mix of energy sources used (including the mix of energy sources used to produce any electricity consumed by the sector). Thus, sector ranking vary when examining CO_2 emissions rather than energy consumption.

- **Globally**, for the end-use sectors, manufacturing (39%) remains the largest CO_2 emitting sector, followed by total transport (25%) and households (20%).
- In **IEA member countries**, CO_2 emissions from end-use sectors increased by 14% between 1990 and 2006. However, the increase in CO_2 emissions was slightly less than the increase in TFC, indicating that the CO_2 intensity of final energy use has fallen.
- **IEA non-member countries** experienced a faster growth in CO_2 emissions (51%) than IEA member countries. About 75% of the growth in CO_2 emissions can be attributable to a significant increase in the manufacturing (54%) and transport (20%) sectors.



Note: Other sectors includes construction, fishing and agriculture/forestry.
Sources: IEA, 2009d; IEA estimates.

Drivers of change in energy consumption

Energy underpins nearly every aspect of a modern economy. Thus, the steady increases in economic activity in all sectors and in most countries since 1990 tend to put an upward pressure on energy consumption.

A starting point for understanding the evolution of final energy consumption is to examine various aggregate energy indicators. For the overall economy, energy intensity – expressed in terms of TFC per unit of GDP or TFC per capita – is the most commonly used indicator.

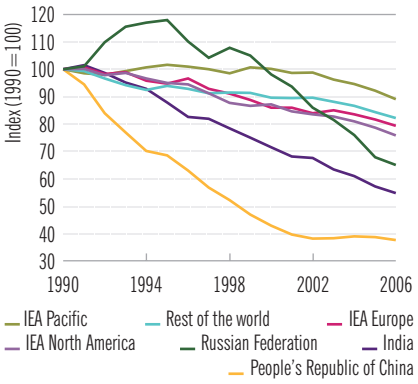
The ratio of **TFC per unit of GDP** measures how much energy is needed to produce one unit of economic output. Since 1990, this indicator has shown a steady decline on the global scale, revealing an improvement in the way energy is used. Overall, producing one unit of GDP in 2006 required 28% less energy than in 1990.

In general, IEA non-member countries have shown a faster decrease in TFC per GDP since 1990 than IEA member countries. These reductions can often be attributed to strong increases in GDP: rapid economic growth drove the introduction of modern, efficient technologies and processes that made it possible to produce the same level of goods and services with less energy.

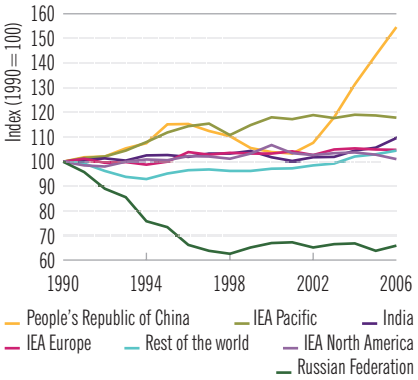
In contrast, **TFC per capita** shows an increase for most countries. The increase in IEA member countries (7%) was slightly higher than that for IEA non-member countries (5%). Two exceptional cases are worth noting:

- In the **Russian Federation**, energy use per capita fell by 34% due to the major economic restructuring that took place in the 1990s. If Russia is excluded from the calculation for IEA non-member countries, then TFC per capita in the remaining countries increased by 18% between 1990 and 2006, as opposed to the actual 5% shown for all non-member countries.
- **China**, which showed the most significant decrease in TFC per unit of GDP (-62%) between 1990 and 2006, had the biggest increase in TFC per capita (55%), reflecting a growth of GDP per capita – an indicator of wealth – of 311%.

Total final energy consumption per unit of GDP



Total final energy consumption per capita



Sources: IEA, 2009a; IEA, 2009b; IEA estimates.

In absolute terms, the largest consumers of energy on a per capita basis amongst IEA member countries in 2006 were **Luxembourg** (351 GJ/cap), **Canada** (204 GJ/cap), **Finland** (202 GJ/cap), and the **United States** (194 GJ/cap); other IEA member countries used on average 95 GJ/cap. By contrast, TFC per capita in **India** is 13 GJ. On average, TFC per capita in IEA non-member countries is only 22% of the level in IEA member countries.

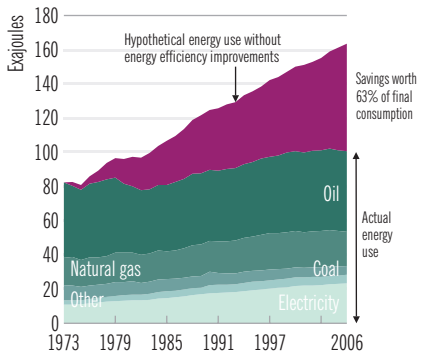
Energy efficiency trends and policies

Aggregate data included in energy balances allow only limited analysis of energy consumption and intensity trends. The collection of more detailed data, by sector and by end-use, permits deeper analysis of the influence of energy efficiency on the trends in energy consumption.

Analysis based on end-use data shows that the overall improvement in energy efficiency in a group of **11 IEA member countries** was 1.5% per year between 1973 and 2006. Without energy savings resulting from these improvements, TFC in the 11 countries would have been 63% higher in 2006. The largest contribution to the energy savings from efficiency for 2006 only was from the manufacturing sector (41%), followed by households (23%) and services (19%). The transport sector contributed least to the savings.

IEA analysis reveals a key finding: policy changes in response to the oil price shocks in the 1970s did considerably more to restrain growth in energy demand and reduce CO_2 emissions than the energy efficiency and climate policies implemented since the 1990s.

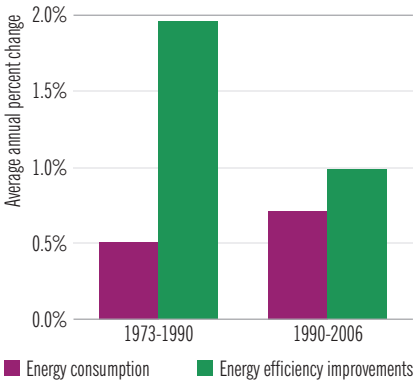
Overall energy savings in IEA11 from improvements in energy efficiency from 1973 to 2006



Notes: Other includes district heat and renewables. Fuel use in electricity and heat production is excluded.
Source: IEA indicators database.

Efficiency gains since 1990 were much lower than in previous decades; energy efficiency improvements for the 11 IEA member countries averaged 1% per year over the 1990 to 2006 period compared to 2% per year between 1973 and 1990. Had the earlier rate of energy efficiency improvement been sustained, there would have been no increase in energy consumption in the IEA11 since 1990. Recent data show some signs that the trends are changing again, and the rate of improvement may be increasing slightly in the last few years.

Rate of energy efficiency improvements, IEA11



Source: IEA indicators database.

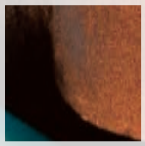
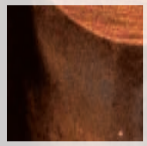
What data are needed to develop effective indicators?

Despite current limitations on the quality, detail and timeliness of existing data, important general trends are evident – and demonstrate that targeted policies can improve energy efficiency, thereby reducing both energy consumption and CO_2 emissions. The following pages provide sector assessments of how energy use has evolved since 1990, the main drivers influencing those trends and the potential for future savings.

More to the point, they also outline the minimal set of data needed to perform more precise analysis at the sector level, and thereby address the knowledge gaps that currently limit understanding and restrain action.

MANUFACTURING SECTOR



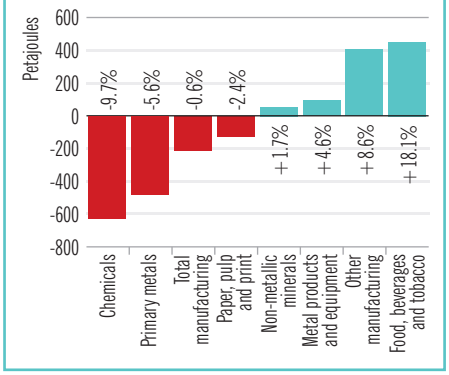
Industries covered:[2] ☒ **Paper, pulp and printing** ☒ **Chemicals** ☒ **Non-metallic minerals** ☒ **Primary metals** ☒ **Food, beverages and tobacco** ☒ **Metal products and equipment** ☒ **Other manufacturing**

TRENDS 1990-2006: energy consumption and CO_2 emissions

Globally, energy consumption in the manufacturing sector increased by 23%. In 2006, it accounted for 33% of TFC and 39% of end-use sectors CO_2 emissions.

- In **IEA member countries**, energy consumption grew by only 4% since 1990. This growth occurred in the least energy-intensive industries while energy used by the five most energy-intensive industries (paper, pulp and printing, chemicals, non-metallic minerals, ferrous and non-ferrous primary metals) decreased by 6%.
- In **IEA non-member countries**, energy consumption rose by 38%, mostly driven by rapid increases in China (134%), Brazil (69%) and India (57%). The five most energy-intensive industries were responsible for over 90% of this growth.

Changes in energy consumption by manufacturing sub-sectors between 1990 and 2006, IEA21



Sources: IEA, 2009a; IEA, 2009b; IEA estimates.

Drivers of change in energy consumption for 21 IEA member countries

Strong increases in manufacturing output have been the primary driver of energy consumption since 1990, as shown by two measures:

- manufacturing **value-added** increased by 45%;
- **production of major commodities** rose by more than 50%.

The upward pressure from increased output was offset by two important factors:

- a **structural shift** toward production from less energy-intensive industries;
- **energy efficiency improvements** in many industries.

Buoyant economic growth and high energy prices have played a role in improving energy efficiency. In order to satisfy increased demand for commodities, countries added new, more efficient capacity, thereby reducing the share of smaller, less efficient production units. To curb rising production costs, many companies invested in new, more efficient plants or carried out retrofits of existing facilities and introduced new, more efficient production processes.

Without the energy savings resulting from energy efficiency improvements in the manufacturing sector since 1990, energy consumption in 21 IEA member countries would have been 29% higher in 2006. The energy savings translate into 716 Mt of CO_2 avoided.

Energy efficiency trends and policies

In manufacturing, the strong decoupling of energy consumption from output demonstrates the effectiveness of efforts to improve energy efficiency.

2. Fuel-processing industries and fuels used as feedstocks are not included in the analysis.

Manufacturers, especially those in sub-sectors with high energy needs, recognised the increased benefits associated with improving energy efficiency and implemented a series of energy-saving measures. At the same time, energy efficiency and climate policies developed by governments helped to stimulate corporate investment in new, and often, best available technologies (BATs).

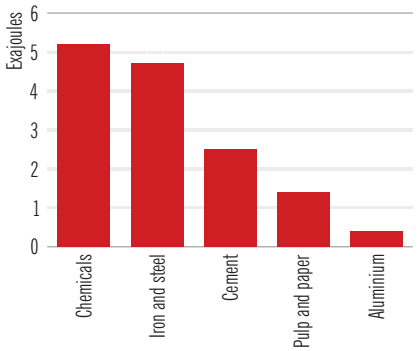
Future potential for energy savings

Despite the impressive recent efficiency gains, the manufacturing sector still shows considerable potential for further energy savings.

According to IEA estimates, **global application of BATs** in the five most intensive manufacturing industries could reduce energy consumption by between 13% and 29%. The estimated savings for the five sectors are 15 EJ per year, equivalent to 13% of energy use in industry in 2006 (IEA, 2009c).[3]

In practice, the rate of implementation of BATs by industry depends on several factors, including relative energy costs, raw material availability, equipment age, rate of return on investment and regulations. Governments have at their disposal a wide range of policy instruments – including market mechanisms, fiscal policies, regulatory measures and information schemes – to stimulate and accelerate the implementation of BATs.

Global potential savings from the adoption of BATs (based on 2006 data)



Note: Estimates of energy savings include fuel used as feedstock in the chemical sector.
Source: IEA, 2009c.

	IEA countries coverage		
	Energy consumption by	Value-added	Commodity production
Total manufacturing	28	25	n.a.
Paper and paper products	8	17	n.a.
* *Pulp*	0	0	21
* *Paper*	0	0	23
Chemicals	28	23	n.a.
Cement	10	0	23
Iron and steel	26	3	24 (crude steel)
Aluminium	0	0	18 (primary production)

What data are needed to develop effective indicators?

To effectively assess the potentials and impacts of energy efficiency measures in the manufacturing sector, countries need to:

- Collect detailed energy consumption data at the sub-sector level.
- Complement value-added data with physical production of key commodities.

Notes: This table presents selected energy-intensive industries only; it does not present an exhaustive list of manufacturing industries covered in the IEA indicators template.
IEA countries coverage indicates the number of IEA member countries for which data are currently available from 1990 to 2006 in the energy indicators database.
n.a. = not applicable.

3. Estimates of potential energy savings include fuel used as feedstock in the chemical sector.

HOUSEHOLD SECTOR

Main uses: ☒ Space heating and cooling ☒ Lighting ☒ Cooking ☒ Water heating ☒ Appliances and equipment

TRENDS 1990-2006: energy consumption and CO_2 emissions

Globally, household energy consumption increased by 20%; it accounted for 28% of TFC in 2006 and 20% of end-use sectors CO_2 emissions.

- In **IEA member countries**, household energy consumption rose by 18%, driven by strong growth in electricity consumption.
- In **IEA non-member countries**, household energy consumption rose by 21%. Combustible renewables, primarily used for cooking and heating purposes, remained the most-used energy source, but electricity was the fastest growing.

For 19 IEA member countries within the household sector, **space heating** energy consumption, corrected for yearly climate variations, increased by only 5%. In contrast, **appliances** energy consumption (mostly electricity) grew by 52% and has overtaken water heating as the second most important energy-consuming end-use.

Global residential energy consumption increased by 20%, while population increased by 24%. Thus, on average, each person is using less energy in their houses.

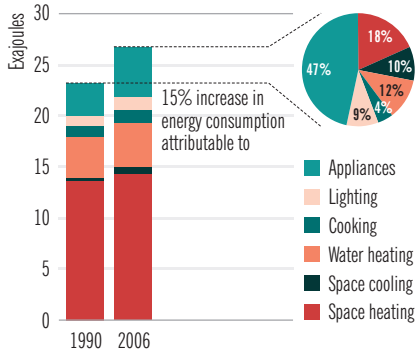
Drivers of change in energy consumption for 19 IEA member countries

The low growth in energy requirements per capita for space heating reflects an impressive 19% improvement in energy efficiency. In fact, efficiency improvements offset most of the increase in energy consumption arising from trends toward larger dwelling sizes and fewer occupants per dwelling.

A significant shift is evident for appliances. The share of large appliances (refrigerators, freezers, dishwashers and clothes washers) in total appliance energy consumption dropped from 47% in 1990 to only 28% in 2006. Increasing ownership of a wide range of small appliances (*e.g.* personal computers, mobile phones and other home electronics) was the key factor driving the rise in household electricity consumption – which is up by 41%.

Households energy consumption in 19 IEA member countries increased by 15% since 1990. Almost half of this increase was due to the large growth in appliances energy consumption.

Energy consumption and contribution to growth by end-use, IEA19



Note: Corrected for yearly climate variations.
Source: IEA indicators database.

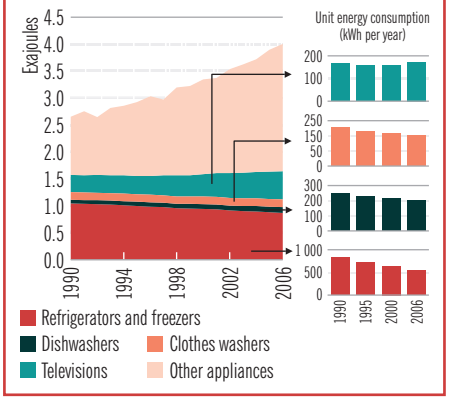
Energy efficiency trends and policies

Energy efficiency policies targeting households in IEA member countries have focused on restraining energy demand from space heating and large appliances through mandatory building codes, energy performance standards and targets, voluntary agreements with industry, and labelling to help guide consumer choices.

Detailed end-use data for 19 IEA member countries show that, in the case of space heating, these policies played a key role in achieving energy efficiency improvements, which averaged 1.3% per year since 1990.

For large appliances, information available for 13 IEA member countries shows a 24% improvement of the average unit energy consumption since 1990. However, deeper analysis clearly indicates that efficiency gains in large appliances were more than offset by two factors: growing stocks of large appliances, and rapid expansion in the stock and use of a broader array of small appliances.

Energy consumption by type of appliances, IEA13



Source: IEA indicators database.

Future potential for energy savings

Across the spectrum of 19 IEA member countries, the energy used to heat a house varies between 47 kJ/m^2 and 158 kJ/m^2. These striking differences in **climate-corrected energy intensities** suggest there are still important opportunities to further improve energy efficiency in space heating.

At the same time, the growing importance of small appliances creates new challenges and demonstrates an urgent need for energy efficiency policies that target this end-use.

What data are needed to develop effective indicators?

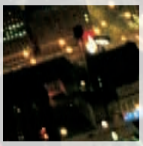
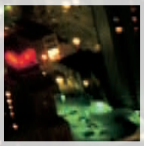
As a starting point to developing policy-relevant indicators in the household sector, countries should aim to collect the following information:

Energy consumption by	IEA countries coverage	Related data	IEA countries coverage
Energy source	28	Total dwellings	27
End-use	20	Occupied dwellings	27
* *Air conditioning*	5	Total dwelling area	24
Appliances		Stock of appliances	14
* *Large appliances*	13	Average UEC of large appliances stock	13
* *Televisions*	13	Annual heating degree-days	27
* *Computers*	4	Annual cooling degree-days	6

Note: IEA countries coverage indicates the number of IEA member countries for which data are currently available from 1990 to 2006 in the energy indicators database.

SERVICE SECTOR



Activities covered: ☒ Trade ☒ Finance ☒ Real estate ☒ Public administration ☒ Health ☒ Food and lodging ☒ Education ☒ Commercial services

TRENDS 1990-2006: energy consumption and CO_2 emissions

Globally, service is, with transport, the fastest-growing sector with an associated 39% increase in energy consumption. In 2006, services accounted for 9% of TFC and 12% of end-use sectors CO_2 emissions.

- In **IEA member countries**, the increase in energy consumption in services was 32%, much lower than the 62% observed in **IEA non-member countries**. Despite the slower increase, IEA member countries still accounted for 71% of global energy consumption in this sector in 2006.
- The **energy mix** of the service sector varies significantly between regions, reflecting differences in the availability of energy sources, the type of activity within the sector, and the end-use mix. **Electricity** is the only energy source for which consumption increased in all world regions.

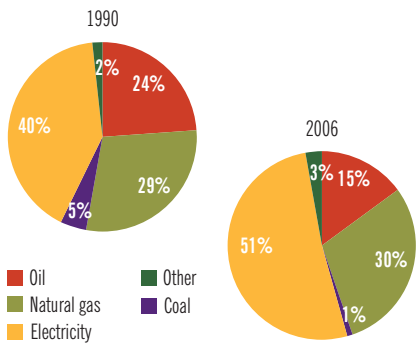
Drivers of change in energy consumption for IEA member countries

Economic activity is the main driver of energy consumption in the service sector; it is represented by the level of value-added output. In recent years, higher economic activity has led to increases in the stock of commercial buildings and to more people being employed in the sector. Both of these factors increase demand for energy services.

At present, a serious lack of detailed data makes it difficult to analyse trends in service energy consumption in most countries. The data available show a rapid increase in electricity consumption and a corresponding reduction in the share of fossil fuel use.

Analysis of the energy sources used by the service sector in IEA member countries helps to better understand which end-uses drove the increase in consumption.

Share of energy consumption by energy source, IEA member countries

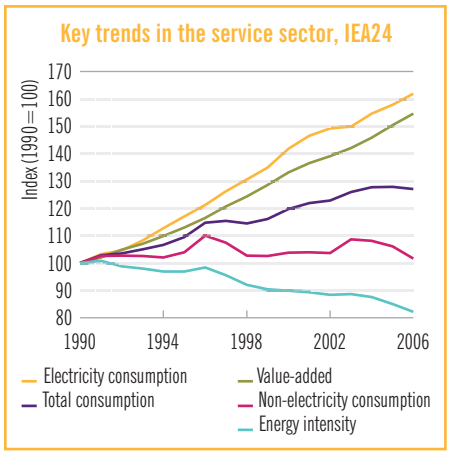


Electricity consumption in service increased by 66% since 1990; it is now by far the dominant energy source. This strong increase reflects the growing importance of electricity-using devices such as lighting, office equipment (including computers) and air conditioning.

By contrast, use of **fossil fuels** (mainly for space heating) increased by only 5%. This decline in the share of fossil fuels reflects limited increases in space heating energy consumption as compared to other end-uses, rather than lower demand for space heating itself.

Note: Other includes district heat and renewables.
Source: IEA, 2009a.

Energy efficiency trends and policies



Source: IEA indicators database.

There is some evidence that energy efficiency improved in the service sector: for **24 IEA member countries**, energy consumption grew less rapidly than economic activity. In addition, energy intensity – the energy used by unit of value-added – fell by 18% between 1990 and 2006, entirely driven by a significant decline in the use of fossil fuels.

However, interpreting these trends in respect to changes in efficiency is difficult due to a lack of more detailed structural information. In the absence of detailed data at the end-use level – and of electricity-using devices in particular – it is not yet possible to quantify the degree to which energy efficiency and policy measures contributed to restraining the growth in energy consumption in the service sector.

Future potential for energy savings

Available data do show that the potential for energy savings in the service sector varies widely for different end-uses. In-depth analysis at the end-use level is needed to develop indicators that can help to define the most important potential for efficiency improvements and support the development of relevant policies.

What data are needed to develop effective indicators?

The service sector represents a dual challenge: it is the fastest-growing consuming sector, yet it is also the sector in which data availability is the most problematic. Given its increasing importance, there is an urgent need to collect the data needed to properly track developments in the main end-uses in the sector.

Energy consumption by	IEA countries coverage	Related data	IEA countries coverage
Energy source	28	Total service floor area	7
End-use	3	Floor area addition	0
		Number of employees	21
		Services value-added	24

Note: IEA countries coverage indicates the number of IEA member countries for which data are currently available from 1990 to 2006 in the energy indicators database.

PASSENGER TRANSPORT

Transport modes: ☒ Light-duty vehicles ☒ Buses ☒ Trains ☒ Planes

TRENDS 1990-2006: energy consumption and CO_2 emissions

Global passenger transport energy consumption data are not available from country energy balances. As a result, analysis of the sector can be performed only for **19 IEA member countries** (IEA19).

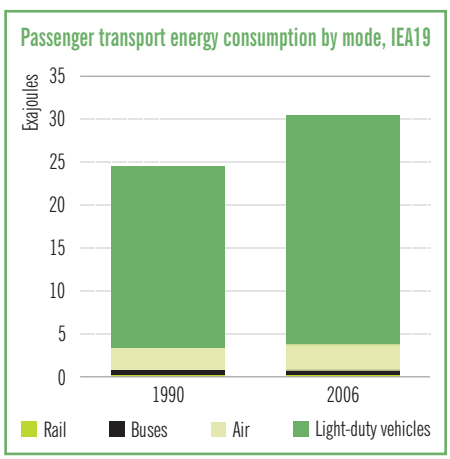
- Passenger transport energy consumption in IEA19 increased by 24%, with shares of the various modes remaining quite stable since 1990. CO_2 emissions increased by 22% over the period and accounted for 23% of end-use sectors CO_2 emissions in 2006.
- **Light-duty vehicles** (LDVs) remained the largest energy consumer, accounting for 87% of the passenger transport energy consumption. They are also the fastest-growing mode, with an increase of 25% between 1990 and 2006.
- **Oil** is the dominant energy source for passenger transport. However, data available for IEA19 indicate that the share of diesel vehicles in the overall stock more than doubled since 1990.

Drivers of change in energy consumption for 19 IEA member countries

LDVs are responsible for 91% of the growth in passenger energy consumption. Given this strong influence, understanding the factors that underpin LDV use is essential to the development of effective policies to restrain their energy consumption and associated CO_2 emissions.

Passenger-kilometres (pkm) and the **efficiency of vehicles** are the two main determinants of LDV energy consumption. Both are affected by a wide range of interacting factors such as: occupancy rate of vehicles; distance travelled; density of population; car ownership; income levels of drivers; local transport policies; and price of fuel.

Indicators that can be built with available data show that only one factor helped to restrain growth in LDV energy demand: energy efficiency, which improved by 6% since 1990.

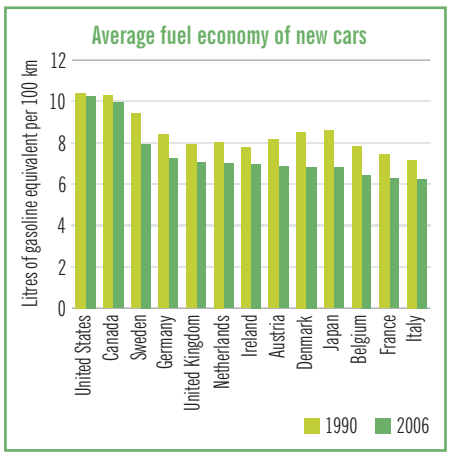


Source: IEA indicators database.

Energy efficiency trends and policies

Most policies targeting this sector focus on car fuel economy and programmes that encourage consumers to buy smaller and more efficient vehicles. The improvement in energy efficiency reflects, at least in part, that those policies had a positive impact.

According to available data, fuel economy of new cars improved by 15% since 1990. However, growth in consumption due to increased number of vehicles and increased travel per capita has more than supplanted any gains achieved through efficiency improvements.



Source: IEA indicators database.

Future potential for energy savings

The average fuel economy of new cars sold varies greatly amongst a smaller sub-set of **13 IEA member countries** – from 10.2 l/100 km in the United States to 6.2 l/100 km in Italy. These variations are explained, in part, by different consumer preferences, but they also suggest significant opportunities to further improve LDV fuel economy in many countries.

Recent IEA analysis estimates that **incremental technology improvements** and **hybridisation** could deliver an average 50% reduction, globally, in new car fuel economy. However, policies will be needed to ensure the benefits from improved energy efficiency are not undermined by consumer preferences toward ever larger, heavier and faster vehicles.

Recent data on passenger-kilometres (pkm) travelled suggest that travel patterns may be changing; since 2004, buses and train pkm have increased more rapidly than LDV pkm. This might indicate that the population is slowly modifying its transport habits and increasingly opting to use more efficient modes of transportation.

What data are needed to develop effective indicators?

Detailed information by passenger transport mode and related activity data are required to assess the success of passenger transport policies.

Energy consumption by	IEA countries coverage	Related data	IEA countries coverage
Energy source	25	Passenger-kilometres by mode	20
Transport mode	21	Stock of passenger cars	26
		Average fuel consumption of car stock	21

Note: IEA countries coverage indicates the number of IEA member countries for which data are currently available from 1990 to 2006 in the energy indicators database.

FREIGHT TRANSPORT

Transport modes: ☒ Trucks ☒ Trains ☒ Ships

TRENDS 1990-2006: energy consumption and CO_2 emissions

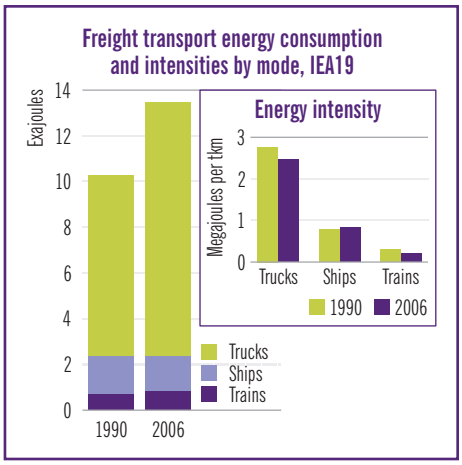
Global freight transport energy consumption data are not available from country energy balances. As a result, analysis of this sector can be performed only for **19 IEA member countries** (IEA19).

- Freight transport energy consumption increased by 31% since 1990. The strong growth in consumption was almost entirely due to higher energy demand for trucking. CO_2 emissions increased by 29% over the period and accounted for 11% of end-use sectors CO_2 emissions in 2006.
- **Trucks** are by far the largest energy user, accounting for 83% of the overall freight transport energy consumption in 2006. Trucks energy consumption increased by 41% since 1990.

Drivers of change in energy consumption for 19 IEA member countries

The increase in freight transport energy consumption was mostly driven by a 39% increase in the level of freight activity as measured by **tonne-kilometres** (tkm) travelled. About 58% of the growth in activity is attributable to the increase in trucking tkm.

The energy intensities of trucks, trains and ships vary significantly, with trucks being the most intensive. The difference in intensity between modes has important implications for energy consumption trends: because of its much higher energy intensity, growth in truck freight haulage drives up energy consumption much more quickly than growth in trains or ships. Consequently, efforts to reduce the intensity of trucking will lead to higher energy savings than reductions in trains and ships.



Source: IEA indicators database.

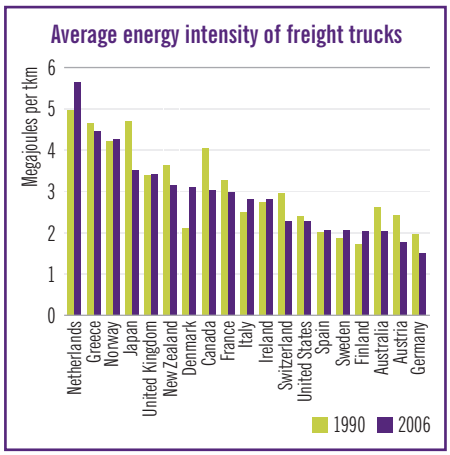
Trains are, by far, the most energy efficient mode of freight transportation. On average, for 19 IEA member countries, it requires 10 times more energy to transport one tonne of goods over one kilometre by truck than by train.

Energy efficiency trends and policies

To date, very few IEA member countries have implemented policies to restrain the growth of energy consumption in freight transport. Japan is the exception: its Top Runner Program defines stringent **energy efficiency standards for heavy-duty trucks** that are the first of their kind in the world. Other countries have implemented **driver training programmes** that provide drivers with on-road energy-saving tips and advice, and **information technology systems** that allow

fleet managers to plan more efficient schedules and routing. Given the limited detailed information available, it is not yet possible to fully analyse the impacts of such policies and programmes.

An aggregate analysis, taking into account the relative changes in intensity by mode, estimates that the overall efficiency of freight transport improved by 0.6% per year since 1990. Without the energy savings resulting from these improvements, freight transport energy consumption would have been 9% higher in 2006. Looking specifically at trucks, the analysis estimates that efficiency (intensity corrected for the change in load factors) improved by 0.7% per year since 1990.



Source: IEA indicators database.

Future potential for energy savings

When examining the energy intensity by mode, country comparisons show three areas for large reductions in freight energy consumption: **better management of the load factors**; **greater use of trains and ships** where possible; and **improved fuel economy of trucks**.

Even though trucks have become somewhat more efficient over time, IEA analysis reveals major opportunities to realise more significant savings through technical and operational measures (such as driver training), and logistical systems to improve efficiency in the handling and routing of goods. According to IEA estimates, better technologies can increase the efficiency of new trucks by 30% to 40%.

Energy consumption by	IEA countries coverage	Related data	IEA countries coverage
Energy source	24	Stock of freight trucks	25
Transport mode	21	Load factors for trucks	19
		Tonne-kilometres by mode	24

What data are needed to develop effective indicators?

Energy consumption by mode and related activity data are required to develop basic indicators for freight transport. Load factors are needed to support the quantification of energy efficiency.

Note: IEA countries coverage indicates the number of IEA member countries for which data are currently available from 1990 to 2006 in the energy indicators database.

ELECTRICITY GENERATION SECTOR

TRENDS 1990-2006: energy consumption and CO_2 emissions

Globally, electricity generation increased by 60%. Associated CO_2 emissions increased by 57% and represented 38% of global fuel combustion-related CO_2 emissions.

- Electricity production increased by 37% in **IEA member countries**. Natural gas represents a growing share in the mix of energy sources used for electricity generation.
- The increase in **IEA non-member countries** was much higher (100%), with most of this growth met by generation from coal.

Drivers of change in energy consumption

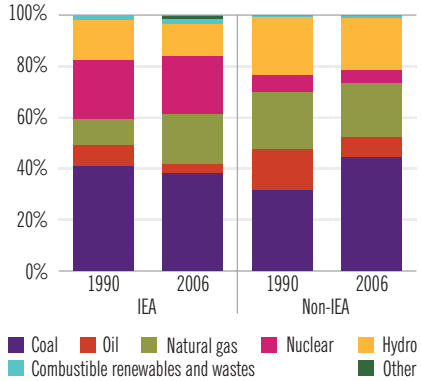
Since electricity supply and demand must be balanced at all times, the increase in demand is the ultimate driver of the increase in production.

Overall, increased electricity demand was mostly driven by the growing number of households, increased activity in the service sector, and widespread diffusion of air conditioning, appliances and electric equipment.

In **IEA non-member countries**, particularly in developing countries, programmes to increase the rate of electrification (especially in rural areas) were also an important factor that increased demand.

Electricity production was responsible for 33% of total global fossil fuel use in 2006 and 38% (10.7 Gt of CO_2) of fuel combustion-related CO_2 emissions. Improving the efficiency of electricity production therefore offers a significant opportunity to reduce dependence on fossil fuels, which also helps to combat climate change and improve energy security.

Electricity generation by energy source



The overall efficiency of combustible fossil fuel sources varies greatly depending on the quality of the input and the technology used to transform it into electricity. The current global average efficiencies of electricity production are 35% for coal, 40% for natural gas and 37% for oil.

The **increased share of natural gas** in the mix of fossil fuels used for electricity production in IEA member countries helped improve fossil fuel efficiency to 40% in 2006, up from 37% in 1990. **Continued reliance on a larger share of coal**, which is currently the least efficient fossil fuel, resulted in much lower average efficiency (33%) in 2006 in IEA non-member countries.

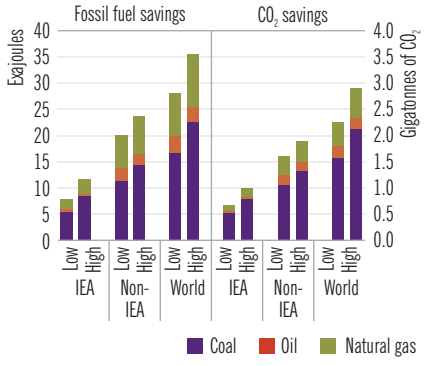
Note: Other includes geothermal, solar, wind, tide/wave/ocean energy, etc.
Sources: IEA, 2009a; IEA, 2009b.

Energy efficiency trends and policies

Reducing transmission and distribution losses is an important means of improving efficiency in the electricity generation sector. In 2006, such losses represented 10% of final electricity consumption worldwide. The situation improved in IEA member countries: overall losses fell from 9% in 1990 to 7% in 2006.

The **stock** and **age of power plants** also are key determinants of efficiency. Efforts to replace old power plants and generation units with newer models (such as supercritical coal-fired generators or combined-cycle gas turbine plants) have led to positive results. However, policies to reduce air pollutants sometimes require the installation of **pollution abatement equipment** that consumes additional energy at the power plant, thereby offsetting some of the efficiency gains achieved through new generation technologies.

Technical fuel and CO_2 savings potential for main activity producers



Source: IEA analysis.

Future potential for energy savings

Analysis shows several opportunities to realise significant gains in efficiency in electricity generation from combustible fuels. Finding ways to reduce the heat loss associated with creating steam to move turbines would be a major step forward.

For fossil-fuelled power plants, estimates suggest the **technical fuel savings potential** for main activity producers is between 23% and 29% of current inputs to electricity generation, with an associated CO_2 reduction potential of 2.3 Gt of CO_2 to 2.9 Gt of CO_2 per year. About one-third of the potential savings would come from IEA member countries. This underscores the importance of improving the efficiency of power production in all countries – developed, developing and in transition.

What data are needed to develop effective indicators?

The electricity sector is well covered in energy balances. However, improvements in the quality of data is needed, especially in term of power plants inputs and outputs, use of renewables to generate power, electricity generation and use from auto-producers, and use of combined heat and power.

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Glossary

Activity refers to the basic human or economic actions that drive energy use in a particular sector. It is measured as value-added output for manufacturing and services; as population levels in households; as passenger-kilometres for passenger transport; and as tonne-kilometres for freight transport.

Auto-producer of electricity or heat is an enterprise which produces electricity and heat for its own use in support of its main business but not as its main business.

Best available technology is taken to mean the latest stage of development (*i.e.* state-of-the-art) of processes, facilities or methods of operation, which include considerations regarding the practical suitability of a particular measure for enhancing energy efficiency.

Carbon intensity is the amount of CO_2 emitted per unit of energy use.

Coal includes hard coal, lignite/brown coal and derived fuels (including patent fuel, coke oven coke, gas coke, BKB, coke oven gas and blast furnace gas). Peat is also included in this category.

Combustible renewables comprise biomass and animal products (wood, vegetal waste, ethanol, animal materials/wastes, etc), municipal waste and industrial waste.

Electricity generation refers to electricity production in electricity-only plants and in combined heat and power (CHP) plants. Only public plants are included in this publication.

Energy intensity is the amount of energy used per unit of activity. This publication uses changes in energy intensity as a proxy for developments in energy efficiency.

Freight transportation includes the domestic haulage of goods by trucks, trains, ships and barges. In this study it does not include international haulage, air freight transport and pipelines.

Fuel mix represents the share of various fuels such as coal, oil, natural gas, heat and electricity that make up final energy use.

Gross domestic product (GDP) is a measure of economic activity, defined as the market value of all final goods and services produced within a country (output approach). In this publication, GDP figures are given for calendar year, expressed in 2000 USD. The conversion from national currency to USD is done using either purchasing power parities (PPP) or market exchange rates (MER).

Households cover all energy-using activities in apartments and houses, including space and water heating, cooking, lighting and the use of appliances. It does not include personal transport.

Light-duty vehicle (LDV) refers collectively to all light-duty vehicles including cars, mini-vans, sport utility vehicles and personal-use pick-up trucks.

Manufacturing covers finished goods and products for use by other businesses, for sale to domestic consumers, or for export. Total manufacturing is divided into the following key industries: food, beverages and tobacco; paper, pulp and printing; chemicals; non-metallic minerals; primary metals; metal products and equipment; and other manufacturing. The fuel-processing industries and fuels used as feedstock are not included.

Natural gas includes gas works gas but excludes natural gas liquids.

Oil comprises crude oil, natural gas liquids and petroleum products, such as heavy fuel oil, gas/diesel oil, liquefied petroleum gas, motor gasoline and kerosene.

Other fuels include geothermal and solar. The "Other" category is very small in the end-use sector.

Passenger-kilometres (**pkm**) are a measure of transport activity and are calculated by multiplying the number of kilometres a vehicle travels by the number of passengers. For example, if a vehicle carries two passengers for one kilometre, then it has travelled two passenger-kilometres (but only one vehicle-kilometre).

Passenger transport includes the movement of people by road, rail, sea and air. Road transport is sub-divided further into LDV and buses. In this study, only domestic air and sea travel are included; international air and sea travel are not covered.

Services include activities related to trade, finance, real estate, public administration, health, food and lodging, education and commercial services.

Structure represents the mix of activities within a given sector, *e.g.* shares of each sub-sector in manufacturing, energy end-uses in households, or the modal mix in passenger and freight transport.

Tonne-kilometres (**tkm**) are a measure of freight transport activity. For example, if a truck carries two tonnes for one kilometre, then it has travelled two tonne-kilometres (but only one vehicle-kilometre)

Total final energy consumption (**TFC**) is the sum of consumption by the different end-use sectors. Backflows from the petrochemical industry are not included in final consumption.

Total primary energy consumption (**TPES**) is made up of the production of primary energy plus energy imports minus energy exports minus international marine bunkers plus stock change (positive or negative).





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TOWARDS A MORE ENERGY EFFICIENT FUTURE

Applying indicators to enhance energy policy

Improving energy efficiency is a shared policy goal of many governments around the world. The benefits of more efficient use of energy are well known. Not only does it reduce energy costs and investment needs for energy infrastructure, it also can increase energy security and environmental sustainability by reducing fossil fuel dependency and CO_2 emissions. At the same time, energy efficiency increases competitiveness and promotes consumer welfare. Yet choosing appropriate indicators for quantifying energy efficiency has not been easy. Many questions remain unanswered.

What are the latest trends in global energy use and CO_2 emissions? How do factors such as demography, economic structure, income, lifestyle and climate affect these trends? What areas offer the greatest potential to further improve energy efficiency, and which data will best support energy efficiency policy development?

This publication answers such questions, using the latest insights from the IEA energy indicators work. The goal is to show policy makers how in-depth indicators can be used to track the progress in efficiency and identify new opportunities for improvements.