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Development of Energy Efficiency Indicators in Russia

INTERNATIONAL ENERGY AGENCY

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WORKING PAPER

INTERNATIONAL ENERGY AGENCY

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Executive summary

For decades, countries around the world have used aggregate indicators to construct a "big picture" of patterns of energy use. One of the most commonly used aggregate indicators is energy intensity: the measure of energy consumption per unit of gross domestic product (GDP). According to this indicator, Russia led G8 countries[1] in the reduction of energy intensity over the 1990s; Russia's energy intensity having improved by 2.5% a year. From 2000 to 2007, Russian energy intensity experienced an even higher rate of improvement with an average annual decrease of over 5%.

However, the usefulness of this indicator is limited and can be misleading; in actual fact, energy intensity is driven by many factors that are not necessarily related to energy efficiency. So it is perfectly possible to have improving energy efficiency, while still seeing rises in energy consumption (the inverse is also true). For instance, given the increase in international hydrocarbon prices during the 2000-07 period and the consequent growth in Russia's GDP, it is likely that the decline in energy intensity seen during this time frame was linked more to economic growth rather than improved energy efficiency.

This speaks to the need for mechanisms that can deliver a better understanding of the factors that affect energy intensity, not only within a given country but on a sector-by-sector basis that adequately reflects that country's economic landscape. Moreover, as each main sector[2] is influenced by different underlying factors, different explanatory data will be needed depending on the sector analysed. Much more detailed – and disaggregated – data than are currently available in standard energy balances are needed for each main end-use sector to assess the role of energy efficiency and the potential for further energy savings.

Over the past years, the International Energy Agency (IEA) has been developing **energy efficiency indicators** for each end-use sector, with the specific aim of helping to disentangle the various factors that drive and restrain energy use. Much of this work has been driven by the fact that improved energy efficiency is a shared policy goal of many governments around the world. The benefits of more efficient use of energy are well known and include reduced investments in energy infrastructure, lower fossil-fuel dependency, increased competitiveness and improved consumer welfare. Efficiency gains can also deliver environmental benefits by reducing greenhouse-gas emissions and local air pollution.

In recent years, the IEA has worked closely with Russia to improve energy data collection in general. While some progress has been made, much more work is required: most data required to understand past trends, assess the largest potential for energy savings and enhance energy efficiency policies are currently not available.

Despite the data gaps identified, analysis of some sectors of the economy indicates that there is a large energy savings potential in Russia. In fact, Russia is sometimes referred to as "the Saudi Arabia of energy efficiency"; its vast potential to reduce inefficient or wasteful energy consumption can be considered a significant "energy reserve". One IEA study estimated that energy efficiency improvements in Russia's district heating sector, alone, could save 30 billion cubic metres per year (bcm/yr) to 50 bcm/yr of natural gas (IEA, 2004). Optimisation of its transmission and distribution systems for natural gas, coupled with reductions in gas flaring by its oil and gas industry, could save up to a further 30 bcm/yr. In the industry sector, the energy savings from the application of best available technologies is estimated at 750 petajoules (PJ).[3]

[1] The G8 countries include Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States.

[2] The main energy-consuming sectors typically analysed include industry, residential, service and transport.

[3] It is important to note that this potential cannot be achieved in the short term. The rate of implementation of best available technologies in practice depends on a number of factors, including capital stock turnover, relative energy costs, raw material availability, rates of return on investment and regulations.

Russia, recognising the benefits of more efficient use of energy, is taking measures to exploit this potential. The president has set the goal to reduce energy intensity by 40% between 2007 and 2020. Furthermore, since 2008, Russia has taken important steps toward creating a legal and institutional framework to enhance efficient energy use and supply. A law on energy efficiency, passed in the Duma[4] in November 2009, introduces several important measures such as: restrictions on the sale of incandescent light bulbs; requirements for electrical products to be labelled according to their energy efficiency rating; provisions on mandatory commercial inventories of energy resources; new energy efficiency standards for new buildings and installations; and reductions in budget spending on purchasing energy resources. In addition, energy-intensive businesses will be required to carry out energy-saving research and to adhere to energy-saving and energy-efficiency programmes. This new protocol will also encompass a transition to a long-term tariff regulation and the establishment of a shared inter-ministerial energy efficiency information and analysis system.

In the past few years, the IEA worked closely with Russia's Federal State Statistics Service (Rosstat) and the newly formed Russian Energy Agency to support the development of energy efficiency indicators in Russia. This work, which has focused on the industrial, residential and transport sectors, is critical to an effective implementation and monitoring of Russia's ambitious energy intensity and efficiency goals. Since 2008, the IEA has been working with Rosstat to establish what data already exists, identify the data gaps, and assess the data quality.

The key findings of the IEA work with Russia on developing energy efficiency indicators form the core of this report. The report provides an overall assessment of recent trends, the current data situation in Russia, a list of the basic data needed to develop indicators, and the usefulness and limitation of some key indicators. It comprises five chapters covering the five main end-use sectors: industry, residential, services, passenger transport and freight transport.

The report also includes two methodological annexes. Annex A describes the IEA indicator approach, which uses the idea of a pyramid to portray the hierarchy of energy indicators (from most detailed to least detailed). Annex B includes the IEA energy methodology to analyse trends in energy consumption.

The data situation in Russia to develop indicators

Industry sector

The IEA has found that for industry, the data available from Rosstat national energy surveys and Russian National Accounts[5] are at a detailed enough level of disaggregation to calculate energy indicators based on physical units on production and provide an initial assessment of the effect of energy efficiency on industry energy consumption. However, several major issues still need to be overcome to develop energy efficiency indicators. For instance, Rosstat uses current Russian roubles in its value-added calculations, but in order to establish an overall indicator for the industry sector, value added in constant currency is required.[6] The IEA is currently working with Rosstat to address this data issue. Questions also exist regarding breaks in Rosstat time series for some data points. More difficult issues remain in relation to defining the coverage of energy consumption data (the boundaries for the industry). The boundaries issues will take much longer to resolve and will demand

[4] Russia's parliament.

[5] The National Accounts is a consistent and integrated set of macroeconomic accounts, balance sheets and tables based on a set on internationally agreed concepts, definitions, classifications and accounting rules. It includes data such as GDP, investment, private consumption and level of government debt.

[6] Value added is the difference between output and intermediate consumption for any given sector/industry – that is the difference between the value of goods and services produced and the cost of raw materials and other inputs used in production.

close collaboration with Rosstat experts and statisticians. More detailed analysis will also be needed to better understand Rosstat's industry energy consumption data.

Residential sector

Some of the necessary data to establish aggregate energy indicators for the residential sector are available for Russia from national annual surveys undertaken by Rosstat. These data include floor area, number of households and source of space heating. New questions added to Rosstat's National Household Income Survey 2010 will start to provide data required to build energy efficiency indicators. The survey will collect information on the stock, age and energy efficiency ranking of large household appliances, as well as on the type of light bulbs used. The national survey will provide data for 2010 and beyond for these new data points, critical for a better understanding of trends in energy consumption of appliances. This national survey will also continue to collect data on the size of dwelling and heated floor area, year of construction and type of heating equipment.

While the expansion of the survey is a positive step in developing an end-use energy database and assessing trends in residential energy and energy efficiency, additional data collection is required for other end-uses such as space heating and cooling, water heating and small appliances.

Service sector

Services is clearly the most difficult sector in which to collect data. At present, there is a serious lack of detailed data in Russia, making it difficult to analyse trends in service energy consumption. Russia is not unique in this regard; most IEA member countries lack detailed end-use data for the sector. Available data in IEA member countries show that the potential for energy savings in the service sector varies widely for different end-uses. As such, in-depth analysis at the end-use level is needed to develop indicators that can help to define the most important potential for energy efficiency improvements and support the development of relevant policies.

Transport sector

Much more work is needed in Russia to understand the structure and trends of energy consumption in the transport sector. Analysis of trends in energy and energy efficiency require a separate analysis for passenger and freight transport, as each is influenced by different underlying factors. In Russia, the necessary disaggregated data are not available for energy consumption, and activity data are only available for some transport modes.

Many data sources exists beyond official Rosstat transport sector data, which can go a long way to completing the picture of structure and trends of energy consumption – especially in terms of individual automotive transport, one of the fastest-growing sectors in IEA member countries and likely in Russia, too. Car registration and the annual car inspection process could provide an effective way to enhance the data on driving trends and automotive stock. Given these systems are already in place to gather this important input data, all that may be needed is a co-ordinating body or agency to set up a data collection system. Data estimates and models are also available from various research institutes. The IEA had very useful discussions and preliminary exchange of information with the Scientific and Research Institute of Motor Transport (NIIAT) in Moscow.

Introduction: the use of indicators to unravel the complexity of energy consumption

Governments are uniquely positioned to establish, through policy implementation, the frameworks within which energy is both produced and consumed across many socio-economic levels. As governments around the world tackle the complex and intertwined challenges of improving energy security and reducing greenhouse-gas (GHG) emissions associated with energy production and consumption – 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. Analysis shows that improving energy efficiency is often the most cost-effective, proven and readily available means of achieving this goal.
- Good quality, timely, comparable and detailed data that go well beyond those currently included in statistical energy balances, are necessary to establish and maintain sound policy. These data must reflect the distinct characteristics of economic activity and resources available in each country.

For the overall economy, aggregate indicators such as total primary energy supply (TPES) and total final energy consumption (TFC) per GDP is often used to construct a "big picture" of current patterns of energy use. Aggregate energy 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, they could often be misleading and consequently it would be incorrect, to rank energy efficiency performance according to a country's TPES or TFC per GDP.

In order to develop estimates of overall energy efficiency, detailed data are required for the main end-use sectors (industry, residential, services and transport). As each sector is influenced by different underlying factors, different explanatory data will be needed depending on the sector analysed. Recent efforts by several countries to collect more detailed end-use data have helped in developing indicators that can be used to understand past trends, assess potential for energy savings and enhance energy efficiency policies.

Understand past trends: Energy balance data for a group of 11 IEA member countries[7] show that energy consumption increased by 22% from 1973 to 2006. More importantly, detailed end-use data available for these 11 countries demonstrate that without improvement in energy efficiency over the same period, energy consumption would have been 63% higher in 2006.

Assess potential for energy savings: Detailed end-use data and indicators are equally essential for assessing the further contribution of energy efficiency. IEA estimates show that large potentials remain across all sectors of the economy.

Enhance 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 more effective 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 also results in reduced

[7] Australia, Denmark, Finland, France, Germany, Italy, Japan, Norway, Sweden, the United Kingdom and the United States.

carbon dioxide (CO_2) emissions. In some cases, however, unexpected changes in consumption patterns within a given sector or sub-sector reduce the overall impact of efficiency gains.

Box 1. The IEA energy efficiency indicators template

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 indicators 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 other data related to energy efficiency.

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, structural effects, energy efficiency trends and 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.

While it is clear energy efficiency policies 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 impact of specific measures.

Clearly, more data – and different kind of data – are needed to support the strategic development, implementation and evaluation of energy efficiency policies.

This paper examines various energy and energy efficiency indicators – their usefulness and limitations – and describes:

- The set of data needed to calculate key energy and energy efficiency indicators;
- Available data in IEA member countries and in Russia from this set of data; and
- What energy and energy efficiency indicators can be derived with this set of data, and what those indicators reveal.

Industry sector

The industry sector covers the manufacturing sector (the manufacture of finished goods and products), mining and quarrying of raw materials and construction. Power generation, refineries and the distribution of electricity, gas and water are excluded from the industry sector.

Russia's industrial sector is vast, including major enterprises in mining, energy, automotive, defence, construction, communication, consumer durables, construction equipment and textiles. But Russia's legacy of its Soviet past is the dominance of heavy industry such as iron and steel, petrochemicals and aluminium – all energy resource intensive. After having been set back by the global economic crisis of 2008, Russian industrial production grew an estimated 11% in 2009. Industrial output in Russia rose by 7.8% in January 2010, a sign that economic recovery was strengthening in Russia. While the production of consumer goods remained flat or increased marginally, production of cars and trains witnessed severe setbacks compared to 2008-09 levels.

Because of its Soviet legacy, Russian industry needs to restructure, streamline costs and ensure that its products meet demand in the most economic and environmentally sound way. The handful of energy efficiency success stories in Russia's industrial sector illustrates how competitive forces spur this on relative to regulate monopolistic markets. Russian industry is slow in realising its energy efficiency potential primarily due to a lack of awareness among managers and insufficient supply of long-term capital to finance energy efficient modernisation (World Bank, 2008). Russia is one of the country with the largest energy savings potential for the five most energy intensive industry (iron and steel, cement, chemicals and petrochemicals, aluminium and pulp and paper) (IEA, 2008; IEA, 2009; IEA 2010). In addition, companies in several sectors lack the incentive to save energy because product prices are growing faster than energy tariffs. In this regard, the continuation of electricity and gas sector reforms are critical to achieving this sector's energy efficiency potential.

Box 2. Energy efficiency trends in manufacturing sector

Globally, energy consumption in the manufacturing sector increased by 29% between 1990 and 2008.[8] In 2008, it accounted for 29% of TFC and 37% of end-use sectors CO_2 emissions. In Russia, manufacturing energy consumption decreased by about 29% between 1993 and 2008, while energy consumption in the five most energy-intensive industries decreased only by 2%.

An analysis of the manufacturing sector for 21 IEA member countries[9] indicates that 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. Energy consumption in those 21 IEA member countries would have been 29% higher in 2006 than it was without the energy efficiency improvements in the sector since 1990.

Despite the impressive recent efficiency gains in IEA member countries, the manufacturing sector still shows considerable potential for further energy savings. The estimated global savings for the five most energy-intensive manufacturing sectors (pulp and paper, chemicals and petrochemicals, iron and steel, aluminium, and cement) are 15 PJ per year – enough to meet the annual energy needs of industry, transport and households in Russia.

[8] Fuel-processing industries and fuels used as feedstock are not included in the analysis.

[9] IEA 21 includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Korea, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States.

Availability of industry data in Russia to develop indicators

To effectively assess the developments in energy efficiency trends, the impact of energy efficiency measures and the further potential for energy savings in the industry sector, the following data are required:

- Detailed energy consumption data by industry;
- Value-added data in constant currency; and
- Physical production of key commodities, where possible.

While energy consumption data are usually available from the energy balances of countries (although only at the two-digit International Standard Industrial Classification [ISIC] level), value-added data are not always available (or are available but not for the same level of detail as the data for energy consumption). Value added in constant currency by industry allows the development of indicators for heterogeneous industry, and are required to aggregate the detailed indicators to assess energy efficiency for the total industry sector.

Box 3. Impact of industrial structure

The value-added data by industry are also required to analyse the impact of structural changes in the sector. This information is essential when trying to understand trends in energy consumption, or when performing country comparisons.

Analysis shows that IEA member countries with high shares of energy-intensive industries (such as cement and iron and steel) usually rank among the most intensive countries. However, if those countries had the same structure as the average IEA countries, the aggregate manufacturing intensity would be reduced considerably; by over 20% in many cases.

In Russia, Rosstat has been collecting for numerous years industry-related data. Rosstat's 11 TER Form (Rosstat energy consumption questionnaire for industry) provides energy consumption at the four-digit ISIC level as well as the production in physical units for the same industrial breakdown. These data are available on an annual basis at both regional and national levels. The information from the 11 TER Form can be used to develop industry-specific indicators, and provide a proxy for the evolution of energy efficiency. The long time series available allows analysis of the evolution of energy efficiency at a detailed level of sectoral disaggregation. However, these multiple indicators do not provide an industry-wide assessment of how energy efficiency in each industry sector influenced the trends in energy consumption for the overall industry.

Physical units of production are the preferred activity variable to build detailed industry indicators. However, for an overall energy efficiency indicator for the industry sector as a whole, aggregation of the various industry-specific indicators is required. Given that physical units of production cannot be added together (one tonne of steel cannot be added to one tonne of clinker), a value-added approach is used from each subsector to provide a common basis.

In doing so, it is essential to use value added in constant currency to avoid including a bias induced by fluctuations on the monetary market. Value added, in current currency, are available from Rosstat's National Accounts at the four-digit ISIC level. However, the deflator to convert the current values to constant ones is only available for the mining, manufacturing and construction sectors. Deflators for the different manufacturing sectors are not available.

The energy consumption data from Rosstat's Form 11 TER and the value added from the National Accounts, if develop in constant roubles, would allow the development of an overall energy efficiency indicators for industry. However, the quality and comparability of the data, and the boundaries of each industry, still need to be validated.

For the industry sector, the IEA energy efficiency indicators template requires three elements: energy consumption data (at the two-digit ISIC level and by energy sources); value added in constant currency (two-digit ISIC level); and physical units of production for heterogeneous industry. These represent the minimum level of information required to develop meaningful energy and energy efficiency indicators.

Box 4. The benefits of energy efficiency indicators for companies

Experience in IEA member countries suggests that industry itself may be very interested in relevant energy efficiency indicators. Companies can use such indicators to draw lessons on how to become more energy efficient, and can benchmark themselves against other companies or chart their own progress over time. Ultimately, indicators can be used to increase competitiveness. With increasing tariffs for Russian domestic electricity and natural gas, more cost-reflective pricing will encourage more energy efficient behaviour – which, in turn, raises net revenues. Further stimulus for energy efficiency through national programmes could bring added incentives to industry: if shareholders view improved efficiency as supporting national goals, the company may see its share price increase.

Collecting data relating to energy use by small- and medium-sized enterprises (SMEs) is not yet a practice in Russia as the underlying legislation for mandatory reporting does not exist. IEA experience is that data from SMEs are an important component of the energy scene. In some IEA countries, SMEs report relevant data on a voluntary basis (in other countries, reporting is mandatory). The IEA also finds that is it often more difficult to collect data from large enterprises: if there are one or two companies in the sector, the enterprises may be averse to reporting due to confidentiality issues.

Industry data IEA member countries are required to report to the IEA through the energy efficiency indicators template,[10] as well as the number of IEA member countries that currently report such data to the IEA, are presented in Table 1. The table also shows which data are currently available from Russia.

Table 1: Industry data needed to develop basic energy and energy efficiency indicators

Data needed to develop indicators	Number of IEA member countries reporting the data			Data available from Russia		
	Energy use	Value added	Commodity production	Energy use	Value added	Commodity production
Agriculture, hunting, fishing and forestry	**28**	**25**	**n.a.**	**Yes**	**No**	**n.a.**
Mining and quarrying	**28**	**24**	**n.a.**	**Yes**	**No**	**n.a.**
Manufacture of coke, refined petroleum products and nuclear fuel	**28**	**18**	**n.a.**	**Yes**	**No**	**n.a.**
Manufacturing	**28**	**26**	**n.a.**	**Yes**	**No**	**n.a.**
Food products, beverages and tobacco products	28	24	n.a.	Yes	No	n.a.
Textiles, wearing apparel, fur and leather	26	24	n.a.	Yes	No	n.a.
Wood and of products of wood and cork, except furniture	24	22	n.a.	Yes	No	n.a.

[10] For each industry sector, energy use data are also required by energy source.

Data needed to develop indicators	Number of IEA member countries reporting the data			Data available from Russia		
	Energy use	Value added	Commodity production	Energy use	Value added	Commodity production
Paper and paper products	27	17	n.a.	Yes	No	n.a.
Pulp	*0*	*0*	*28*	*Yes*	*No*	*Yes*
Paper	*0*	*0*	*28*	*Yes*	*No*	*Yes*
Publishing, printing and reproduction of recorded media	8	18	n.a.	Yes	No	n.a.
Chemicals and chemical products	28	24	n.a.	Yes	No	n.a.
Rubber and plastics products	14	24	n.a.	Yes	No	n.a.
Non-metallic mineral products	28	25	n.a.	Yes	No	n.a.
Cement	*10*	*0*	*28*	*Yes*	*No*	*Yes*
Clinker	0	0	0	Yes	No	Yes
Basic metals	28	23	n.a.	Yes	No	n.a.
Casting of iron and steel	*28*	*0*	*28*	*Yes*	*No*	*Yes*
Casting of precious and non-ferrous metals	*0*	*0*	*n.a.*	*Yes*	*No*	*n.a.*
Aluminium	0	0	0	Yes	No	No?
Motor vehicles and other transportation equipment	23	23	n.a.	Yes	No	n.a.
Other manufacturing	28	21	n.a.	Yes	No	n.a.

Notes: n.a. = not applicable as the sector as defined in the table is too heterogeneous to have a single measure of physical production. 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. As the IEA has not yet received value-added data in constant currency, the value-added data are indicated as not being available from Russia. Coverage for Russia is based on IEA knowledge of the data situation in Russia for 2000 onward; these have been validated by Rosstat.

Key indicators for the industrial sector

Information collected through the IEA energy efficiency indicators template is used to develop energy and energy efficiency indicators that explain the changes in energy consumption over a period of time. Key energy and energy efficiency indicators that can be developed with the data collected through the template, as well as the purpose and limitation of those indicators, are presented in Table 2.

More detailed indicators can be built by collecting information at the process level for each sub-industry and facility characteristics. However, such data are available only for very few countries and for a limited number of sub-industries.

It is also possible to couple the information on energy consumption with data on energy prices in manufacturing, energy expenditures and capacity production to analyse the impact of these factors on the trends in energy consumption.

In some manufacturing sectors, portion of the energy consumption is influenced by weather conditions. The influence on energy consumption is different from industry to industry. Given the very limited information available on the impact of weather in industry, and the lack of internationally recognised methodology to perform such an adjustment in the industry, the IEA methodology does not take into account weather conditions in analysing the manufacturing sector.

Table 2: Key indicators to understand trends in energy and energy efficiency in industry

	Indicator	Data required	Purpose	Limitation
ENERGY AND ACTIVITY INDICATORS	**Total industry energy consumption by energy source**	• Total industry energy consumption by energy source.	• Insights on the role of the final energy mix on total final energy consumption. • Insights on the trends in CO_2 emissions.	• Observed energy trends not necessarily a result of improved (or worsening) energy efficiency. • One element, amongst many others, influencing trends in energy consumption. • Can be attributed to changes in relative fuel prices, shifts in industry structure and processes and implementation of environmental legislation that favours the use of cleaner fuels.
	Energy consumption by industry sectors and by energy source	• Energy consumption by industry sectors and by energy source.	• Explain the role energy mix played on the trend in energy consumption in each industry. • Insights on the trends in CO_2 emissions. • Not influenced by industry structure when developed at a very disaggregated level.	• Observed energy trends not necessarily a result of improved (or worsening) energy efficiency. • Influenced by changes in relative fuel prices, shifts in industry processes and implementation of environmental legislation. • Influenced by industry structure if develop at an aggregate level (*e.g.* two digits ISIC).
	Composition of industry value added (in constant currency)	• Value added in constant currency by industry sector at the two-digit ISIC level (or more detail).	• Provide information on the relative importance of each sector. • Insights of the impact of the structure of the industry on energy consumption. • Qualitative information helping to explain trends in energy consumption.	• Value added is influenced by a range of pricing effects unrelated to changes in the level of physical production. • Composition of industry value added, at two-digit ISIC level, may mask some important structural shift within an industry sector. • Does not provide the link between value added and energy required to quantify the impact of the structural change.
	Total industry energy consumption by unit of value added	• Total industry energy use. • Total industry value added (in constant currency).	• Reflects the trends in overall energy use relative to value added. • Indicates the general relationship of energy use to economic development.	• Influenced by factors such as geography, climate and structure of the economy. • Changes over time are influenced by factors not necessarily related to energy efficiency.

	Indicator	Data required	Purpose	Limitation
ENERGY INDICATORS	**Industry sectors energy consumption by unit of value added**	• Energy consumption by industry sector. • Corresponding value added (in constant currency).	• Indicate the general relationship of energy use to economic development.	• May hide some important structural shift within an industry (but this impact will be somewhat offset by using more detailed energy and value added data). • Value added are influenced by a range of pricing effects that are unrelated to changes in the underlying physical production.
ENERGY EFFICIENCY INDICATORS	**Industry sector energy use by unit of physical production**	• Energy consumption by industry sector. • Corresponding physical unit of production.	• Often called the "specific" or "unit energy" consumption. • Indicate the relationship of energy use to physical production. • At the disaggregated level, can give a better measure of the technical efficiency of a particular production process.	• It is not possible to compare indicators defined in differing units. • Cannot provide an aggregate picture of energy efficiency for the whole of industry.
	Decomposition of changes in industry energy consumption	• Energy consumption by industry sector and energy source. • Corresponding physical unit of production (if available). • Corresponding value added (in constant currency).	• Quantification of the factors underlying the changes in energy consumption over a defined period of time. • Changes in energy consumption are decomposed between industry structure effect, energy mix effect, and specific intensity effect (a proxy of energy efficiency). • This is the best indicator for total industry that can be developed with the data required in the IEA energy efficiency indicators template.	• This proxy for energy efficiency still includes effects that are not related to technical efficiency (such as the impact of climatic conditions and the change in the processes used within a facility).

Residential sector

The residential sector includes those activities related to private dwellings. It covers all energy-using activities in apartments and houses, including space and water heating, cooling, lighting and the use of appliances. It does not include personal transport, which is covered in the transport sector.

Between 1993 and 2004, residential energy consumption in Russia was greater than for the industry sector, as is typical for lower-income countries in harsh climates. However, in 2005 the commercial energy consumption data appear to have been readjusted upward, and resulted in a dramatic reduction in energy consumption in the residential sector. As a result, in 2005, Russian TFC in the industrial sector (5 169 PJ) surpassed that of the residential sector (4 628 PJ). Following this reduction, according to IEA data based on annual submissions from Rosstat, residential consumption has remained relatively flat over the 2005 to 2008 period.

On a per-capita basis, residential energy consumption roughly equals that in Canada, even though Canada has three times Russia's per capita floor space and electric appliances are larger and more widespread. Thus, Russian residential energy consumption is at least two-to-three times more energy intensive than Canada's. The reasons are known: lack of consumer control over heat regulation, low share of private ownership of apartments (landlords usually having little interest in investing in energy efficiency improvements) and price subsidies. Large potential for energy savings exists in the residential sector. A study from the IEA estimated that energy efficiency improvements in Russia's district heating sector could save 30 bcm/yr to 50 bcm/yr of natural gas (IEA, 2004).

The most significant barriers to energy efficiency in residential housing relate to building standards, public behaviour and difficulties in organising and financing energy efficiency improvements in common areas (World Bank 2008).

Box 5. Energy efficiency trends in residential sector

Globally, residential energy consumption increased by 20% between 1990 and 2006; it accounted for 28% of TFC in 2006 and 20% of end-use sectors CO_2 emissions. In Russia, residential energy consumption decreased by 32% between 1993 and 2006, and accounted for 26% of TFC in 2006.

Detailed end-use data for the residential sector are available for 19 IEA member countries,[11] allowing a deeper analysis of the factors influencing residential trends in energy consumption. The analysis indicates that the low growth in energy requirements for space heating per capita 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.

The analysis also reveals a significant shift in appliances energy consumption. The share of large appliances (*e.g.*, 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 and mobile phones) was the key factor driving the rise in residential electricity consumption – which is up by 41%.

Overall, residential energy consumption in these 19 IEA member countries increased by 15% since 1990; almost half of this increase was due to the growth in energy consumption of appliances.

[11] IEA 19 includes Australia, Austria, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom, the United States.

Availability of residential data in Russia to develop indicators

Total residential energy consumption, by energy source, is available from energy balances. As each end-use is influenced by different factors, the analysis of energy efficiency trends in the residential sector requires, at a minimum, detailed information at the end-use level, and associated activity data. Furthermore, as space heating is greatly influenced by climatic conditions, notably in countries with cold climates such as Russia, an adjustment is required to account for the yearly variation in weather conditions.

For developing policy-relevant indicators in the residential sector, the following data are required:

- energy consumption by major end-uses and by energy sources;
- main activity variables for the sector, including number of households and residential floor area;
- information on the stock and efficiency not only of large appliances, but also of small appliances given their growing importance; and
- information on heating and cooling degree-days to adjust for weather conditions.

Some activity data are available for Russia from Rosstat's National Households Income Survey on an annual basis for several decades. These include number of houses and floor area by dwelling type and year of construction, heated floor area and type of heating system. The survey also collects information on the access of households to the electricity and gas grid, and if dwellings are connected to the district heating system or have individual heating devices (and which energy source is used).

The IEA is encouraged by the new questions Rosstat included in its annual Household Budget Survey. Starting in 2011, the survey will include questions on: additional heat sources used by households; metering devices; number and type of light bulbs; number of appliances and year of acquisition; efficiency ranking; and class of large appliances. The survey, which will be conducted in 2011, will provide data for 2010 and beyond for these new data points.

Despite these positive developments, the minimal set of data required to develop energy efficiency indicators is not available for Russia. More information, at the end-use level, is necessary.

Box 6. Determining priority area for developing end-use data

Even in IEA member countries, developing the data for each end-use is a challenge and can be resource intensive (both in term of human and financial resources). The development of basic indicators can help to identify which end-use should be a priority for energy efficiency initiatives and policies in the residential sector and where to start in terms of data collection strategy. Once priority areas are determined, efforts should first concentrate on these end-uses. For example, if space heating is a priority area, then supplementary information (such as type of heating device, insulation of houses, age of capital stock and efficiency rating of heating equipment) could be collected to develop in-depth indicators, allowing the development of targeted actions.

Data that IEA member countries are required to report to the IEA through the energy efficiency indicators template, as well as the number of countries that are currently able to provide the data are presented in Table 3. It also presents which data are currently available from Russia.

Table 3: Residential data needed to develop basic energy and energy efficiency indicators

Data needed to develop indicators	Number of IEA member countries reporting the data	Data available from Russia
Energy consumption by:		
Energy source	28	Yes
End-use (and energy source)	20	No
Space heating	*25*	*No*
Space cooling	*5*	*No*
Water heating	*24*	*No*
Cooking	*23*	*No*
Lighting	*21*	*No*
Appliances	*24*	*No*
Refrigerators	2	No
Freezers	12	No
Refrigerator/freezer combinations	13	No
Dish washers	13	No
Clothes washers	14	No
Clothes dryers	4	No
Television/home entertainment	13	No
Personal computers/information and communication technology	5	No
Other appliances	24	No
Total dwellings	27	Yes
Total occupied dwellings	27	Yes
Total dwelling area	24	Yes
Stock of appliances	14	Yes
Refrigerators	1	Yes
Freezers	19	Yes
Refrigerator/freezer combinations	17	Yes
Dishwashers	15	Yes
Clothes washers	17	Yes
Clothes dryers	5	Yes
Television/home entertainment	13	Yes
PC/information and communication technology	4	Yes
Average unit energy consumption of large appliances stock	13	No
Annual heating degree-days	27	No
Annual cooling degree-days	6	No

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. Coverage for Russia is based on IEA knowledge of the data situation in Russia; which has been validated by the Russian Federation.

Key indicators for the residential sector

The data collected through the IEA energy efficiency indicators template provide a basis to better understand energy consumption trends in the residential sector, identify major trends by end-use and help identify areas for further investigation. Key indicators that can be developed with the set of data collected through the IEA energy efficiency indicator template as well as the purpose and limitation of those energy and energy efficiency indicators are presented in Table 4. For the buildings sector (residential and services), variation in weather conditions may have an important impact on trends and level of energy consumption. If the indicators are developed without taking the climatic conditions into consideration, the trends observed in aggregate indicators may be misleading.

More indicators can be developed by coupling the information on energy use with other data such as dwelling type, personal consumption expenditures, dwellings characteristics, energy expenditures or residential energy prices.

Table 4: Key indicators to understand trends in energy and energy efficiency in residential

	Indicator	Data required	Purpose	Limitation
ENERGY AND ACTIVITY INDICATORS	**Residential energy consumption by energy source**	• Energy consumption by energy source.	• Insights on the role of the final energy mix on total final energy consumption. • Insights on the trends in CO_2 emissions. • Provides qualitative information on which end-use might have been the fastest growing or is the most important.	• Observed trends in energy not necessarily a result of improved (or worsening) energy efficiency. • One element, among many others, influencing trends in energy consumption. • Changes can be attributed to increase in the use of appliances (mostly electricity), changes in fuel accessibility, replacement of heating systems and introduction of regulations and standards.
	Population per occupied dwelling	• Population. • Number of occupied dwelling.	• Occupancy rate is one of the factors influencing trends in energy consumption (there is an inverse relationship between occupancy rates and energy demand).	• Provide little information on its own, *i.e.* if the decrease results from a decrease in population, the impact on energy consumption may be negligible.
	Average dwelling size	• Total floor area. • Number of dwellings.	• Dwelling area usually has a major impact on energy consumption for space heating, lighting and cooling.	• Provide useful information only for end-uses that are impacted by the dwelling area. • One element, among many others, influencing trends in energy consumption.
	Residential energy consumption by energy source per capita	• Energy consumption by energy source. • Population.	• Can be constructed for many countries and provides a consistent basis for comparison. • Provides qualitative information on which end-use might have been the fastest growing.	• The indicator is influenced by the penetration rate of different appliances, the number of people per house, the trends in house size and house type, the efficiency of water and space cooling devices, the type of light bulbs used, the efficiency of the building shell, etc.
	Residential energy consumption per household	• Energy consumption. • Number of households.	• Provides a general overview of the trends in aggregate energy intensity. • When energy use by end-use is not known, energy use per household can be	• Does not measure energy efficiency developments. • Influenced by many factors not related to energy efficiency.

	Indicator	Data required	Purpose	Limitation
			used as an energy-intensity indicator. Some important conclusions can be drawn if the weather, ownership of energy-using appliances and dwelling area are known.	
ENERGY AND ACTIVITY INDICATORS	**Residential energy consumption per floor area**	• Energy consumption. • Total floor area.	• Monitor energy use in the residential sector. • Combined with energy use per household, provides useful insights on what might have been the main driver of energy consumption.	• Does not measure energy efficiency developments. • Influenced by many factors not related to energy efficiency.
	Residential energy consumption by end-use	• Energy consumption by end-use.	• Provide an indication of the trends in energy consumption and the relative importance of each end-use. • Provide an indication of priority areas to further improve data collection or develop energy efficiency policies.	• Provides little information on the impact of energy efficiency on the trend in energy consumption by end-use.
	Share of large appliances' energy consumption in total appliance energy consumption	• Large appliances energy consumption. • Total appliances energy consumption.	• Help understand trends in energy consumption for the appliances end-use. • Provides an indication of which segment of the appliance market is driving energy consumption. • Allow the development of more targeted policies.	• Influence by the age of the stock, the efficiency rating of the new appliances entering the market and the ownership level among other.
	Residential end-use energy consumption by floor area or households	• Energy consumption by end-use. • Number of occupied dwellings. • Occupied floor area.	• Related to, but not identical to, the inverse of energy efficiencies. • Used as a proxy for energy efficiency in many countries.	• Influenced by many non-efficiency factors including: type/age of heating equipment, ownership rate for appliances.

	Indicator	Data required	Purpose	Limitation
ENERGY EFFICIENCY INDICATOR	**Decomposition of changes in energy use: activity, structure and intensity effects**	• Energy consumption by end-use. • Population. • Dwelling area. • Appliance ownership. • People per dwelling.	• Provide a general understanding of the trends that influenced change in energy consumption. • Quantify the role of the activity, structure and end-use intensities on the development of energy consumption.	• Does not provide how different factors are impacting on each end-use.
	Decomposition of changes in space heating energy use: conversion efficiency, dwelling size, useful intensity and occupancy effects	• Space heating energy consumption by energy source. • Dwelling area. • People per dwelling. • Population.	• Allow the quantification of the useful energy intensity effect on total energy consumption (a proxy for energy efficiency). • This is the best indicator that can be developed for space heating with the data required in the IEA energy efficiency indicators template.	• This proxy for energy efficiency still includes effects that are not related to technical efficiency such as changes in the mix of housing type.

Service sector

The service sector includes activities related to trade, finance, real estate, public administration, health, education and commercial services.

According to IEA data, energy consumption in Russia's service sector increased over 65% during the decade between 1998 and 2008. This is largely due to a statistical readjustment in 2005. Notably, between 2005 and 2008, Russia's energy consumption in the service sector has increased by 17%. Given the strong economic growth Russia experienced until 2008, it is not surprising that its service sector grew so quickly. The global financial crisis also affected Russia, and we can expect a slowdown in energy consumption between 2008 and 2009. If Russian energy efficiency policies are effectively implemented into the future, this will be visible in its service sector.

Box 7. Energy efficiency trends in service sector

Globally, service is, with transport, the fastest-growing sector with an associated 39% increase in energy consumption between 1990 and 2006. In 2006, services accounted for 9% of TFC and 12% of end-use sectors' CO_2 emissions. 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.

Availability of service data in Russia to develop indicators

Energy consumption, by energy sources, is available for the service sector from country's energy balances. The assessment of energy efficiency improvements in the service sector requires, at minimum, data for:

- energy consumption by major end-uses and by energy sources;
- main activity variables for the sector including value-added data in constant currency, floor area and number of employees; and
- information on heating and cooling degree-days to adjust for weather conditions.

Given that detailed value added and employment data are available from Rosstat for the mining and manufacturing sectors, it is possible that this information is also available for the services sector (ISIC 50-99). Deflators are available by service category[12] from Rosstat National Accounts to convert the value added in current Roubles to constant Roubles. The data situation for the service sector in Russia is at par with most IEA member countries. However, it should be emphasised that, at present, the serious lack of detailed data in this sector across all IEA member countries makes it difficult to analyse trends in service energy consumption.

As the service sector only accounts for 8% of TFC in Russia, and given the data limitations in the residential and transport sector, the IEA does not think that service should be the priority area for data collection.

[12] Bulk and retail trade, maintenance of automobile transport, motorcycles, household goods, and personal items, hotels and restaurants, transport and communications, financial activities, real estate operations, rental and providing services, state governance and defence, social security, education, health care and social services, other municipal, public and personal services.

Data that IEA member countries are required to report through the IEA energy efficiency template, as well as the number of countries that are currently able to provide the data, are presented in Table 5. The information collected is used to develop basic energy indicators to explain the changes in energy consumption over a period of time.

This basic set of data is only a starting point. It would allow the service energy consumption to be adjusted for weather conditions, and would provide a preliminary analysis of the main consuming end-uses. Collecting this information by type of building (health, schools, warehouses, etc.) would support an analysis of the structure of the service sector and allow the development of detailed indicators that would facilitate policy development.

Table 5: Service data needed to develop basic energy and energy efficiency indicators

Data needed to develop indicators	Number of IEA member countries reporting the data	Data available from Russia
Energy consumption by:		
Energy source	28	Yes
End-use	3	No
Space heating (and by energy source)	3	No
Space cooling	3	No
Lighting	2	No
Other (and by energy source)	3	No
Total service floor area	27	No
Floor area addition	27	Yes
Number of employees	24	Yes
Services value added	14	No
Annual heating degree-days	27	No
Annual cooling degree-days	6	No

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. Coverage for Russia is based on IEA knowledge of the data situation in Russia; which has been validated by the Russian Federation.

Key indicators for the service sector

In the absence of detailed information on energy consumption, activity and other relevant data, only general indicators can be calculated for the service sector. Some of the key indicators that can be developed with the data reported in the template are presented in Table 6. The table does not present indicators at the end-use level (which would be similar to those in the residential sector) as only a very limited number of countries can report this information.

Table 6: Key indicators to understand trends in energy and energy efficiency in services

	Indicator	Data required	Purpose	Limitation
ENERGY INDICATORS	**Service energy consumption by energy source**	• Total service energy consumption by energy source.	• Insights on the role of the final energy mix on total final energy consumption. • Insights on the trends in CO_2 emissions. • Provide qualitative information indicating which end-use might have been the fastest growing.	• Observed trends in energy not necessarily a result of improved (or worsening) energy efficiency. • One element, among many others, influencing the trends in energy consumption. • Can be influenced by increase in the use of office equipments and space cooling, introduction of regulations and standards, and relative energy prices.
	Service energy consumption per services value added	• Total service energy consumption. • Total service value added (in constant currency).	• Reflect the trends in overall energy use relative to value added. • Indicates the general relationship of energy use to economic development.	• Depends on factors such as climate, geography and the structure of the service sector. • Influenced by change in services structure. • Different service sector activities can produce very different levels of economic output. • Value added are influenced by a range of pricing effects that are unrelated to changes in the energy consumption.
	Service energy consumption by energy source per floor area	• Total service energy consumption by energy source. • Total service floor area.	• Combined with the previous indicator, can provide indications on the nature of the sector driving energy consumption. • Can provide insights on the end-use driving the change in energy use.	• Depends on factors such as climate, geography and the structure of the service sector. • Influenced by change in services structure; different building types have very different energy requirements.
	Decomposition of changes in energy consumption: activity, structure and intensity effect	• Total service energy consumption. • Total service value added (in constant currency). • Service floor area. • Total number of employees.	• Provide a general overview of the main factors influencing the trends in services energy consumption. • Quantify the role of different drivers on the aggregate energy intensity of the sector. • The best indicator that can be built at present with data available at IEA.	• Does not represent an estimation of the energy efficiency for the service sector. • Influenced by many non-efficiency factors such as the changes in the structure of the building sector and changes in end-use.

Transport sector

Transport energy consumption in Russia is available from the energy balance. However, it is not disaggregated by transport segment (passenger and freight). As a result, it is difficult to make any conclusions on the energy consumption trends in Russia's passenger transport sector. Any Moscovite can agree that since the early 1990s individual automotive vehicle ownership in Moscow has skyrocketed, as evidenced by the major daily traffic jams. Other major cities in Russia have experienced similar trends, but Moscow is by far the most striking.

In terms of the transport sector overall – including both passenger and freight and all modes of transport – as reported in Russia's energy balance, the transport sector saw its energy consumption drop to its lowest point in 1997 at less than 2800 PJ. In 1998, energy consumption in Russia's transport sector jumped over 16%, a sign of the huge economic recovery which began in the second half of that year. Over the period from 1998 to 2008, energy consumption in Russia's transport sector increased 25%.

Passenger transport sector

Passenger transport includes the movement of people by road, rail, water and air. Road transport is further sub-divided into light-duty vehicles (LDV) and buses. Only domestic air and water are included; international air and water travel are not covered.

Box 8. Energy efficiency trends in passenger transport sector

Global passenger transport energy consumption data are not available from a country's energy balances, as energy balances report only total transportation. As a result, analysis of the sector can be performed for only 19 IEA member countries.[13] For those 19 countries, passenger transport energy consumption between 1990 and 2006 increased by 24%, with the shares of the various modes remaining quite stable. Light-duty vehicles are, by far, the largest energy consumer, accounting for 87% of the energy consumption.

Passenger-kilometres (pkm) and the efficiency of passenger transport modes (energy consumption per pkm) are the two main determinants of energy consumption. Both are affected by a wide range of interacting factors such as: occupancy rate of vehicles; distance travelled; density of population; vehicle ownership; income levels of drivers; local transport policies; and price of fuel. Indicators that can be built with available data from the IEA energy efficiency indicators template show that only one factor helped to restrain growth in road transport energy demand: energy efficiency. Energy efficiency for LDVs improved by 6% since 1990.

Availability of passenger transport data in Russia to develop indicators

In many countries, passenger transport represents a significant and growing share of total energy consumption. In order to develop useful energy efficiency indicators in this sector, a large number of data are required. In the IEA energy efficiency indicators template, the minimal set of data required to develop indicators include:

- Energy consumption by transportation mode;
- Information on the passenger transportation fleet by mode (stock of vehicles);

[13] IEA 19 includes Australia, Austria, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States.

- Passenger kilometres by mode; and
- Vehicle kilometres by mode.

Transport energy consumption in Russia is only available from the energy balance; these data are disaggregated by mode (road, rail, water and air) but not by transport segment (passenger and freight). As a result, it is currently not possible to develop indicators for this sector.

Most activity data are available from Rosstat and disseminated in the publications *Main Indicators of Transport Performances in Russia* (Rosstat, 2010a) and *Transport in Russia* (Rosstat, 2010b). For passenger transport, available information includes passenger-kilometres, vehicle kilometres and vehicle stock for buses, trains and airplanes. Information for LDV is not available. As LDV generally represents the most important transportation mode, priority should focus on collecting activity data for this transportation mode.

Activity variables are equally important for developing indicators. As is the case for energy consumption, activity data can be collected or estimated through different means. Different countries are adopting different strategies to collect or develop passenger transport energy consumption and activity data: survey targeting households for LDVs; collecting information through fleet managers or operators for buses and trains; and developing modelling analysis to estimate energy consumption. The strategy adopted depends on several factors such as the availability of data driving energy consumption, the existence of surveys that can be amended to include more questions, etc.

The IEA identified potential sources of data that can constitute a starting point for estimating energy consumption by mode in the passenger transport sector, such as data available from administrative sources *e.g.* vehicle registration, information collected during the mandatory car annual verification, and data available from research institutes. Given the nature of administrative data, the collection of information from this source may require (as is the case in some IEA member countries) an official agreement between all the parties involved to support an adequate use of the information and ensure that the confidentiality of information is maintained.

Data that member countries are required to report to the IEA through the energy efficiency indicator template, the number of countries that are currently able to provide the data as well as the data currently available from Rosstat are presented in Table 7. The information collected is used to develop basic indicators to explain the changes in energy consumption over a period of time. Countries would benefit by complementing the data requested in the template with more detailed information on, for example, the vehicle stock turnover, size/class of vehicle and travel patterns.

Key indicators for the passenger transport sector

Numerous indicators, providing useful information to better understand the trends in energy consumption and energy efficiency, can be developed with the minimal set of data available from the IEA energy efficiency indicators template. The key indicators are presented in Table 8 along with an explanation of their purpose and limitations.

Table 7: Passenger transport data needed to develop basic energy and energy efficiency indicators

Data needed to develop indicators	Number of IEA member countries reporting the data	Data available from Russia
Energy consumption by:		
Energy source	25	Yes
Transportation mode	21	No
Cars, Sport utility vehicles (SUVs) and personal light trucks	22	No
Motorcycles and three-wheelers	10	No
Buses	22	No
Passenger train	24	No
Domestic passenger airplane	23	No
Domestic passenger ships	5	No
Passenger-kilometres by:	20	No
Cars, SUVs and personal light trucks	26	No
Motorcycles and three-wheelers	6	No
Buses	23	Yes
Passenger train	25	Yes
Domestic passenger airplane	20	Yes
Domestic passenger ships	4	Yes
Vehicle kilometres by:		No
Cars, SUVs and personal light trucks	23	No
Motorcycles and three-wheelers	11	No
Buses	19	No
Passenger train	2	No
Domestic passenger airplane	3	No
Domestic passenger ships	1	No
Vehicle stocks by:		
Cars, SUVs and personal light trucks	26	No
Motorcycles and three-wheelers	24	Yes
Buses	25	Yes
Passenger train	0	Yes
Domestic passenger airplane	0	No
Domestic passenger ships	1	No

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. Coverage for Russia is based on IEA knowledge of the data situation in Russia; which has been validated by the Russian Federation.

Table 8: Key indicators to understand trends in energy and energy efficiency in passenger transport

	Indicator	Data required	Purpose	Limitation
ENERGY AND ACTIVITY NDICATORS	**Share of passenger-kilometres by mode**	• Passenger-kilometres by mode.	• Provide assessment of the change in the share of modes. • Provide useful qualitative information on activity trends in the sector. • Provide qualitative information on how change in activity influences change in energy consumption.	• Only activity driven, does not provide a measure of energy efficiency. • Travel patterns are influenced by many diverse factors such as income, age profile of drivers, gender of drivers, household size, flexible working and leisure activities, geographic characteristics and local transport policies.
	Energy use per passenger-kilometre by transportation mode	• Passenger transport energy consumption by transport mode. • Passenger-kilometres by transport mode.	• Energy intensities by mode is a meaningful summary indicator. • Intensities can be used to help develop transportation energy policies.	• Still affected by factors that are not related to energy efficiency such as vehicle weight for LDV, vehicle occupancy and vehicle features. • If developed at the aggregate level (total LDV) may mask important structural changes (number of cars compared to SUVs).
ENERGY EFFICIENCY INDICATORS	**LDV fuel intensity**	• Stock of LDV. • LDD vehicle kilometres. • LDV energy consumption.	• Provide insights on the actual fuel economy of the vehicle stock. • As opposed to LVD energy use per passenger-kilometre, it is not influence by vehicle occupancy.	• If developed at the aggregate level (total LDV) may mask important structural changes (shift from cars to SUVs in some countries.
	Decomposition of changes in total passenger energy use: activity, structure and intensity effects	• Passenger transport energy consumption by mode. • Passenger-kilometres by mode.	• Quantify the factors influencing changes in energy consumption.	• Does not reveal how different factors, such as an increase in car ownership, are affecting each transport mode.
	Decomposition of changes in LDV energy use: ownership effect, usage effect and fuel intensity effect.	• LDV energy consumption. • Stock of LDV. • Population. • Distance travelled.	• Quantify the effect of LDV fuel intensity (a proxy for energy efficiency) on LDV energy consumption. • The best indicator that can be developed for LDV with the data required in the IEA energy efficiency indicators template.	• Includes effects that are not related to lab-tested fuel economy such as size of vehicles and geographic conditions.

Freight transport sector

Freight transport includes the domestic movement of goods by road, rail, air and ships water. Transport through pipelines is excluded.

Box 9. Energy efficiency trends in freight transport sector

As is the case with passenger transport, freight transport[14] energy consumption data are not available from country energy balances and the analysis can be performed only for 19 IEA member countries.[15]

For these 19 countries, freight transport energy consumption increased by 31% between 1990 and 2006. Trucks are by far the largest energy user, accounting for 83% of the overall freight transport energy consumption in 2006.

The energy intensities of trucks, trains and ships vary significantly. For the 19 countries for which the information is available, trains are the most energy efficient mode of freight transport. On average, for the 19 countries, it requires 10 times less energy to transport one tonne of goods over one kilometre by train than by truck. 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. Important energy savings can also be achieved by increasing the share of rail, ships and air in freight transport.

Availability of freight transport data in Russia to develop indicators

In order to develop useful energy and energy efficiency indicators in this sector, a large number of data are required. In the IEA energy efficiency indicators template, the minimal set of data required to develop indicators include:

- Energy consumption by transportation mode;
- Information on the freight transportation fleet by mode (stock of vehicles);
- Tonne-kilometres by mode; and
- Load factors by mode.

Transport energy consumption in Russia is available only from the energy balance; these data are disaggregated by mode (road, rail, water and air) but not by transport segment (passenger and freight). As a result, it is currently not possible to develop indicators for the freight transport sector. It is essential to collect or develop the energy consumption information to develop indicators. As is the case in the passenger transport segment, different countries are adopting different strategies to collect or develop this information such as usage of truck fuel meter; collecting information through fleet managers or operators; and developing modelling analysis to estimate energy consumption. The strategy adopted depends on several factors.

Activity variables are equally important for developing indicators. While tonne-kilometres provide the basis for developing freight transport indicators, it is important to complement this information with load factors (as there is a strong correlation between changes in load factors and changes in the intensity of truck freight haulage) and stock of vehicles. As is the case for energy consumption, activity data can be collected or estimated through different means.

[14] While air freight transport data are requested in the IEA indicators database, the analysis excludes this mode because of lack of data separating domestic and international journey.

[15] IEA 19 includes Australia, Austria, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States.

Table 9: Freight transport data needed to develop basic energy and energy efficiency indicators

Data needed to develop indicators	Number of IEA member countries reporting the data	Data available from Russia
Energy consumption by:		
Energy source	24	No
Transportation mode	21	No
Freight and commercial road transport	22	No
Freight trains	4	No
Domestic freight airplanes	5	No
Domestic freight ships	22	No
Freight tonne-kilometres[16] by:	24	Yes
Freight and commercial road transport	19	Yes
Freight trains	0	Yes
Domestic freight airplanes	0	Yes
Domestic freight ships	0	Yes
Freight tonnes transport[17] by:		Yes
Freight and commercial road transport	6	Yes
Freight trains	5	Yes
Domestic freight airplanes	4	Yes
Domestic freight ships	3	Yes
Vehicle kilometres by:		
Freight and commercial road transport	20	No
Freight trains	3	No
Domestic freight airplanes	0	No
Domestic freight ships	0	No
Vehicle stocks[18] by:		
Freight and commercial road transport	25	Yes
Freight trains	0	Yes
Domestic freight airplanes	0	No
Domestic freight ships	0	No

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. Coverage for Russia is based on IEA knowledge of the data situation in Russia; which has been validated by the Russian Federation.

Activity data are available from Rosstat and disseminated in the publications *Main Indicators of Transport Performances in Russia* (Rosstat, 2010a) and *Transport in Russia* (Rosstat, 2010b). The

[16] Covers only large companies; small trucking firms and individual owners are not included.
[17] Covers only large companies; small trucking firms and individual owners are not included.
[18] Covers only large companies; small trucking firms and individual owners are not included.

available information includes tonne-kilometres, load factors and vehicle-kilometres. The activity data are available for trucks, trains and planes. No information is available for ships. However, the information collected by Rosstat is currently available only for large companies; small trucking firms and individual owners are not included. But additional questions that will be added to the National Household Budget Survey may help in gathering information on individual vehicles used for freight transportation.

Other potential existing sources of data (such as administrative data, or data from research institutes) can constitute a starting point for estimating freight transport energy consumption by mode.

Data that member countries are required to report to the IEA through the energy efficiency indicator template, the number of countries that are currently able to provide the data as well as the data currently available from Rosstat are presented in Table 9. The information collected is used to develop basic energy indicators to explain the changes in energy consumption over a period of time. This is a starting point for developing indicators. Countries would benefit by complementing the data requested in the template with more detailed information on, for example, the vehicle stock turnover, the size/class of trucks, or the empty versus loaded kilometres travelled.

Key indicators for the freight transport sector

The information required in the indicators database allows the development of the key energy and energy efficiency indicators presented in Table 10.

Table 10: Key indicators to understand trends in energy and energy efficiency in freight transport

	Indicator	Data required	Purpose	Limitation
ENERGY AND ACTIVITY INDICATORS	**Share of tonne-kilometres by mode**	• Freight transport tonne-kilometres by mode.	• Provide assessment of the change in the share of modes. • Provide useful qualitative information on activity trends in the sector. • Provide qualitative information on how change in activity influence change in energy consumption.	• Only activity driven, does not provide a measure of energy efficiency. • Tonne-kilometres are influenced by many factors such as availability of infrastructure, capacity utilisation, type of goods moved, and the size and geography of the country.
	Energy use per tonne-kilometre by transportation mode	• Freight transport energy consumption by mode. • Freight transport tonne-kilometres by mode.	• Energy intensities by mode are meaningful summary indicators. • Intensities can be used to help develop transportation energy policies.	• Still affected by factors that are not related to energy efficiency such as vehicle weight for trucks and load factors. • May mask important structural changes in the road segment.
	Truck average load per vehicle	• Truck average load per vehicle.	• Help explain the changes in truck energy consumption per tonne-kilometres. • Strong correlation between changes in load factors and changes in the energy intensity of truck freight haulage.	• This indicator, taken by itself, does not provide indication on the trend in energy efficiency for trucks. • The average load can result from the change in the composition of the fleet.
ENERGY EFFICIENCY INDICATOR	**Decomposition of changes in energy use: activity, structure and intensity effects.**	• Freight transport energy consumption by mode. • Freight transport tonne-kilometres by mode.	• Quantify the factors influencing change in energy consumption.	• Does not provide how different factors, for example change in the load factors, are affecting each transport mode. • More detailed information is required to develop strong indicators to better support development of energy efficiency policies.

Conclusions and next steps

Developing, applying and deriving benefit from energy efficiency indicators implies a long-term commitment to collecting and analysing a broader range of energy data. Many IEA member governments have taken decades to establish effective and least-cost data collection systems based on strong co-ordination among the main statistical agency and other departments and agencies and the private sector.

The IEA is keen to continue its work with Russia in this area. Given the political momentum generated by the president's ambitious energy efficiency goals, the time is ripe for a push forward on developing such a co-ordinated system of data collection for energy efficiency indicators. Moreover, there is now an increasing and realistic understanding of the availability of data needed (and the gaps in data) to underpin the provision of energy efficiency indicators.

A key message the IEA has been promoting in discussions with Russian counterparts is the need to prioritise requirements for energy efficiency indicators. Specifically, the IEA recommends that this be done in consultation between energy experts (who are involved in the design, implementation and monitoring of energy efficiency policies) and statistical and analytical experts (who are responsible for the collection and analysis of data). Currently, data collectors are overwhelmed by the proposals for collection of many different data. Moreover, the creation of an overly large and complex system of energy efficiency indicators may prove to have a limited value added. At this early stage, Russia may derive greater value from a more simple set of indicators that concentrate on key aspects of energy efficiency in high energy intensity sectors such as industry, transport and residential.

While the clear commitment at the highest political level in Russia for substantial energy efficiency is widely recognised, there is not yet consensus on the key indicators needed by those developing energy efficiency policy and monitoring its implementation. Given the cross-agency nature of energy efficiency indicators, it may be beneficial to form a cross-governmental working group to improve co-ordination. The working group should ideally include all the major players, including government departments and institutions, and, where appropriate, research institutions and trade bodies (particularly where these hold relevant data or analytical expertise).

There could be benefit in a concrete focus, for example, such as having the working group initially explore co-ordination needs in Russia's transport sector, which the IEA found to have the largest data gaps. Russia is not unique in this respect: the transport sector is one of the most difficult sector in which to collect reliable data. The IEA has singled out the approaches of New Zealand and the United Kingdom as best practice examples; both countries have published reports[19] outlining their data collection system in this sector.

This cross-governmental working group should take into account wide international experience, including that of the IEA, the European Union and individual countries. A co-ordinating body could be identified to take the lead on this, such as the Russian Energy Agency.

The IEA stands ready to continue working with Russia in this important area to ensure the effective implementation of its Law on Energy Efficiency and the achievement of its ambitious energy efficiency goals.

[19] *Transport Statistics Great Britain,* Department of Transport, 2009 Edition; and *New Zealand Transport Statistics*, Ministry of Transport, July 2009.

Annex A. The IEA indicator approach

Governments around the world are facing the complex and interlinked challenges of reducing energy consumption and associated GHG emissions while also meeting economic development goals. There is a growing recognition that improving energy efficiency is often the most economic, proven and readily available means to do this.

Tracking trends in energy efficiency is not an easy task. While overall energy consumption may be increasing due to robust GDP growth and/or an expanding population, energy efficiency may well be improving. Energy efficiency is only one of a number of factors that impact energy use. As such, it is possible to have improving energy efficiency while still seeing increases in energy consumption. Some factors that may cause (explain) growth in energy consumption include: population growth; a colder or warmer than usual winter; a change in structure of the industrial sector; an increase in wealth (as measured by GDP per capita); an increase in the level of ownership of appliances and/or equipment; and a change in consumer behaviour or preferences. Disentangling these various factors that drive and restrain energy use is the key purpose of energy indicators. In this respect, energy indicators provide policy makers with the tools to make informed policy decisions to target the key end-use area or consumer behaviour that is driving energy consumption.

The benefits of the IEA approach

The IEA indicator approach uses a pyramid that portrays a hierarchy of energy indicators from most detailed (at the bottom of the pyramid) to least detailed (at the top of the pyramid). This illustrates conceptually how the most detailed and disaggregated data and indicators can be combined to reveal the more aggregated ones higher up on the pyramid. This hierarchy is important because it shows how detailed changes (which may be the result of policies, technological progress, structural reform or behavioural change) can be linked to higher order, more aggregate quantities, showing how the former affects the latter. With this hierarchy, one can better explain more aggregate changes in energy use in terms of components and more carefully choose the depth of analysis required. This hierarchy will be different from country to country as it depends on the data availability and the questions that need to be answered.

Examples:

- The five most energy intensive industrial sectors are pulp and paper, chemicals and petrochemicals, iron and steel, cement and aluminium. Because of their much higher energy intensity, growth in these industrial sectors will drive up energy consumption much more quickly than growth in less intensive sectors. For example an increase in cement, using about 20 Megajoules (MJ) per unit of GDP, will have a much bigger impact on energy consumption than an increase in the fabrication of metal products, using less than 5 MJ per unit of GDP.
- In the iron and steel sector, a relative decrease in the use of open hearth furnace (a very intensive process) will have a downward effect on energy consumption. So a decrease in the iron and steel intensity (in terms of energy use per unit of production) will not necessarily indicate an improvement in energy efficiency in a particular production process: it can be caused by a switch of production from open-hearth furnaces to blast furnaces.

The IEA indicator pyramid

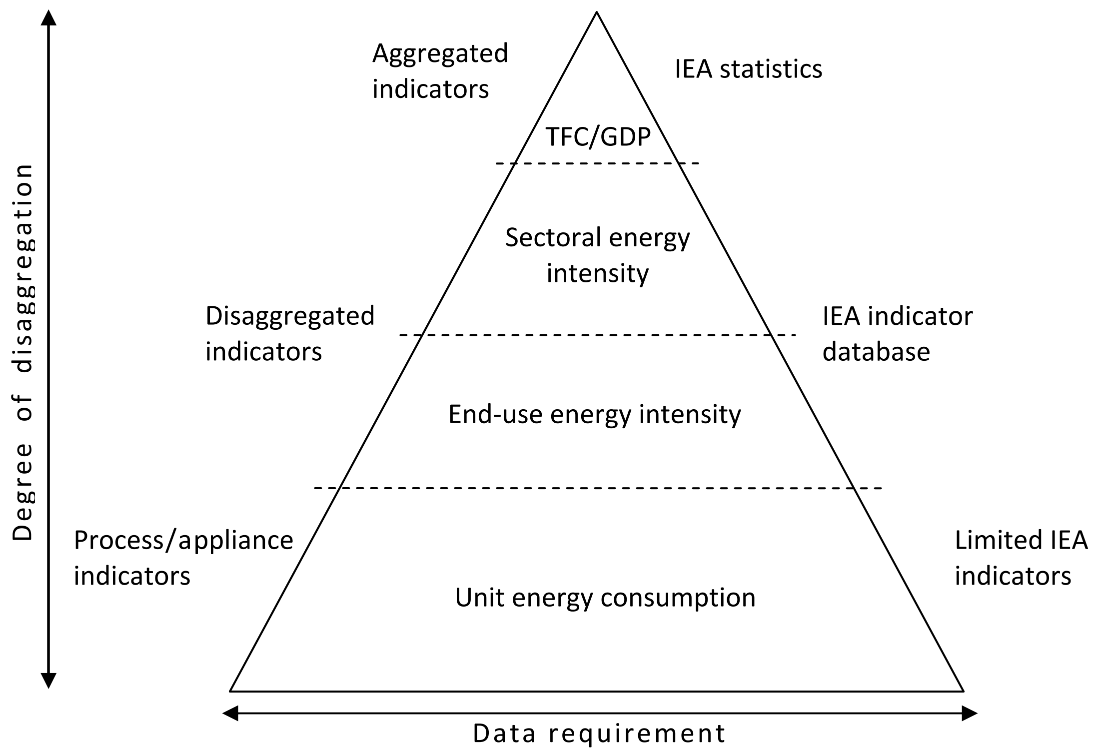
The top row of the pyramid (the most aggregate indicator) is defined as the ratio of energy use to gross domestic product (GDP). Alternatively, it could be defined as the ratio of energy use to another macro-economic variable, such as population.

The second row of elements can be defined as the energy intensity of each major sector, as measured by energy use per unit of activity in each sector.

Lower rows represent the sub-sectors or end-uses that make up each sector and progressively provide more detail *e.g.* characterising particular processes or appliances.

Joining each level of energy intensities are structural variables that indicate how to weight these intensities to form a more aggregate parameter of intensity or use. Descending lower down the pyramid requires more data and more complex analysis to re-aggregate back up to a higher level. However, each descent also provides a better measure of "technical" energy efficiency defined for a specific technology, process and/or end-use, but also required more data.

Figure A.1: The IEA indicator pyramid



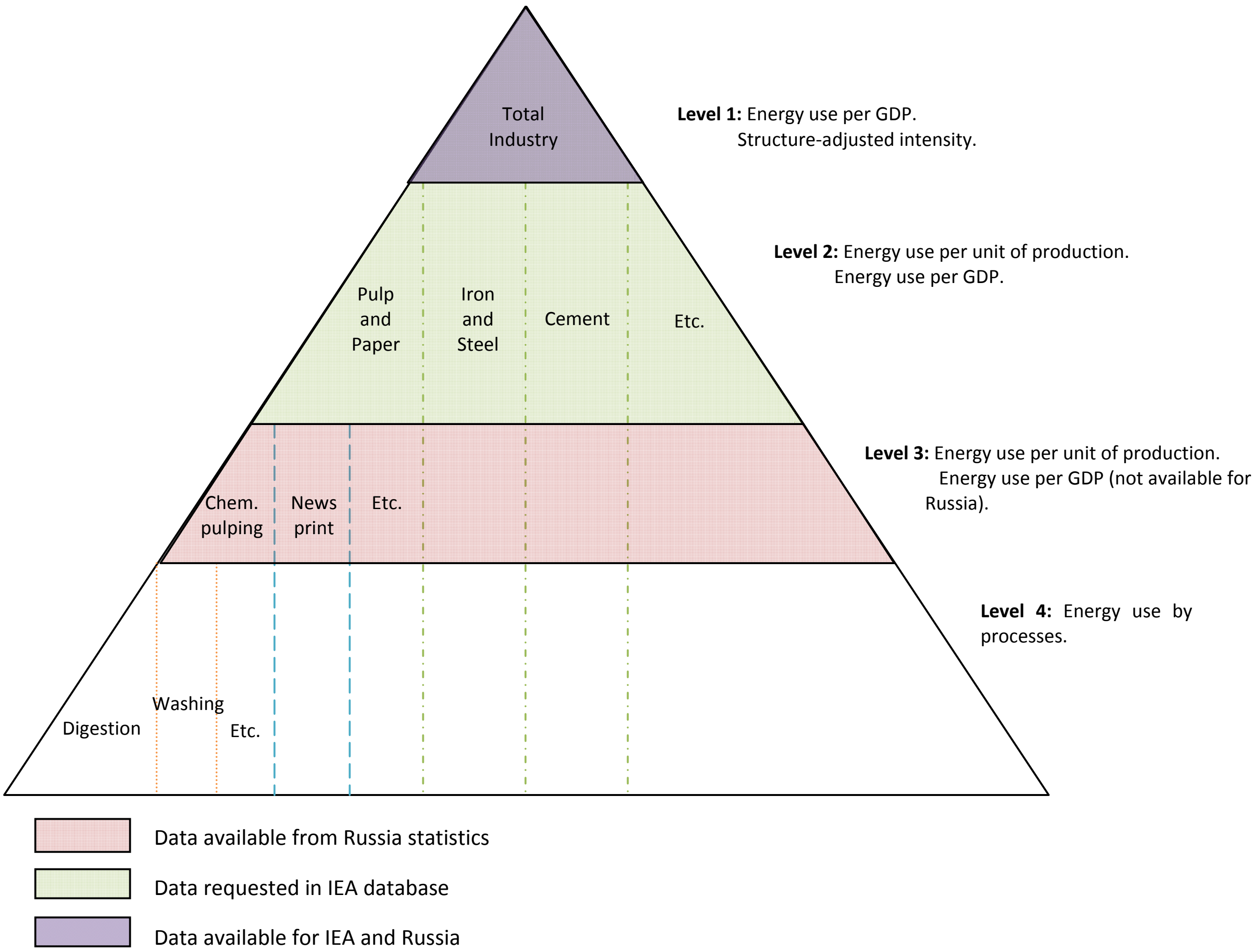
Note: Indicators shown are just on example among those available.

Example of indicator pyramid: Industry sector

The industry sector covers the manufacture of finished goods and products, mining and quarrying of raw materials, and construction. Power generation, refineries and the distribution of electricity, gas and water are excluded.

The industrial pyramid shows how this sector can be disaggregated and the different indicators that can be used at each level (Figure A.2). This is only an illustration and may not be relevant for all countries.

Figure A.2: Industry sector pyramid



Note: Russia has very detailed energy and production statistics for industry. However, it is not possible to aggregate them to higher levels in the pyramid due to lack of associated GDP data in constant currency. For IEA countries, the IEA database contains information at Level 2 for 21 member countries in the industrial sector. Some countries have more detailed information than what is available in the IEA database.

Level 1: Total industry sector

The commonly used indicator at the aggregate level is energy use per unit of GDP. This ratio measures how much energy is needed to produce one unit of economic output. However, it would be misleading to evaluate the performance of energy efficiency based on this indicator as it is affected by many non-energy efficiency factors such as the structure of the industry, the quality of resources and, for some industrial sectors, weather conditions.

For this reason, many countries develop structure-adjusted intensity for the total industrial sector. Constructing the structure-adjusted indicator requires the energy use and GDP data at *Level 2* or *3* of the pyramid.

Level 2 and level 3: Industry sectors

The industries represented in *Level 2* and *3* usually differ by country according to the data available and the relative importance of each industry.

At these levels, the best indicator to assess energy efficiency is energy use per unit of production. However, as some industries are too heterogeneous to have one measure of production, GDP (or another monetary value such as gross output) is the second-best choice.

Level 4: Process indicators

The IEA indicator database does not contain information on *Level 4*. Only a limited number of countries have this information for a limited number of industries. However, even partial information at this level can help explain the trends in energy consumption.

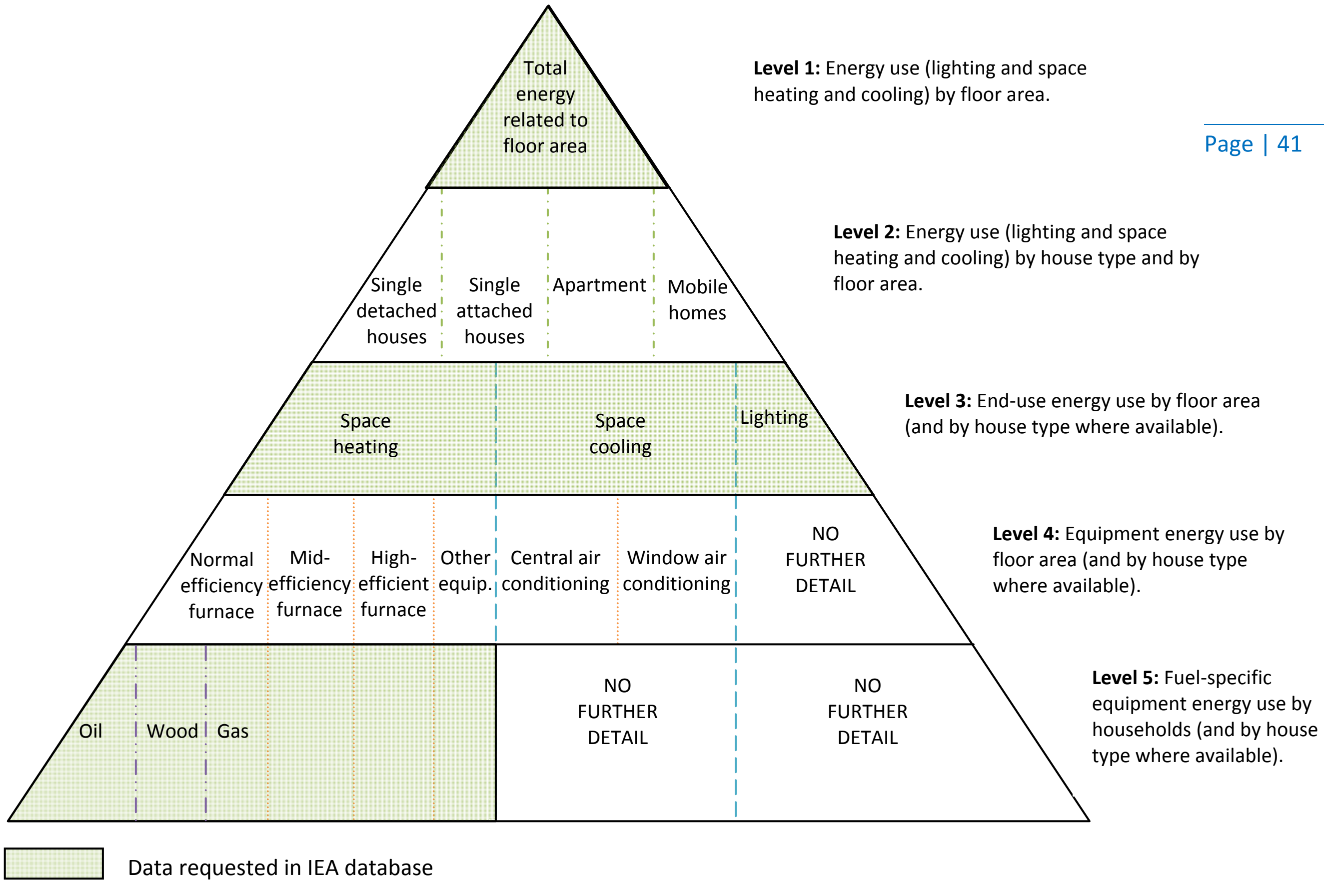
Example of indicator pyramid: Residential sector

The residential sector includes those activities related to private dwellings. It covers all energy-using activities in apartments and houses, including space and water heating, cooling, lighting and the use of appliances. It does not include personal transport, which is covered in the transport sector.

There are numerous ways to define the analytical framework in the residential sector. The level of detail selected greatly depends on the information available. For example, Canada is using two different pyramids: one for end-uses with energy consumption related to the number of households and one for end-uses with energy consumption related the floor area. The indicators are then aggregated by using weighted energy consumption.

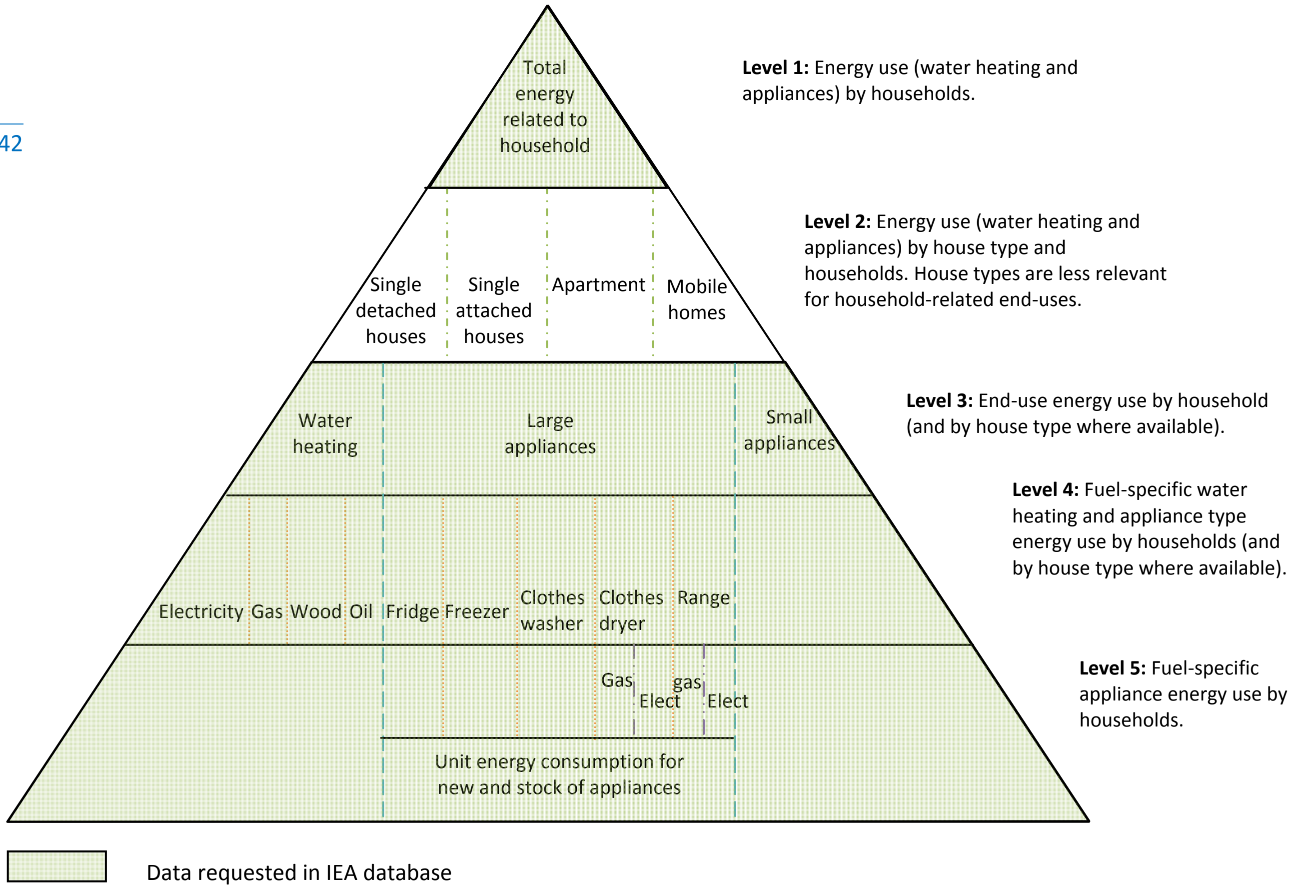
The example below shows the two indicators pyramids for the residential sector. These pyramids would be applicable to countries with rather detailed end-use data. This is not the case in each country. As previously mentioned, the pyramid should be adapted to account for countries specificities and data situation.

Figure A.3: Residential sector pyramid based on floor area



Note: For Russia, the information is not available by end-uses; but if the pyramid is to be defined without the breakdown by end-use, it would be possible to do the analysis at the Level 2. Information by house type and by housing systems is available in some countries (such as Canada). However, this information is not collected by the IEA. The IEA database contains information for levels 1, 3 and 5 for 19 IEA member countries. Some countries have more detailed information than what is available in the IEA database.

Figure A.4: Residential sector pyramid based on household



Note: For Russia, the information is not available by end-uses; but if the pyramid is to be defined without the breakdown by end-use, it would be possible to do the analysis at the Level 2. Information by house type and by housing systems is available in some countries (such as Canada). However, this information is not collected by the IEA. The IEA database contains information for levels 1, 3, 4 and 5 with the number of country reporting the data to IEA depending on the level of the pyramid. Some countries have more detailed information than what is available in the IEA database.

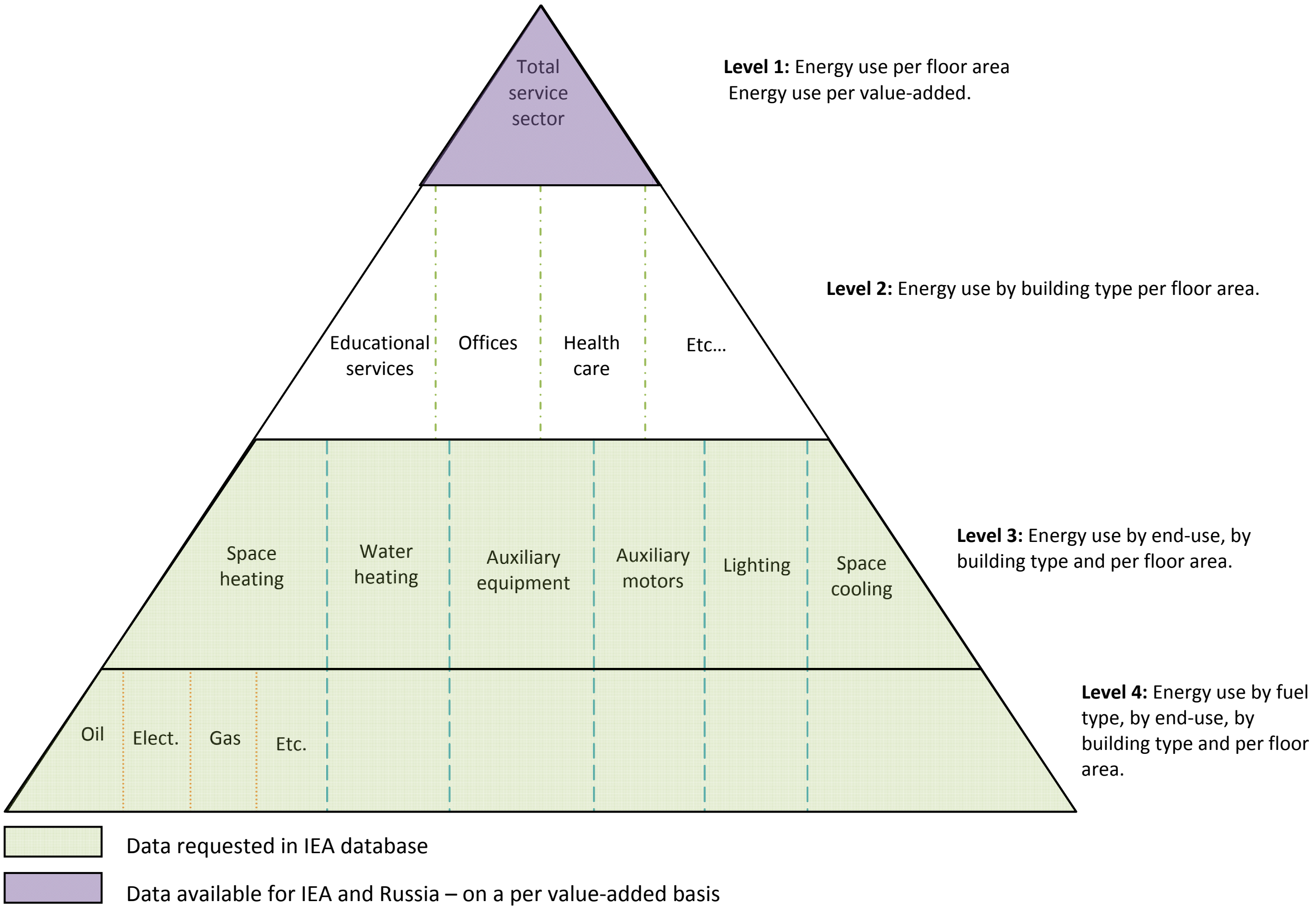
Example of indicator pyramid: Service sector

The service sector includes activities related to trade, finance, real estate, public administration, health, education and commercial services.

Very few countries are able to analyse the energy efficiency trends in the service sector. The general aggregate indicator used is service energy consumption by unit of value added in the service sector. However, different service sector activities can produce very different levels of economic output while consuming nearly the same amount of energy. For example, buildings in the finance sector can have the same final energy demand profile as buildings in the retail sector, yet generate significantly different levels of economic output.

Energy consumption by floor area is considered by some countries as the best indicator for this sector.

Figure A.5: Service sector pyramid



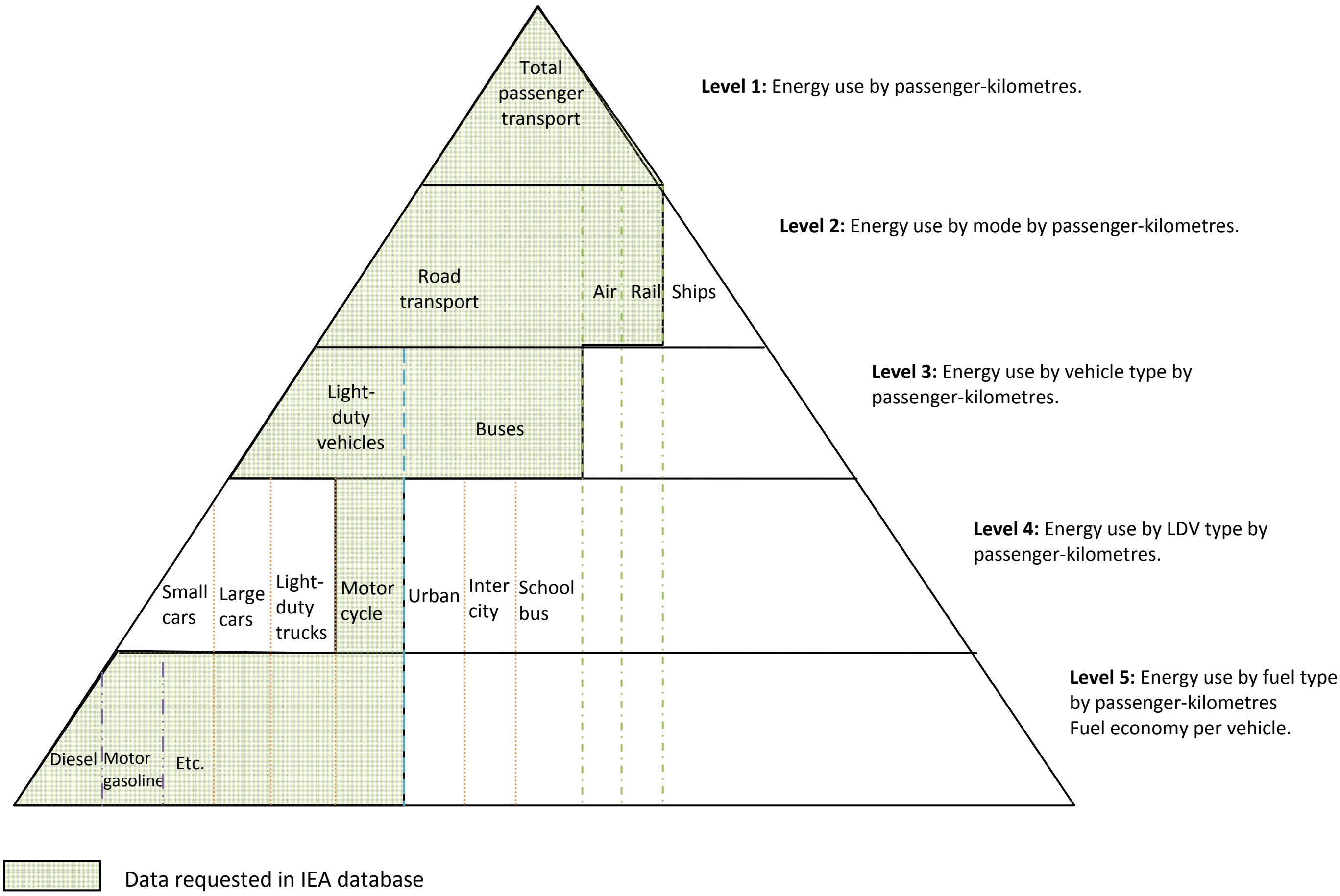
Notes: For Russia, total energy consumption and value-added data are available. For IEA member countries, only three countries report energy use by end-use to the IEA (Level 3). Only seven countries report total service floor area. The IEA is analysing the service sector intensity based on value added. Some countries have more detailed information than what is available in the IEA database.

Example of indicator pyramid: Transport sector

The transport sector includes the movement of people and goods by road, rail, water and air. Pipelines and international air and water transport are excluded from the analysis.

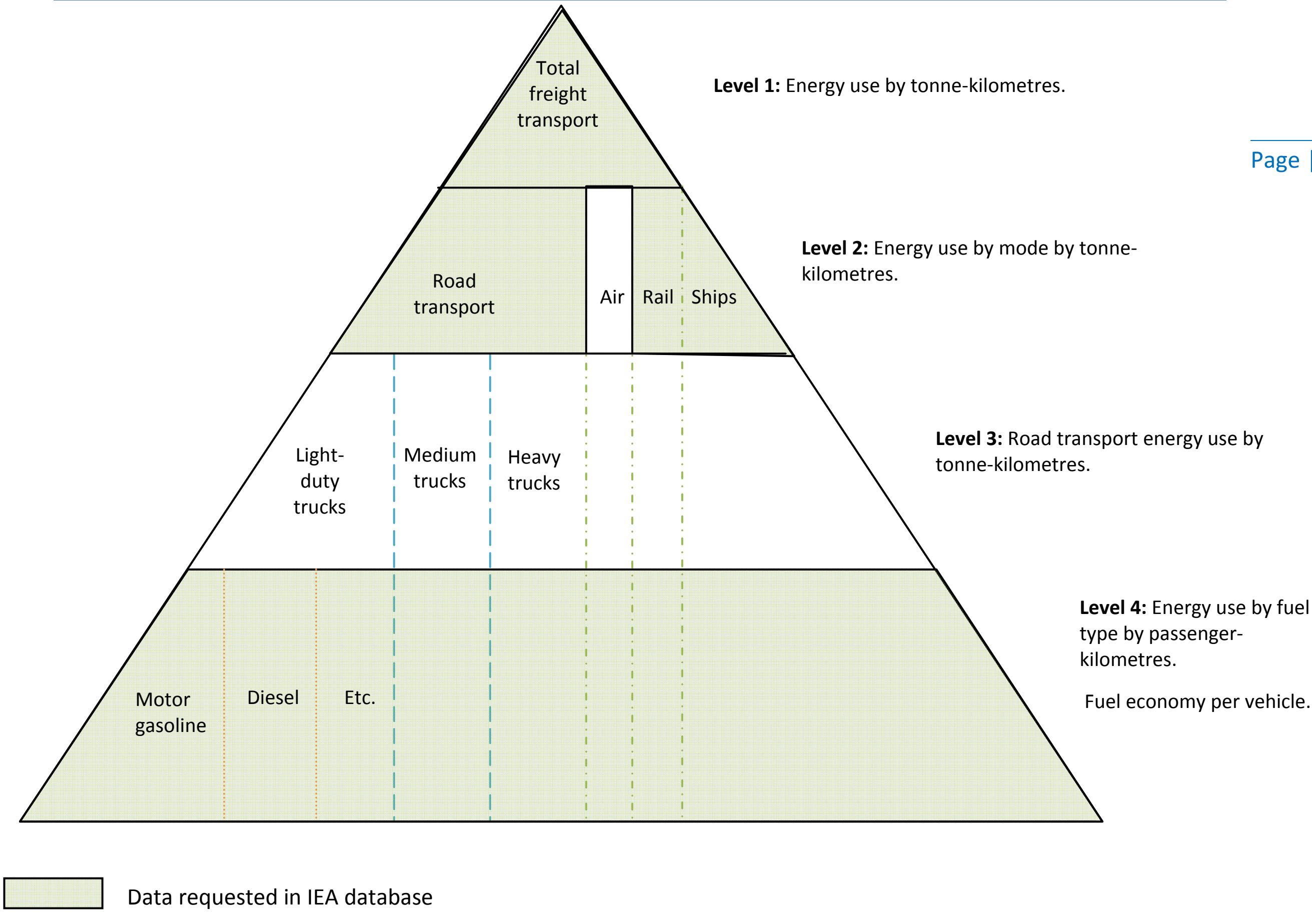
While it is possible to present energy use for the total transport sector, a more detailed analysis of this sector requires passenger and freight transport to be analysed separately since they are affected by different underlying factors.

Figure A.6: Passenger transport sector pyramid



Notes: Only activity information for buses, air and rail is available for Russia. The IEA database does not contain information by type of buses. Ships are not included in the IEA analysis due to lack of information. In the IEA database, light-duty vehicles are only disaggregated only between motorcycles and other LDVs. Some countries have more detailed information than what is available in the IEA database.

Figure A.7: Freight transport sector pyramid



Notes: Only activity information is available for Russia. The IEA database does not contain information by type of road freight vehicles. Air travel is not included in the IEA analysis due to lack of information. Some countries have more detailed information than what is available in the IEA database.

Annex B. The IEA methodology for analysing energy consumption

The decomposition of changes in energy consumption

The analysis of energy end-use trends distinguishes between three main components affecting energy consumption: aggregate **activity**, sectoral **structure** and **energy intensities** (see Table B.1 for more details).

Aggregate activity (A) is measured in one of the following ways, depending on the sector: as value added for manufacturing industry and services; as population in the residential sector; or as passenger-kilometres and tonne-kilometres, respectively, for the passenger and freight transport sectors.

Sectoral structure (S) represents the mix of activities within a sector and further divides activity into industry sub-sectors, measures of residential end-use activity or transportation modes.

Energy intensity (I) refers to energy use per unit of activity.

To separate the effect of various components over time, the IEA uses a factoral decomposition approach that analyses changes in energy use within a sector, using the following equation:

$$E = A \cdot \sum_r (S^r \cdot I^r)$$

In this decomposition, the symbols represent the following parameters:

E Total energy use in a sector.

A Overall sectoral activity.

r Sub-sectors or end-uses within a given sector.

S^r Share of sub-sector or end-use "r" in a sector.

I^r Energy intensity of each sub-sector or end-use "r".

The **activity effect** can be calculated as the relative impact on energy use that would have occurred in year *t* if the structure and energy intensities for a sector had remained fixed at their base year values (t=0) while aggregate activity had followed its actual development.

$$E_t^A = \frac{A_t \cdot \sum_r (S_0^r \cdot I_0^r)}{E_0}$$

Similarly, the **structure effect** is determined by making the calculation using constant aggregate activity and energy intensities but varying the sectoral structure.

$$E_t^S = \frac{A_0 \cdot \sum_r (S_t^r \cdot I_0^r)}{E_0}$$

The **intensity effect** is calculated by assuming that the sectoral structure and aggregate activity for a sector had remained fixed at the base year values while energy intensities had followed their actual development.

$$E_t^I = \frac{A_0 \cdot \sum_r (S_0^r \cdot I_t^r)}{E_0}$$

Thus, by calculating the relative impact on energy use from changes in each of these components, it is possible to isolate the impacts on energy use related to improved end-use energy efficiency (reductions in energy intensities) – *i.e.* to separate these impacts from changes deriving from shifts in the activity and structure components.

In this analysis, the **hypothetical energy use** (HEU^I) is defined as the energy use that would have occurred in year *t* if energy intensities in each sector remained constant at their base year values. It is calculated by dividing actual energy use in year *t* by the intensity effect in that year.

$$HEU_t^I = \frac{E_t}{E_t^I}$$

Energy savings from reduced energy intensities can be defined as the difference between the hypothetical energy use and actual energy use.

$$SAVINGS_t^I = HEU_t^I - E_t$$

Table B.1.: Summary of variables used for the decomposition

Sector	Sub-sector	Activity (A)	Structure (S)	Intensity (I)
Residential				
	Space heating	Population	Floor area / population	Space heating energy[1] / floor area
	Water heating	"	Population / occupied dwellings	Water heating energy[2] / occupied dwelling
	Cooking	"	Population / occupied dwellings	Cooking energy[2] / occupied dwellings
	Lighting	"	Floor Area / population	Lighting energy / floor area
	Appliances	"	Appliances ownership / population	Appliances energy / appliance ownership
Passenger Transport				
	Car	Passenger-kilometre	Share of passenger-kilometre	Energy / passenger-kilometre
	Bus	"	"	"
	Rail	"	"	"
	Domestic air	"	"	"
Freight Transport				
	Truck	Tonne-kilometre	Share of tonne-kilometre	Energy / tonne-kilometre
	Rail	"	"	"
	Domestic shipping	"	"	"

Sector	Sub-sector	Activity (A)	Structure (S)	Intensity (I)
Manufacturing[4]				
ISIC 15-16	Food, beverage and tobacco	Value added	Share of value added	Energy/value added
ISIC 21-22	Paper, pulp and printing	"	"	"
ISIC 24	Chemicals	"	"	"
ISIC 26	Non-metallic minerals	"	"	"
ISIC 27	Primary metals	"	"	"
ISIC 28-32	Metal products and equipment	"	"	"
ISIC 17-20, 25, 33-37	Other manufacturing	"	"	"
Services				
ISIC 50-99	Services	Value added	Share of value added	Energy/value added
Other Industries[3]				
ISIC 1-5	Agriculture and Fishing	Value added	Share of value added	Energy/value added
ISIC 45	Construction	"	"	"

Notes:
1) Adjusted for climate variations using heating-degree days.
2) Adjusted for household occupancy.
3) The following ISIC groups are not included in the analysis: 10-14 Mining & 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 by the IEA.
4) Based on ISIC rev. 3.1.

By introducing the dimension of fuel mix and carbon intensity (or CO_2 intensity), the decomposition of energy use can be extended to address changes in CO_2 emissions (G). In this case, fuel mix (F) represents changes in fuel shares (including electricity) among end-uses. Carbon intensity (C) refers to the CO_2 emissions per unit of energy used.

$$F_t^{r,t} = \frac{E_t^{r,f}}{E_t^r} \qquad C_f^{r,t} = \frac{G_t^{r,f}}{E_t^{r,f}}$$

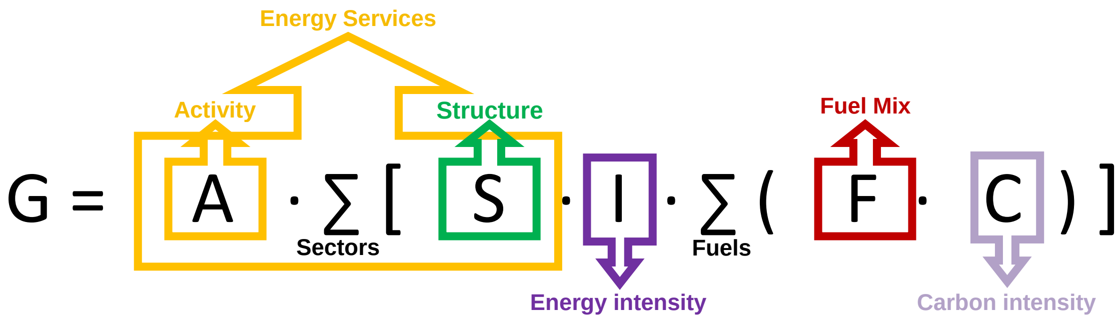
The **CO_2 emissions** (G) in a sector can then be decomposed into the activity, structure, energy intensity, fuel mix and carbon intensity effects according to the following formula:

$$G_t = A_t \cdot \sum_r \left[S_t^r \cdot I_t^r \cdot \sum_{f \epsilon fuel} \left(F_t^{r,f} \cdot C_t^{r,f} \right) \right]$$

This makes it possible to calculate the hypothetical CO_2 emissions as well as CO_2 savings. For example, the following two formulas present the carbon intensity effect and corresponding savings.

$$G_t^C = \frac{A_0 \cdot \Sigma_r \left[S_0^r \cdot I_0^r \cdot \Sigma_f \left(F_0^{r,f} \cdot C_t^{r,f} \right) \right]}{G_0} \qquad CO_2SAVINGS_t^C = \frac{G_t}{G_t^C} - G_t$$

Figure B.1.: Basic overview of factors in CO_2 decomposition



Regional aggregates for hypothetical energy use are calculated as the sum of hypothetical energy uses across all countries in a particular region. Energy savings for a region are then calculated as a difference between the hypothetical energy use and the actual energy use. The same approach is used for CO_2 emissions.

A number of different index-number techniques can be used to analyse factors affecting energy use. The IEA uses the Laspeyres indices approach which is relatively simple to interpret. However, the indicator results are affected by this choice of approach, and by the selection and definition of the activity, structure and intensity variables. In addition, it is important to keep in mind that individual countries that have created their own indicators may have different results. Some of these countries have used a different decomposition method and chosen different variables.

Sectoral coverage

The analysis done by the IEA considers energy use in the manufacturing, residential, service, passenger and freight transport sectors in the categories shown in Figure B.2. It does not consider "other industries" in detail, as data for these activities are scarce.

All energy data in the IEA energy indicators publications are expressed on a net calorific value basis (using lower heating values). Data definitions are based on the methodology used in the IEA energy statistics and balances, although there are some important differences. In the IEA energy balances, coal transformation losses are included as energy transformation. The IEA indicator approach allocates these losses to the primary metals sector (ISIC 27) in which the secondary coal products are consumed. With the energy balances method, petroleum products used as feedstocks for industrial chemicals are included as non-energy use in the TFC. These products are not included at all in the indicator approach. Similarly, the energy balances approach includes energy use for refining in the transformation sector whereas the indicator approach considers refining as part of ISIC 23 (manufacture of coke, refined petroleum products and nuclear fuels), which is excluded for the indicators analysis.

The indicators analysis study also excludes some aspects of transportation such as natural gas pipelines, and fuel use for private boats and military vehicles. Both approaches exclude international marine bunkers from TFC. International air traffic is included in the IEA statistics but not in the indicator approach.

Further information on the scope of individual sectors is provided below.

The **manufacturing sector** of industry produces finished goods or products for use by other businesses, for sale to domestic consumers or for export.

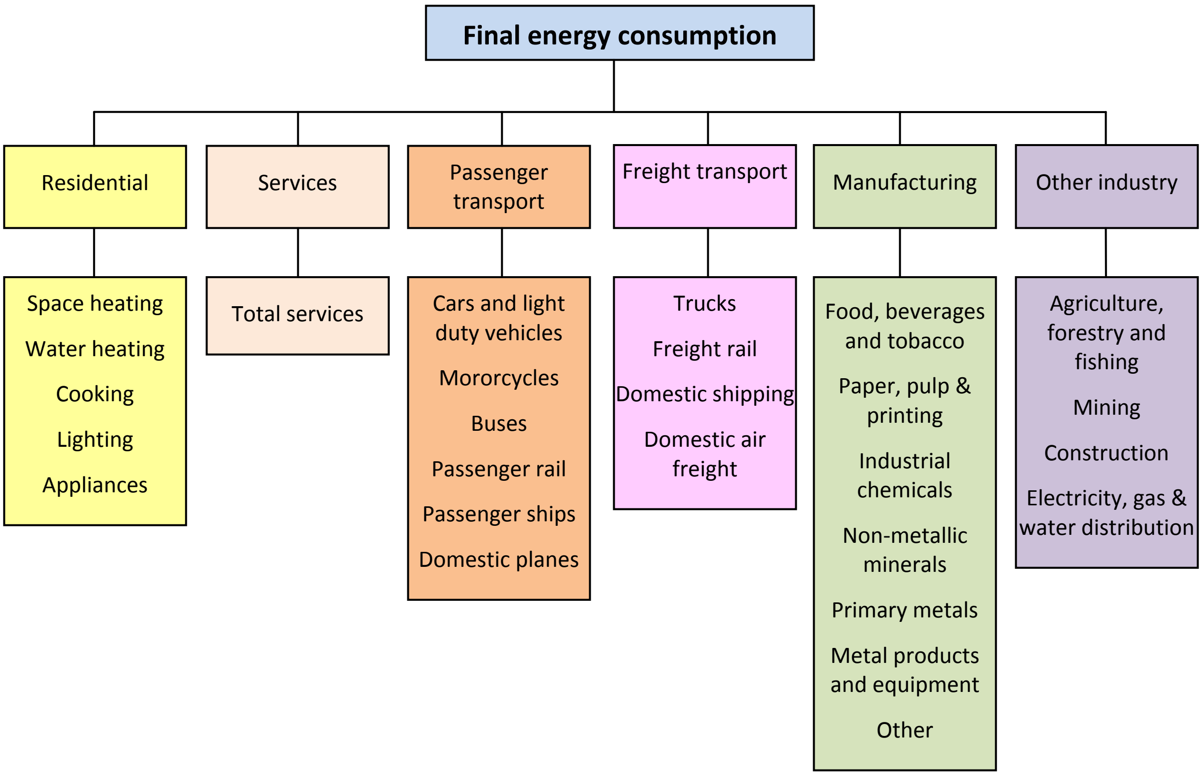
The **residential sector** includes those activities related to private dwellings. It covers all energy-using activities in apartments and houses, including space and water heating, cooking, lighting and the use of appliances.

The **service sector** includes activities related to trade, finance, real estate, public administration, health, education and commercial services.

Passenger transport includes the movement of people by road, rail, water and air. Passenger road transport is further subdivided into cars and buses. International air travel is excluded due to a lack of consistent and comparable data for IEA countries.

Freight transport includes the movement of goods by road, rail and water. It excludes air freight transport because of a lack of comprehensive and consistent data for this mode.

Figure B.2. Disaggregation of sectors, sub-sectors and end-uses in IEA energy indicators approach



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Annex D. Abbreviations, acronyms and units

APEC	Asia-Pacific Economic Cooperation
bcm	billion of cubic metres
CO_2	carbon dioxide
GDP	Gross domestic product
GHG	Greenhouse gas
IEA	International Energy Agency
ISIC	International standard industrial classification
LDV	Light-duty vehicles
MJ	Megajoules (10^6 joules)
NIIAT	Scientific and Research Institute of Motor Transport (Moscow)
PJ	Petajoules (10^{15} joules)
Pkm	passenger-kilometres
Rosstat	Federal State Statistics Service (Russia)
SUV	Sport utility vehicle
TFC	Total final energy consumption
TPES	Total primary energy supply

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