renewable energy & energy efficiency partnership

# Global Status Report on Energy Efficiency 2008

**IMPLEMENTING ORGANISATION: ECOFYS**

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**Authors**
Kornelis Blok, Pieter van Breevoort, Lex Roes, Rogier Coenraads, Nicolas Müller

**With contributions from**
Wina Graus, Mirjam Harmelink, Suzanne Joosen, Corinna Klessmann, Tomasz Kowalczewski, Małgorzata Lechwacka, Attila Morotz, Maarten Neelis, Guido Paola, Lynn Price (Lawrence Berkeley National Laboratory), An Zhou, Nan Zhou (Lawrence Berkeley National Laboratory)

**Editor**
Rolf de Vos (Ecofys)

**Reviewers** (REEEP)
Marianne Moscoso-Osterkorn, Binu Parthan

**Advisor**
Horst Biedermann (CESARUS)

Design and layout by Ontwerpgroep Lâle, Amersfoort, Netherlands
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# EXECUTIVE SUMMARY

There is wide agreement that energy efficiency improvement is one of the key strategies to achieve greater sustainability of the energy system. In the past, the contribution of energy efficiency has already been considerable. Without the energy efficiency improvements achieved since the 1970s, current energy use would have been much higher.

However, the potential for energy efficiency improvement is much larger than has already been implemented. In the period leading to 2050, it is possible to stabilise worldwide energy use at the current level, while economic growth continues at 2.7 percent per year. However, this will require the ambitious adoption of existing and new energy-efficient technologies.

In addition, policies to promote energy efficiency are very important to overcome existing market barriers such as high initial investment costs, split incentives, lack of information and ingrained habits of producers and consumers.

In this report, we evaluate the progress in the field of energy efficiency in various sectors such as buildings and appliances, manufacturing industry, transport, agriculture and energy supply in the past years as well as the potential for further energy efficiency improvements for the coming years. This report also addresses what is required to enhance and speed up the rate of energy efficiency improvements to reach its potential levels.

Our main findings are:

*Progress in the field*

**1 Energy efficient technologies are rapidly increasing their market share**

These include heat pumps, compact fluorescent lamps, A-label appliances (the most energy efficient appliances in the EU) and hybrid cars. Especially in China and India, the uptake of more energy-efficient industrial technologies is strong because the greatest amount of new plant construction is taking place there. The total investment for energy-efficient technologies is currently estimated to be 60 billion Euros per annum.

**2 Despite most countries having both voluntary and mandatory policies in place, the incentives for change are not yet sufficient**

Many countries have labelling systems for electric appliances in place and some countries have introduced labelling for buildings. Energy efficiency standards are now in place in most countries, but it makes economic sense to make them more stringent, especially in developing countries. Voluntary agreements on energy efficiency exist in some countries, with mixed results.

**3 New policies and regulations do not show a broad impact yet**

Several innovative policy instruments are being explored, like energy performance standards for buildings, white certificate systems and emission trading systems. The impact of these systems is yet to be determined. Probably the most important new initiative is the Top-1000 programme in China, which sets energy saving targets for 1000 companies making up one third of China's energy consumption. The role of energy efficiency in carbon finance (for example the Clean Development Mechanism) is still small (6 percent) but the number of projects is rapidly increasing.

**4 Energy efficiency is still underappreciated regarding resource and capacity allocation to institutions**

The efforts in terms of market development, policy and research for energy efficiency are much smaller than those for the supply side of the energy system. In many countries there are structural constraints or policies are not clearly linked to regulations on the ground. Awareness and capacity building must supplement policies to be successful.

To conclude, we observe a variety of progressive and innovative developments. The market shares of energy-efficient technologies are increasing, new technologies are being developed, policy interest is growing and policies are becoming more successful. Definitely, a further decoupling of energy use from GDP can be seen, see Figure ES.1. In spite of this, the world energy use is still increasing by nearly 15 percent every 5 years and the required level of change in the energy system has not been achieved. The energy efficiency efforts in buildings, appliances and transport are still too limited.

*The energy efficiency potential*

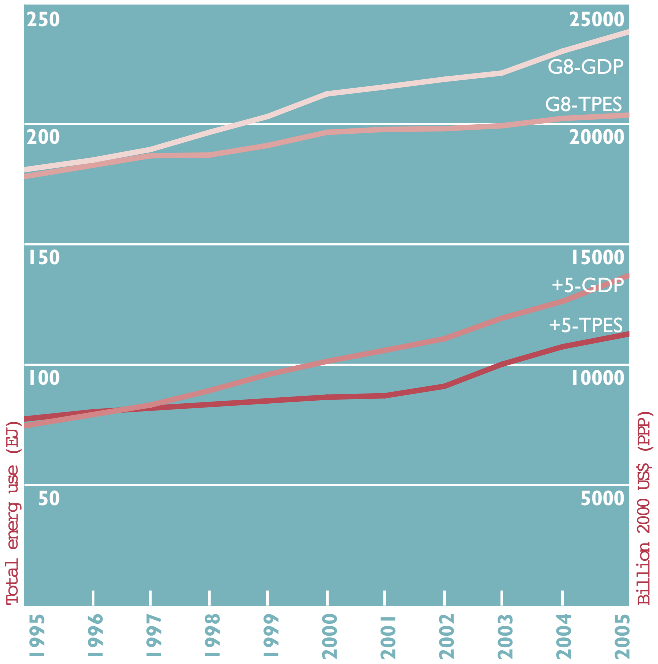
**5 There is a huge and cost-effective global potential for energy efficiency and it is also the most cost effective solution for avoiding $CO_2$ emissions.**

In 2050, it is estimated that energy efficiency improvements could reduce the primary energy demand by approximately 300 EJ, resulting in an annual emission reduction of approximately 20-25 Gtons $CO_2$ (compared to a business-as-usual scenario).

It makes more economic sense to invest in energy efficiency now rather than bearing the costs of the impacts of climate change later. Apart from climate change, increasing energy prices and energy security concerns are important incentives to stimulate energy efficiency. Especially for some developing countries which are experiencing high economic growth, usually accompanied by a strong increase in energy use, energy efficiency improvement is a cost-efficient option to alleviate the increasing energy demand, thus reducing energy costs and securing their energy supply.

**Figure ES.1**

**The development of total primary energy use (TPES) and GDP for the group of G8-countries and for the group of 5 major developing countries (+5)** Source: IEA




*What is needed*

**6 Short term results can be achieved with global initiatives in markets and policies**

Two major developments are needed to enter an era that will harvest the huge potentials of energy efficiency. Firstly, markets for energy efficiency have to be expanded globally to cover all sectors in all countries. Secondly, effective policy incentives need broadening, making use of the valuable experiences and good practices that are already available today.

**7 Data, necessary to evaluate energy efficiency, should be collected for all regions and sectors**

To be able to design and implement the right policies and standards, data on energy use is highly important. Unfortunately data is missing on specific energy use in buildings and transport, especially for developing countries.

Generally, energy related data (floor area, energy use, insulation values) on non-residential buildings is scarce. Specific energy performance per type of building is not available, while this information is necessary to quantify the impact of individual energy efficiency measures.

To monitor and assess industrial energy efficiency and the potentials to improve this efficiency, data on the current worldwide performance of industrial installations is missing. Also, energy use data at the desired levels of aggregation is often lacking or lacks sufficient quality.

**8 An intensification of R&D is urgently needed**

Many sectors are showing strong technological progress. Examples include more efficient glazing systems, passive houses that are now being built in large series, refrigerators, freezers and air conditioners that are rapidly becoming more efficient, a new generation of light sources entering the market, and natural gas fired power plants reaching conversion efficiencies above 60 percent. However, the investment in R&D does not match the potential of energy efficiency: governments in developed countries spend about 1 Euro per person per year.

**All in all, prospects for new initiatives from the private sector and from governments to boost energy efficiency potentials are good. Climate change concerns are a key driver for different energy-intensive sectors to developed energy strategies which starts with energy efficiency as a key element.**

# 1 – ENERGY USE AND ENERGY EFFICIENCY

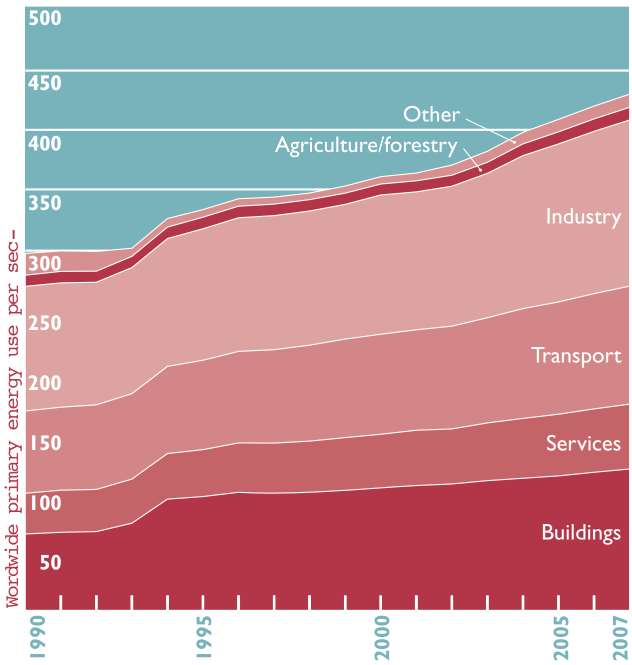
As economies in the world grow, the world energy demand increases. This has been the prevailing trend for many years, but in the future the world will not necessarily be subject to this law. There is a way to increase our activities and yet decrease our energy use – it is called energy efficiency.

In the last decades, energy efficiency has already made considerable progress. Without these measures adopted from 1973 onwards, energy use for the 11 IEA countries (36 percent of global primary energy use) would already have been 56 percent higher in 2004[1,10]. This represents a fuel cost saving of at least 400 billion Euros (current fuel prices).

And there is more to come. This report reveals the achievements and the promising potentials of energy efficiency, seen in the light of climate change and supplying affordable energy to everybody, particularly to people with low income in developing countries.

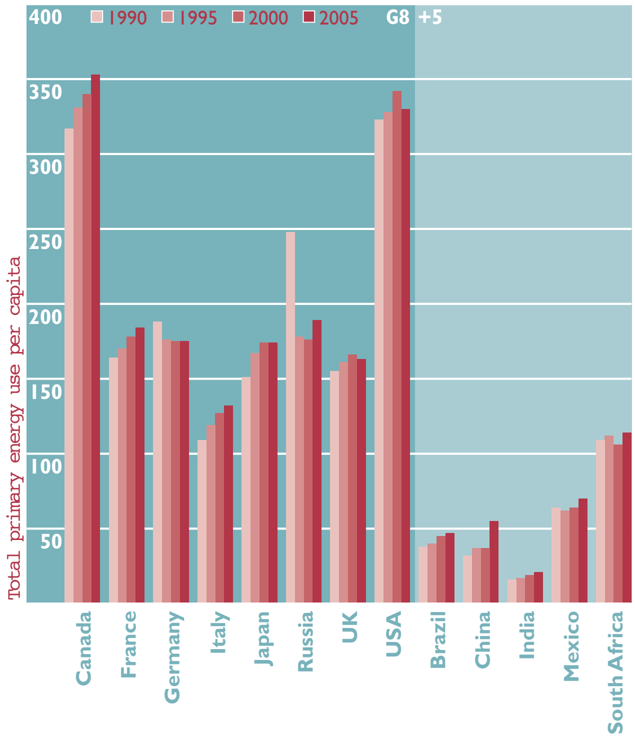
Despite the historic improvement in energy efficiency, global energy use is still growing. During the period 2001-2006, the global energy demand increased by 15 percent (2.8 percent per year). Growth occurred across all sectors within most countries and is directly related to the growth of human activities. Global Gross Domestic Product (GDP) increased by 3.8 percent per year[2]; steel production even grew by nearly 7 percent per year[3] and the amount of passenger cars by approximately 2.2 percent[4] per year.

**Figure 1.1**
**Development of worldwide primary energy use by sector**
Source: IEA, BP[5]




There is a lot of economic growth lying ahead of us, supposedly resulting in a large increase in energy demand. Developed countries, now responsible for two-third of the global energy use, are still increasing their demand. Developing countries are growing even more rapidly, while decreasing the wide disparity in per capita energy use across the world (Figure 1.2). China experienced the strongest annual growth over the period 2000-2005, both in absolute (3.6 GJ/year) terms and percentual (8.4 percent). This growth was aligned with the annual growth in GDP per capita in this period (8.9 percent).

**Figure 1.2**
**Development of primary energy use per capita in the G8+5 countries** Source: IEA[6]




With this ongoing growth in human activities in mind, we may ask ourselves: Will it ever be possible to stabilise our energy use?

This is where energy efficiency becomes relevant. Improvement of energy efficiency means doing more with less[7], or more precisely, reducing the energy demand per unit of activity. In this way, energy efficiency is essential in making the world energy system more sustainable[8]. It reduces local air pollution and global climate change, while improving the security of energy supply and making modern energy affordable for the entire world population. Many investments in energy efficiency improvement are cost efficient, especially with the current high fuel prices (25 US$ in 2002 to 65 US$ in 2007). Energy efficiency improvement increases the security of supply, since a nation can do more with less energy, thus reducing the amount of energy it has to import.

Energy efficiency is inherent to innovation but historically the rate is low. Typically, in a given year, a particular activity is covered by 99 percent of the energy that was required for the same activity in the year before.

This 1 percent yearly efficiency improvement obviously was not enough to offset the growth of human activities in the last decades Furthermore, the rate of improvement in energy efficiency decreased from 2 percent between 1973 and 1990 to 0.9 percent after 1990 (in IEA-11 countries)[10]. In order to substantially limit the growth or stabilise the total energy use, the rate of energy efficiency improvement should be between 2 to 4 percent per year[9].

Technically, these rates are viable, as many reports point out. This report answers the question whether we are indeed on the way to accelerate the rate of energy efficiency improvement to the required levels. The subject of energy efficiency is already on the political agenda: At the 34th G8 summit in Japan, all G8 members pledged to maximise implementation of the "25 Energy Efficiency Policy Recommendations by IEA to G8". These cover all energy using sectors and IEA estimates that global energy demand will be reduced by 20 percent (relative the World Energy Outlook projections) by 2030 were these policies to be fully implemented around the world.

Policies to promote energy efficiency are important to overcome existing market barriers such as high initial investments, split incentives (the investor in energy saving measures does not benefit from the lower energy bill.), lack of information and ingrained habits of producers and consumers.

Initially, the report sheds light on energy efficiency in various sectors: buildings and appliances, manufacturing industry, transport, agriculture and energy supply. Then, energy efficiency for the economy as a whole will be discussed. The results will apply to the world, but the emphasis will be on the G8+5 countries: the eight major industrialised countries and the five major developing economies.

## 2 – ENERGY EFFICIENCY IN BUILDINGS AND APPLIANCES

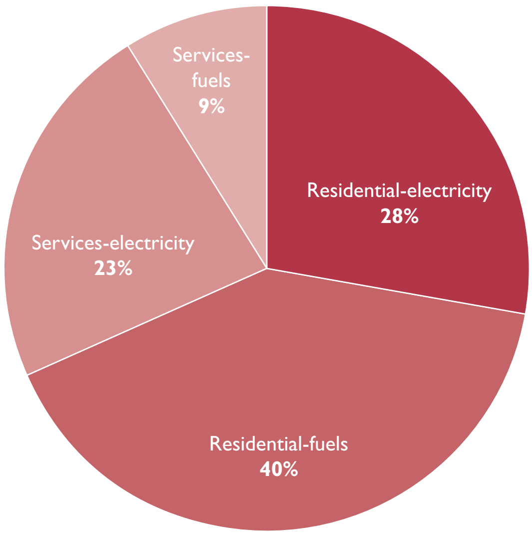
Buildings and appliances are responsible for over one third of the global primary energy use. In other words, all buildings in the world use the same amount of primary energy as all the United States of America.

In recent years, energy efficiency improvement for space heating was limited (3.5 percent in 2000-2004). Electric appliances show an accelerating improvement (10-15 percent in 2000-2005), with further technological developments in sight.

Many successful policies already exist, but for insulation of existing buildings stronger incentives are required. For most developing countries these measures are interesting as well, since they can be very cost-efficient.

Energy makes buildings comfortable through lighting, heating, cooling and ventilation. A breakdown of energy use in buildings is provided in Figure 2.1. Included in the total energy use of households are traditional fuels that are predominantly used for cooking in large parts of Africa and South Asia. These fuels represent 17 percent of the total energy use of households worldwide. Residential fuel has the largest share in the residential energy consumption.

**Figure 2.1**
**Breakdown of worldwide primary energy use in buildings in the year 2005** Source: IEA



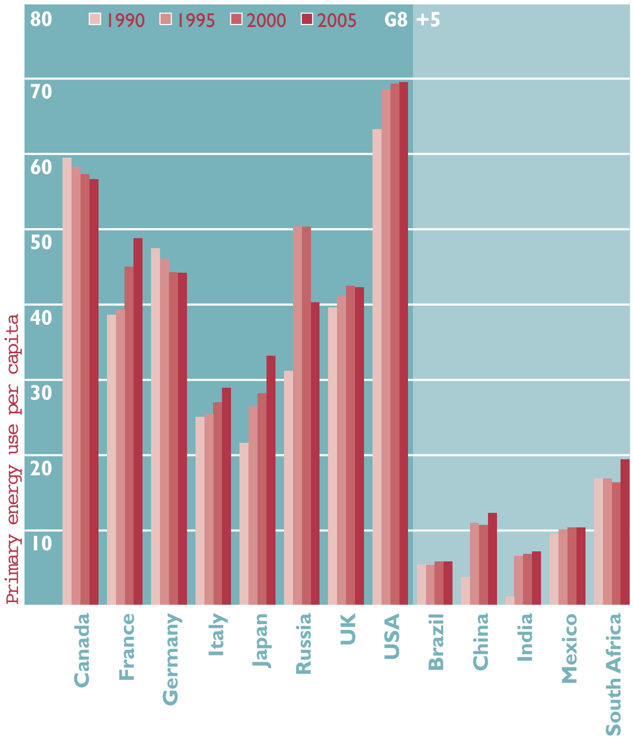

Worldwide energy use in buildings is steadily growing. During the last period of five years for which data is available the growth amounted to 11 percent (2 percent per year). Growth was particularly strong in the service sector. The electricity use grew much faster (3 percent per year) than the use of fuels (1 percent per year).

There is a wide variation of individual energy use in households, ranging from 7 to 70 GJ per capita per year (see Figure 2.2). Some countries show a declining trend, but for most of the countries the energy use per capita is still increasing. The strongest annual percentual growth occurred in China (2.8 percent), South Africa (3.3 percent) and Japan (3.4 percent).

For the service sector, energy use even ranges from 1 to 60 GJ per capita (Figure 2.3). Furthermore, Figures 2.2 and 2.3 reveal a large difference in per capita energy use between the G8 and the +5 countries.

Figure 2.2

**Primary energy use per capita in households in the G8+5 countries** Source: IEA




## Energy efficiency developments

The energy use for space heating largely depends on the climatic conditions of a country. Usually, we account for the various climate conditions, through the number of 'heating degree-days' and 'cooling degree days'.

The trends in the development of the specific energy use for space heating can be found in Figure 2.4. After an initial decline of the specific energy use in the 1980's, we saw in many countries a stabilisation in the nineties until now. The average weighted improvement in specific energy use over the period between 2000 and 2004 was 3.5 percent (0.7 percent per year). The relatively high heating intensities in (Northern) China can be attributed to the presence of district heating.

For electric appliances no generic data is available. However, also here we see a trend of further energy efficiency improvement. This is exemplified by the case of Canada, where an increase in household appliance ownership is observed, without the expected corresponding increase in household electricity consumption, see Figure 2.5. The improvement in energy efficiency can be estimated to be 2.5 percent per year (12 percent in five years).

Figure 2.3

**Primary energy use per capita in the service sector in the G8+5 countries** Source: IEA

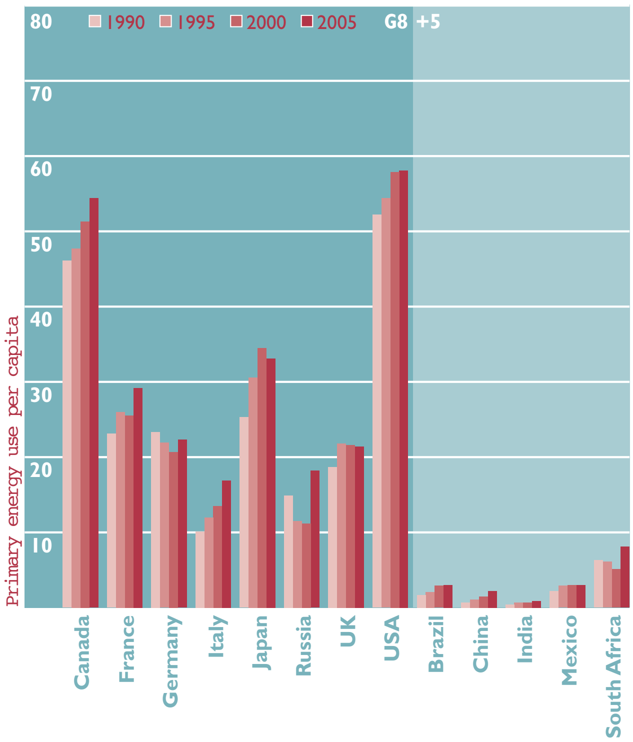



Figure 2.4

**Trends in specific energy use for space heating in selected countries** Source: IEA[10]

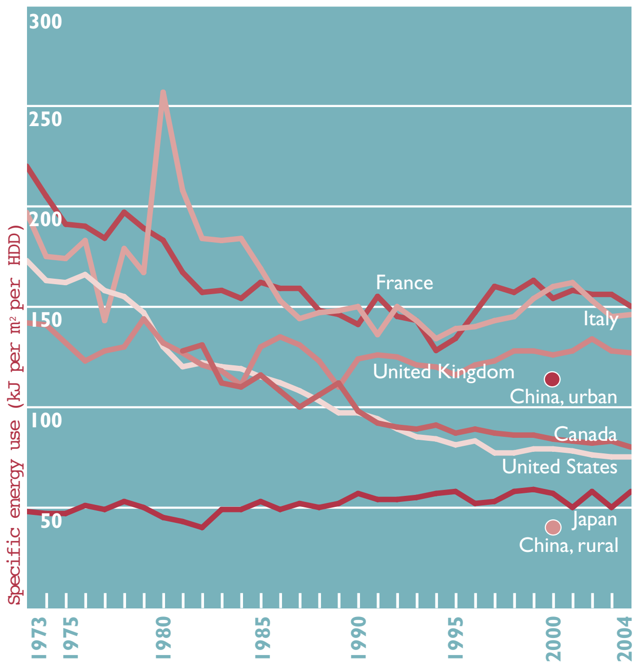


**Figure 2.5**

**Trend in household appliance stock and electricity end use in Canada** Source: OEE Canada[11]

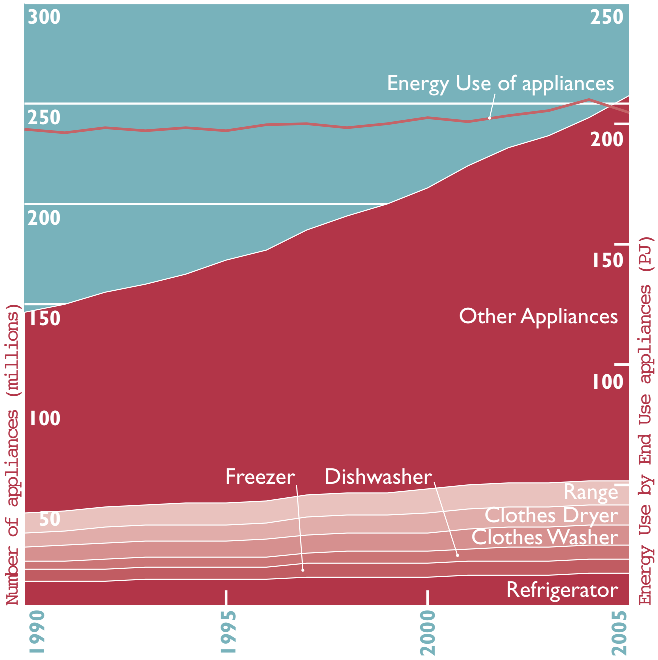
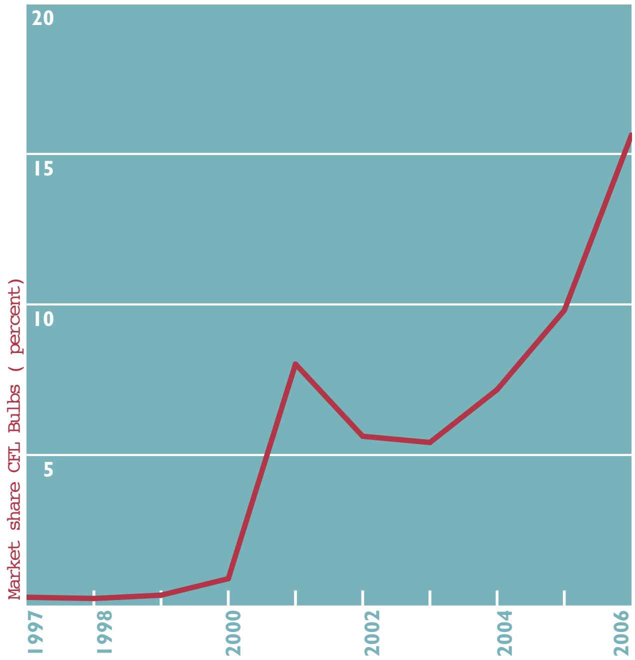



**Figure 2.6**

**Development of the market share of compact fluorescent lamps in the USA** Source: NEEA[12]




## Market and technology developments

A number of energy efficiency technologies are rapidly entering the market. The progress is particularly high for compact fluorescent lamps. For instance, the market share of these lamps in the US showed a growth of 60 percent in 2006 (Figure 2.6).

And still the innovation in lighting – estimated to use 9 percent of worldwide primary energy use[13]– continues. An interesting new technology is the LED-lamp[14]. LED technology promises even higher efficiencies than compact fluorescent lamps. The most advanced LED lights produce more than 100 lumen per Watt, while 70 lumen per Watt is already commercially available. In comparison, the best compact fluorescent lamps are now producing 60 lumen per Watt and a traditional incandescent light bulb only 15 lumen per Watt. However, the number of LED models available is still limited, and so is their market share.

Also efficient household appliances are rapidly expanding their market share. For example, the European market share of A label cooling equipment has more than doubled between 1999 and 2003 (Figure 2.7). The A-label represents the highest efficiency, G is the lowest. Meanwhile, appliance technologies are also steadily improving, shifting the A label to even higher efficiencies. An example is the refrigerator, which made substantial progress in the last decade (see Figure 2.8). The average improvement in energy use of new models in Japan in this period was 12 percent per year. During this period, the total energy efficiency improvement of refrigerators in Japan saved the construction of one complete power plant[15].

**Figure 2.7**

**Development of the market for refrigerators and freezers for various label classes. A is the most efficient label, G is the least efficient** Source: Lebot (2004), Bertoldi et al. (2006)[16]

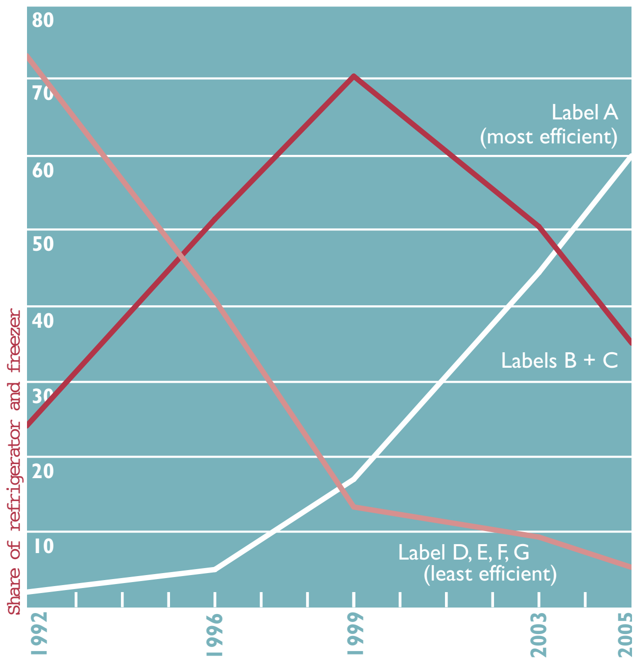


Figure 2.8

**Development of the energy performance of newly sold refrigerators in the USA and Japan** Source: NRDC, LBNL[17]

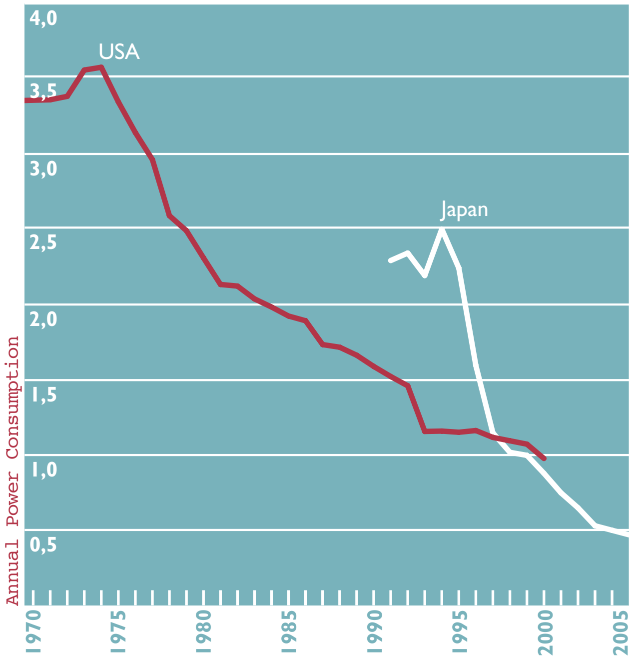
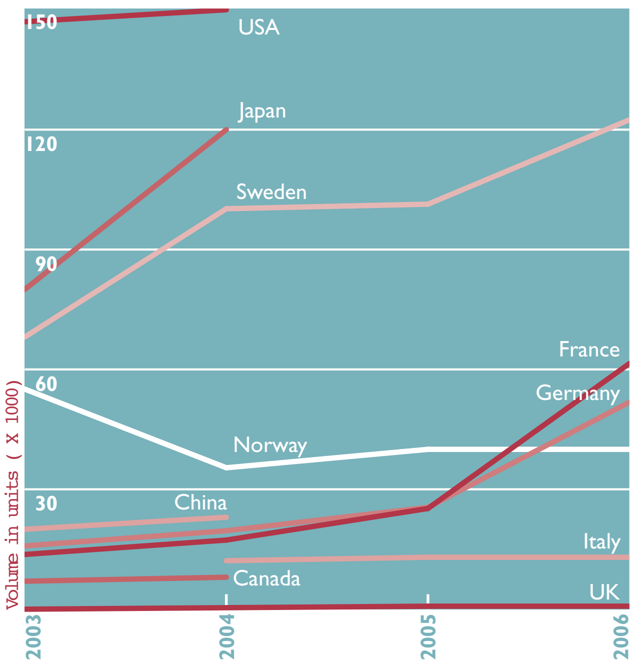



Figure 2.9

**The global heat pump market (2003-2006)** Source: EHPA[19]




One of the emerging technologies for heating buildings is the heat pump (Figure 2.9). The world market in 2003 and 2004 was dominated by US and Japan, together accounting for about 55 percent of the total market. The EU market is dominated by Sweden, covering about 40 percent of the EU market and 20 percent of the global market in 2004. But other countries are rapidly increasing their share. In 2006 Germany and France saw the largest growth in sales, respectively 103 percent and 144 percent increase with compared to 2005.

In the United States heat pumps are mainly found in the service sector, while in Japan domestic hot water applications in the residential sector dominate and in Sweden applications in single/double family houses[18].

In the area of glazing systems the progress is also continuous. Whereas conventional double glazing from the 1980's transmits 3 Watt of heat per m$^2$ per °C. This value has, through the application of argon filling and special coatings, already reached a level below 1 Watt per m$^2$ per °C.

Besides the efficiency improvement of individual devices, the integral design of buildings is an important development. By applying several measures simultaneously such as insulation, orientation of the house, recycling of exhaust heat, buildings can become low-energy, or even zero-energy. An interesting category is formed by the 'passive houses', which typically use less than 13-18 kJ per m$^2$, while a conventional house uses 50 to 150 kJ per m$^2$ (compare to Figure 2.4). To date, about 10,000 houses have been built as passive houses[20].

## Policy developments

For several decades, energy efficiency improvements in buildings have been subject to policies in virtually all countries considered in this report. For new buildings the standard requirements for insulation have been gradually tightened. Nevertheless, in most countries the insulation requirements are still far behind the state-of-the-art insulation that would be cost-effective (Figure 2.10). A newer development can be found in the introduction of energy performance standards for buildings. Such standards do not set requirements for each of the individual building components, like walls, roofs, glazing and boilers, but rather set one requirement for the building as a whole. European Union regulations are already asking for such an energy performance standard in all the Member States. However, currently only 20 percent of the Member States have fully implemented the Energy Performance Building Directive (EPBD) in their national policy[21].

It is generally acknowledged that major savings can be achieved through the further improvement of existing buildings[22]. Financial incentives for improving insulation and other measures exist in several countries, but the total support is far from sufficient to lead to a meaningful rate of retrofitting of these existing buildings. At present, EU legislation is introducing mandatory certification (labelling) for all buildings that are built, sold, or rented out. This law is expected to lead to a labelling of the entire existing building stock, though the labelling rate depends on the churn rates of buildings.

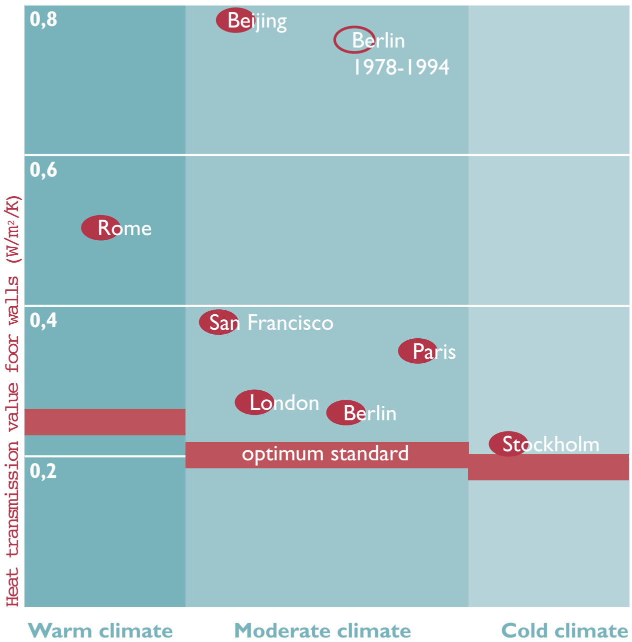
**Figure 2.10**

**The status of regulation for wall insulation in various countries**

Sources: Eurima, LBNL[22]

Most countries have legal requirements for the insulation value of new buildings. The requirement is generally expressed as the *heat transmission value*. This value is an indicator of the extent to which walls transmit heat. The lower the value, the smaller heat losses are. The dots represent the legal requirements for the heat transmission value at different locations in the world in 2007. In general, countries with a colder climate have more stringent requirements. The example of Berlin shows that requirements have substantially become more stringent in the past decade. Some developing countries nowadays have insulation standards as well, although less stringent. For China, there is no clear overview how many buildings are compliant with the indicated building code. A more stringent standard is feasible for Beijing, but monitoring the current standard is just as important.

Also the optimum standard is indicated. This is the standard that leads to the optimum result from an economic point of view. The figure shows that in virtually all countries considered the requirements are still higher than the optimal conditions.




An important barrier in considerable parts of the building sector is the split incentive. A well known example is the tenant-landlord problem. A tenant has to pay the energy bill (operational costs) and will benefit from energy saving measures, such as insulation. However, a landlord, who is responsible fo the building and investments in energy saving measures, wants to minimize the initial cost. This leads towards a situation that even cost-effective measures are not implemented.

Minimum energy performance standards can help to overcome this barrier, by setting strict requirements so that cost-effective measures on end-users level have to be taken. In addition, energy labels are useful to integrate the operational energy costs in the market value of a building. It can be expected that in the coming decade a building with lower operational costs will get a better market price.

For electric appliances, energy efficiency standards exist for some countries, including the US, since the 1970's. Since then, these standards have gradually become more stringent. In Japan, the Top Runner Programme was introduced in 1999 (box 2.4). In this programme, the product with the best energy efficiency will be used as the reference value for setting the standard. Potential technology improvements are considered as well. Results of the Top Runner program for selected appliances are presented in Table 2.1. For all products, results are beyond expectations. A major effort is underway in the European Union, where so-called eco-design standards are being developed for 20 types of energy-using equipment[24]. Measures for computers, office lighting, street lighting, standby- losses and chargers are planned to be adopted in 2008, for televisions in 2009. Measures for other product groups will be submitted and developed in the coming two years[25].

**Table 2.1**

**Achieved efficiency improvements in the first phase of the Japanese Top Runner Programme**[23]

| Product | Period | Expected | Actual |
|---|---|---|---|
| TV receivers | 1997-2003 | 2.5% | 4.2% |
| VCRs | 1997-2003 | 11.9% | 17.3% |
| Room air conditioners | 1997-2004 | 12.6% | 13.2% |
| Refrigerators | 1998-2004 | 5.1% | 10.8% |
| Freezers | 1998-2004 | 3.6% | 4.9% |
| Vending machines | 2000-2005 | 6.7% | 7.5% |
| Computers | 1997-2005 | 17.9% | 40.7% |
| Magnetic disk units | 1997-2005 | 15.5% | 36.0% |
| Fluorescent lights | 1997-2005 | 2.0% | 4.8% |

Labelling of appliances is becoming common practice worldwide. In Ghana an energy efficiency standard programme connected to a labelling programme for some appliances has existed in voluntary form since June 2005 and in mandatory form since June 2006 (box 2.1). In India a labelling system for green buildingswas set up (box 2.2). The US Energy Star programme is further expanding, both in energy applications and geographical coverage (box 2.5). Some European countries have introduced new types of policies, e.g. tradable energy efficiency certificates or white certificates (box 2.3).

To improve the efficiency of lighting, a ban on incandescent lamps has been widely discussed. Incandescent light bulbs will be phased out in Cuba, Venezuela, Australia (by 2010), Canada (2010), Philippines (2010) and in the United States (2014)[26]. Several EU-countries are also considering a ban.

Within the scope of this report it is not possible to give a full overview of all policies in place. However, present efficiency policies can be characterised as follows: some countries have ambitious policies in place or being implemented, but a much wider application of such policies is needed to achieve a higher impact. This especially concerns the energetic performance of existing buildings.

Box 2.1 **GOOD PRACTICE**

**Appliance and Energy Efficiency Standards and Labelling Programme, Ghana[27]**

- The programme requires that importers and retailers of Room Air conditioners and Compact Fluorescent Lamps (CFL) import and sell only products that satisfy the minimum energy efficiency standards.
- For Room Air conditioners a minimum Energy Efficiency Ratio (EER) of 2.8 watts of cooling per watt of electricity input is required.
- For CFL lamps a minimum light production of 33 lumen per Watt is required. Besides, CFLs should have a minimum lifetime of 6000 hours. Only products with these minimum performances receive a label. Labels are indicated with stars: the more stars displayed in the label the more energy efficient the product.
- Estimated energy savings from efficient room air conditioners are at least worth 8 million US-dollars, with 132000 tons of $CO_2$ emissions and power generation capacity savings of approximately 29 MW by 2010.

Box 2.2 **GOOD PRACTICE**

**TERI Green Rating for Integrated Habitat Assessment (GRIHA), India[28]**

- GRIHA is a program set up by the Indian Energy and Resources Institute (TERI).
- Its aim is to introduce a tool for measuring and rating a building's environmental performance in the context of India's varied climate and building practices.
- This tool, by its qualitative and quantitative assessment criteria, will be able to 'rate' a building on the degree of its 'greenness'.
- The rating will be applied to new and existing building stock of varied functions – commercial, institutional and residential.
- The programme supports 'green building' with benefits like reduced energy consumption, reduced air and water pollution, reduced water consumption and reduced destruction of natural areas, habitats and biodiversity.

Box 2.3 **GOOD PRACTICE**

**Energy Efficiency Commitment, UK[31]**

- This programme requires electricity and gas suppliers to achieve an overall saving of 130 TWh in the Great Britain households. Each licensed energy supplier with a minimum of 50000 consumers has individual targets according to the number of consumers.
- Suppliers are setting up energy efficiency improvement plans with a maximum of flexibility. For example they subsidise low income households by covering some costs of cavity wall insulation or by supplying free CFL lamps.
- Already in May 2008 the programme exceeded its initial target with an overall saving of 185 TWh. The insulation measures accounted for 77 percent of the total savings, followed by lighting with 12 percent, heating and CHP with 7 percent and appliances with 4 percent.

**Box 2.4 GOOD PRACTICE**

**Top Runner Programme, Japan[30]**

- **Japan's Top Runner programme is a regulatory scheme designed to stimulate the continuous improvement of energy efficiency of products like household and office appliances and vehicles.**
- **Through Parliamentary decision in 1998, the programme is incorporated as an element of the Japanese Law Concerning the Rational Use of Energy (the Energy Conservation Law). It is administered by the Agency for Natural Resources and Energy under METI, the Ministry of Economy, Trade and Industry.**
- **Top Runner is a maximum standard value system; the (available) product with the highest energy efficiency will be used as a base in the standard establishment process. Potential technology improvements are considered as well.**
- **The Top Runner scheme is expected to contribute substantially to Japan's overall energy savings ambition. The total savings are expected to fall within the range of 16 to 25 percent of the entire national savings target by 2010, which totals about 2,000 to 2,500 PJ.**

**Box 2.5 GOOD PRACTICE**

**US Energy Star Programme[29]**

- **ENERGY STAR is a joint program of the US Environmental Protection Agency (EPA) and the US Department of Energy. It started in 1992 stimulating energy efficiency improvement in the residential, commercial and industrial sector in order to reduce greenhouse gas emissions and energy consumption.**
- **This voluntary labelling program covers major appliances, office equipment, lighting, heating and cooling, home electronics, commercial and industrial building. The labelling standards are implemented in Australia, Canada, EU, Japan, New Zealand and Taiwan. Furthermore, ENERGY STAR supports the China Standard Certification Center (CSC) to harmonise its energy efficiency standards.**
- **In the US in 2007, 500 million ENERGY STAR products have been sold across 50 product categories and 120,000 homes have been built with the ENERGY STAR label (bringing the total to 840,000). EPA estimates that the ENERGY STAR programme prevented 40 million tons of greenhouse gas emissions in 2007.**

## 3 – ENERGY EFFICIENCY IN MANUFACTURING INDUSTRY

The manufacturing industry experienced a strong growth in energy use in developing countries (25 percent in the period 1995-2005). At the same time, substantial energy intensity improvements were observed in countries like China and India. Technological development is steady but slow. Policies are in place in several countries, but need to be enhanced in order to accelerate the uptake of more efficient technology.

In the manufacturing industry, energy is needed to produce a wide range of commodities, from basic materials to consumer goods. Figure 3.1 provides the sectoral breakdown of industrial energy use. Most of the energy is used by a limited number of sectors that produce basic materials, such as iron and steel, cement and basic chemicals. These 'heavy' industries accounted for most of the increased energy use in the sector, largely due to an increasing demand for these materials in developing countries. Energy use in manufacturing industry grew by 14 percent (2.6 percent per year) in the period between 2001 and 2006 (Figure 3.2). A decrease of 1.5 percent per year was observed in developed countries (G8), compared to an increase of 8.4 percent per year in developing countries (+5). The strongest growth took place in China at a rate of 12 percent per year.

Despite these differences in growth rates, the energy use per capita is still far higher in developed countries (Figure 3.2) where per capita energy use in manufacturing industry ranges from 6 GJ per year in India to 94 GJ per year in Canada in 2005. Different levels of industrialisation, energy efficiency and imports or exports of energy intensive products explain these differences. The three countries with the lowest manufacturing energy use per capita in 1990 (China, India and Brazil) experienced the strongest increase in the manufacturing energy consumption per capita over the period between 1990 and 2005. Per capita industrial energy use in the developing countries is still much lower than in the G8 countries.

**Figure 3.1**
**Development of global industrial primary energy use by sector** Source: IEA

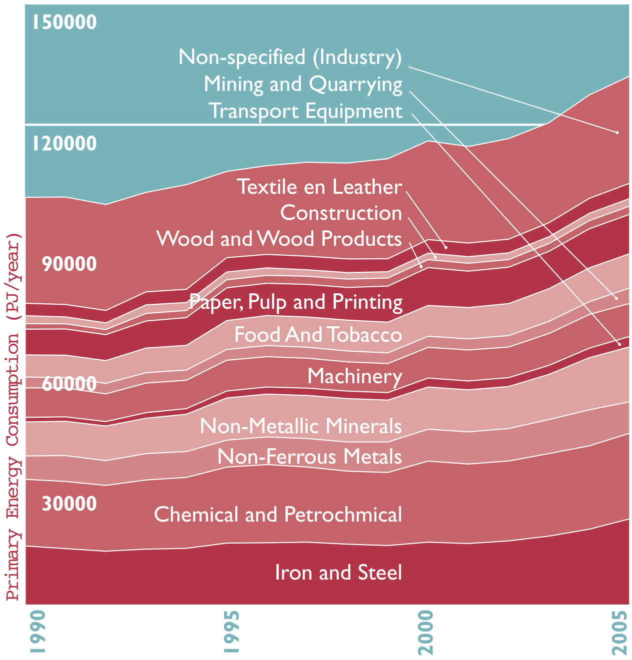
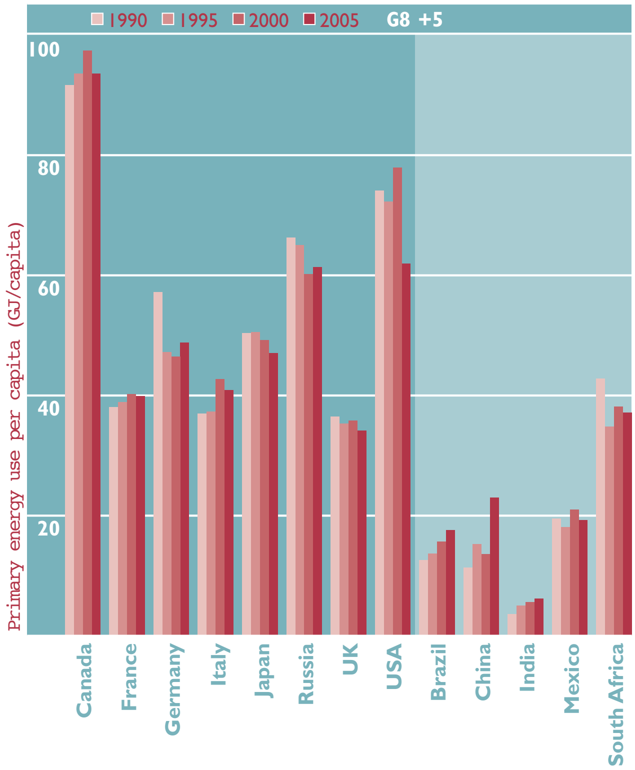



**Figure 3.2**
**Development of industrial primary energy use per capita in the G8+5 countries** Source: IEA




## Energy efficiency developments

Most sectors in the manufacturing industry produce a range of products, so it is generally not possible to apply a simple indicator of energy efficiency. Instead, an aggregate indicator, the energy efficiency index (EEI) is used[32]. A decrease of the EEI means that the energy use per unit of product was reduced.

Figure 3.3 shows the development of the energy efficiency index for the iron and steel industry for the G8+5 countries. For these countries, the energy efficiency improvement amounted to 9 percent over the last five years (1.8 percent per year). It is striking that in some countries (e.g. South Africa) the energy efficiency deteriorated, which may be caused by the strong increase in steel demand, which led companies to take less efficient plants into operation again.

It is worth mentioning the strong progress in energy efficiency that has taken place in China (7.4 percent per year) and India (7.9 percent per year). The likely explanation is a rapid expansion of production capacity with relatively efficient technology.

In cement-making the first, and the most energy-intensive, step is the production of clinker. Figure 3.4 provides the development of specific energy use for clinker production. Between 2000 and 2005, the energy needed per tonne of clinker decreased on average by 0.5-1.0 percent per year.

**Figure 3.3**
**Development of the energy efficiency in the iron and steel industry, expressed as the energy efficiency index**
Sources: IISI, Phylipsen (2000)[35]

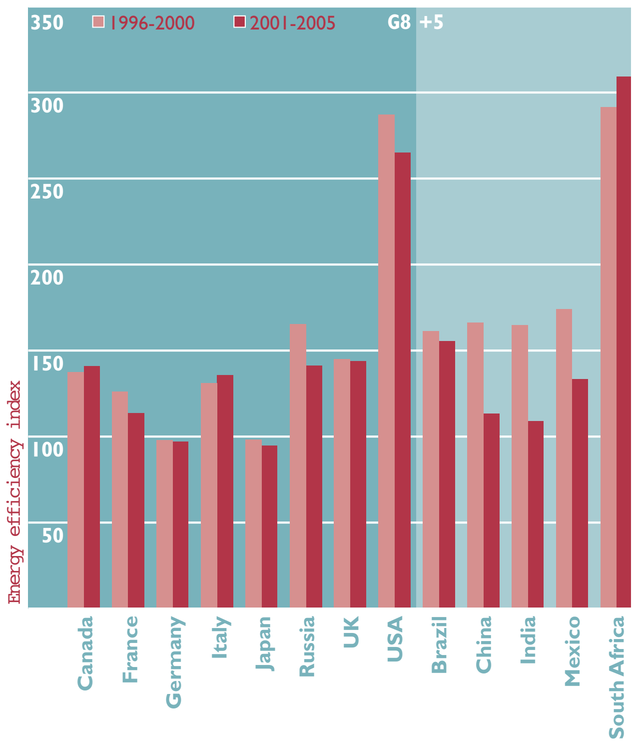


**Figure 3.4**

**Development of the specific energy use in the cement industry, expressed as the energy use per tonne of clinker**

Sources: IEA, USGS, BDZ, Infociments, CCAP[36]

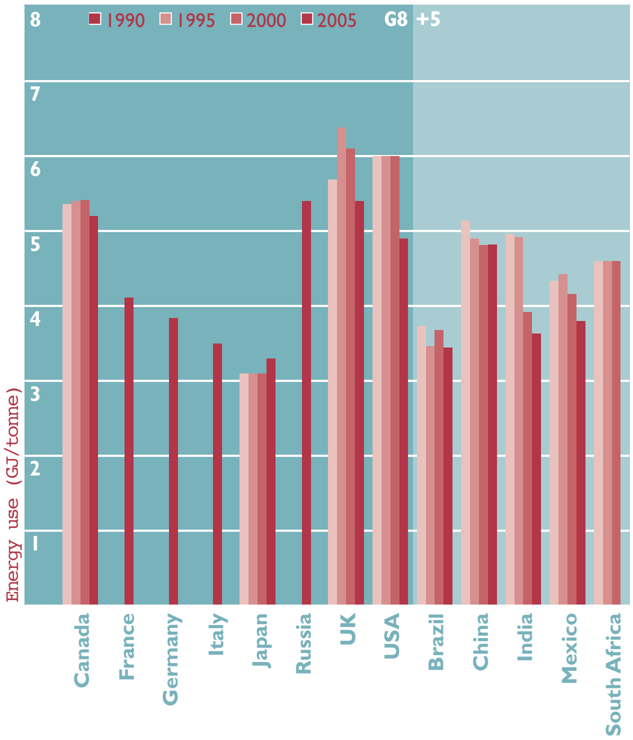



**Figure 3.5**

**Specific energy consumption in ammonia ($NH_3$) production in 1995 and 2000. The dotted line indicates the best-practice level for ammonia ($NH_3$) production in 1995 and 2005**

Sources: IEA, Phylipsen (2000), USGS, LBNL[37]

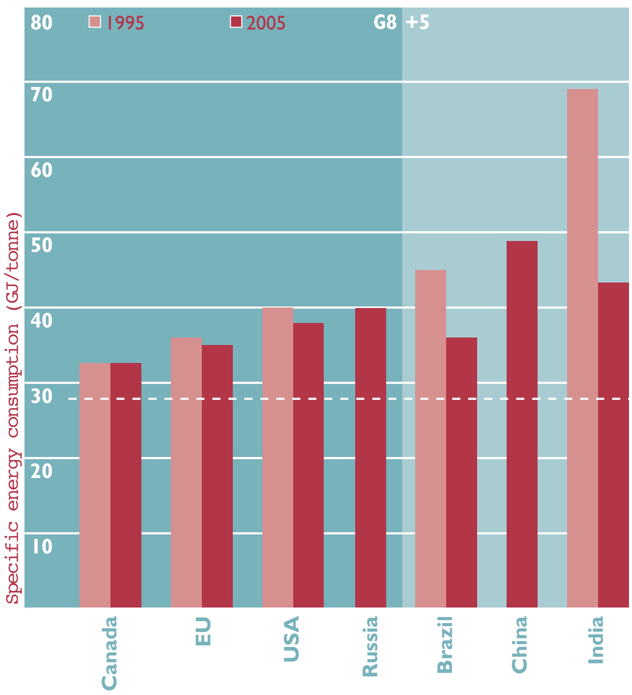
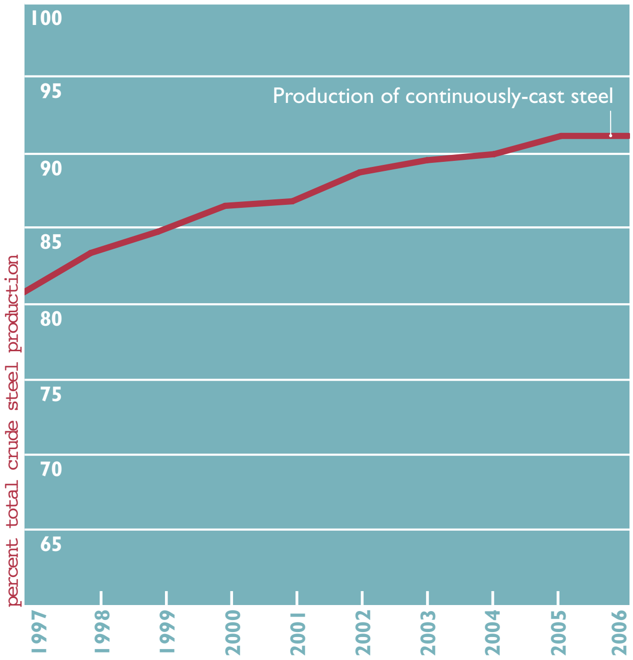



**Figure 3.6**

**Global share of continuously-cast steel in total steel production** Source: IISI[3]




Ammonia production consumed more energy than any other process in the chemical industry and accounted for 18 percent of the energy consumed in this sector. Ammonia is mainly applied as a feedstock for fertilizer production. The specific energy use for ammonia production is given in Figure 3.5. G8 countries, for which data is available, show a slow decline in specific energy use. The average progress (weighted according to production volumes) is 15 percent over the period 1995-2005 (1.7 percent per year). Also in this case progress in developing countries (Brazil and India) is much faster. The specific energy consumption in China is higher than average and Figure 3.5 reveals a large efficiency improvement potential.

## Market and technology developments

In manufacturing industry, we observe a slow but steady introduction of new technologies. The iron and steel industry might serve as an example. Here an important breakthrough would be the replacement of the conventional blast furnace technology that has been dominant during two millennia, with smelt reduction technology (currently commercially applied in South Africa, India, South Korea and Australia) that no longer needs the energy-intensive coking process.

Continuous casting has long been regarded as the most efficient technology for casting steel. The market share of this technology has now reached over 90 percent (Figure 3.6). More efficient technologies which can further decrease the energy used for the steel finishing are emerging: thin-slab casters are becoming common for new plants and strip casters are finding their first commercial application.

## Policy developments

One type of policies that has definitely played a dominant role in the area of industrial energy efficiency is the 'voluntary programme'. After first appearing in Denmark and the Netherlands, voluntary programmes are now in place in many countries in the world. The character of voluntary programmes can widely vary, from completely voluntary programmes on the one hand, to negotiated agreements with well-defined targets and monitoring and verification procedures in place on the other hand (Figure 3.7). According to the evaluation of the IPCC[33], voluntary agreements have definitely played a role in national policies. The majority of them did not lead to significant savings beyond business-as-usual, but there are some exceptions that showed a measurable impact.

Nowadays, there is a tendency towards more binding standards and regulations. An interesting development is the Top-1000 Energy-Consuming Enterprises Programme in China (see box 3.1). Under this programme absolute energy use targets for 2010 are set for a thousand companies with the largest energy use, together accounting for nearly half of China's industrial energy use. The targets were set in 2006, and first evaluation reports already show significant savings[34].

In the European Union, a substantial part of industrial $CO_2$ emissions are presently included in the EU Emission Trading System. Its impact so far is likely to be limited, but that may change in the coming decade (see further discussion under Energy Supply).

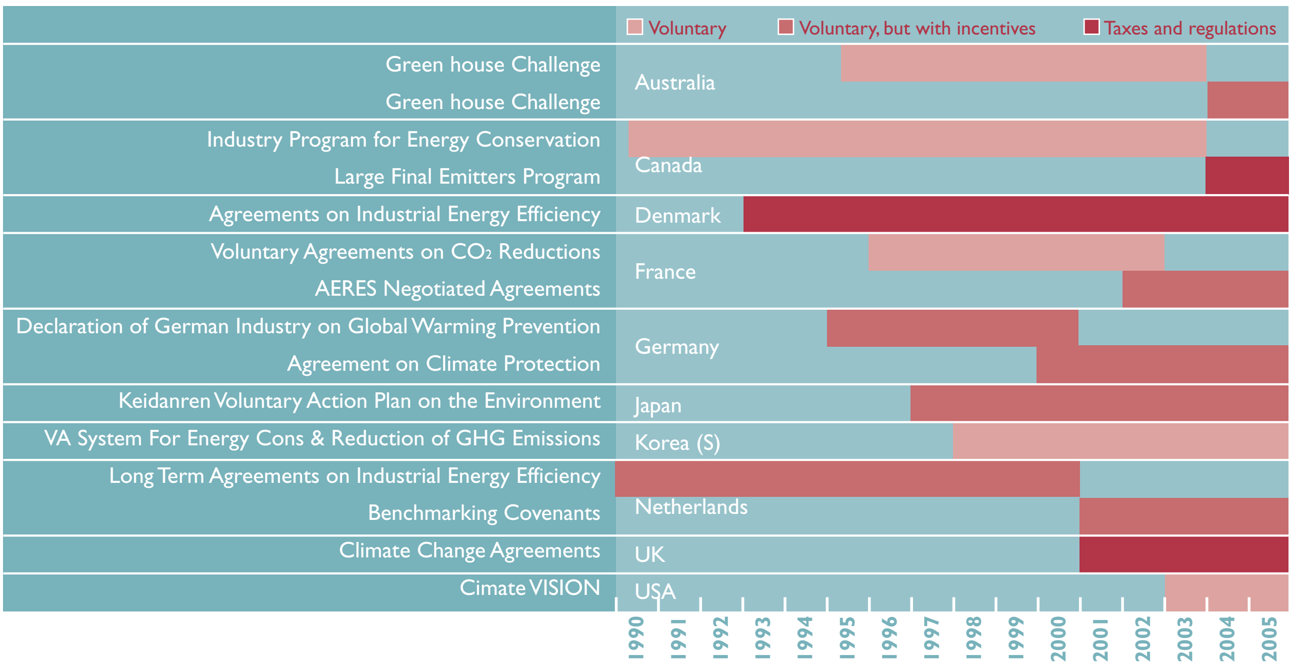
**Box 3.1 GOOD PRACTICE**

**Top 1000 Energy Consuming Enterprises Programme, China[39]**

- **In 2005, the Chinese government announced an ambitious goal of reducing energy consumption per unit of GDP by 20 percent between 2005 and 2010.**
- **One of the key initiatives for realising this goal is the Top-1000 Energy-Consuming Enterprises programme.**
- **The energy consumption of these 1000 enterprises (mostly found in the industry and power sector) amounted to 22,900 PJ in 2006, which is about 33 percent of the total energy consumption in China.**
- **Under the Top-1000 programme, 2010 energy consumption targets were announced for each enterprise. The target is to reach annual savings of 2,900 PJ in the 2006-2010 period.**
- **Activities to be undertaken include benchmarking, energy audits, development of energy saving action plans, information and training workshops and annual reporting of energy consumption.**

**Figure 3.7**

**Overview of status and development of major voluntary programmes for industrial energy efficiency** Source: LBNL[38]



## 4 – ENERGY EFFICIENCY IN TRANSPORT

Transportation is responsible for almost one third of world energy use. Sixty-five percent of this energy for transportation is used in developed countries. During the last decade the progress in energy efficiency, new technologies and new policies has been significant, but much more attention is needed, especially in air and freight transport. Developing countries are lagging behind in energy efficiency, but they use more transportation means that are less energy-intensive.

Energy used bringing people and goods from one location to another is responsible for 30 percent of the global energy use. Of this energy use, about two-thirds are for passenger transport and about one-third for freight transport.

Worldwide energy use in transport increased rapidly: by 2.3 percent per year for the last five years for which information is available. The growth amounted to 1 percent per year in developed countries (G8) and 5 percent per year in developing countries (+5) (Figure 4.1). Especially in this sector the gap between developed and developing countries is big.

In the area of passenger transport, the car is the dominant means of transportation, responsible for about half of the world passenger transport kilometers. It is important to recognise that buses, mini-buses and two- and three-wheelers make an important contribution to total passenger transportation, about one third. These transportation modes with low energy-intensity are especially important in developing countries.

### Energy efficiency developments

The energy efficiency of new cars is depicted in Figure 4.2. After improvements in the 1980's, the specific energy consumption of cars stayed at a more or less constant level during the 1990's. Improvements in engine and vehicle technology were offset by an increase in car size and engine power. In recent years, however, a clear change in trend can be observed in European countries and Japan, with an average improvement of 4 percent in the period between 1999 and 2004 (1 percent per year). One of the basic causes for this is the ACEA agreement, which will be discussed in the policies section of this chapter.

For developing countries, less comprehensive information is available; however, for most countries the specific energy use is estimated to be on the high end of the range: 11–12 litres per 100 km, for Africa even higher[40]. This is to a large extent due to the age of vehicles. Africa is importing second hand vehicles from industrialised countries on a large scale.

### Market and technology developments

Probably no other industry sector than the car manufacturers has taken so many technology initiatives to achieve a greater sustainability. In the 1990s of the last century, the world saw a step up in R&D in the area of new engine technologies, including electric, hybrid and fuel cell technologies, resulting in thousands of patents in these areas.

One technology that made it to the market is the hybrid car, which combines an electric motor with a fuel engine or fuel cell. Sales of hybrid cars are rapidly growing (see for example, Figure 4.3). The market share of hybrids in the total of newly sold cars in the United States was nearly 3 percent by the end of 2007[41].

**Figure 4.1**
**Primary energy use per capita in transport sector in the G8+5 countries for the year 1990, 1995, 2000 and 2005** Source: IEA

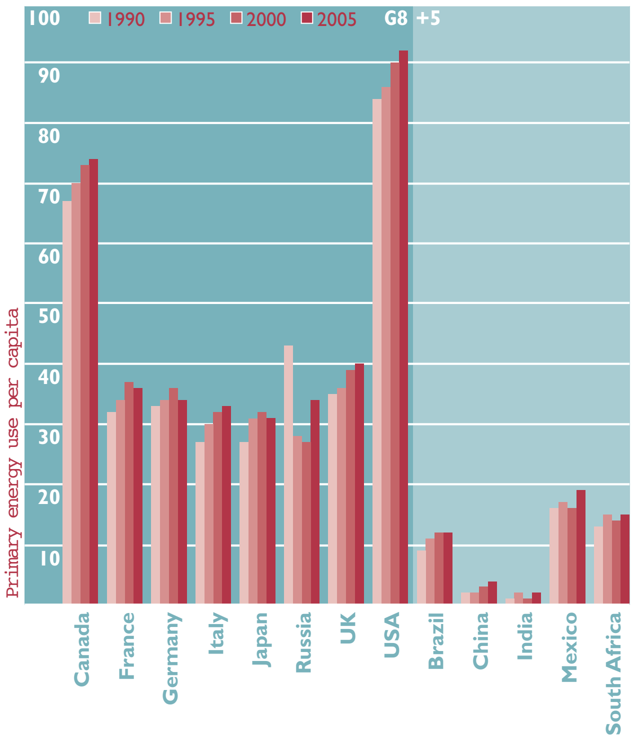
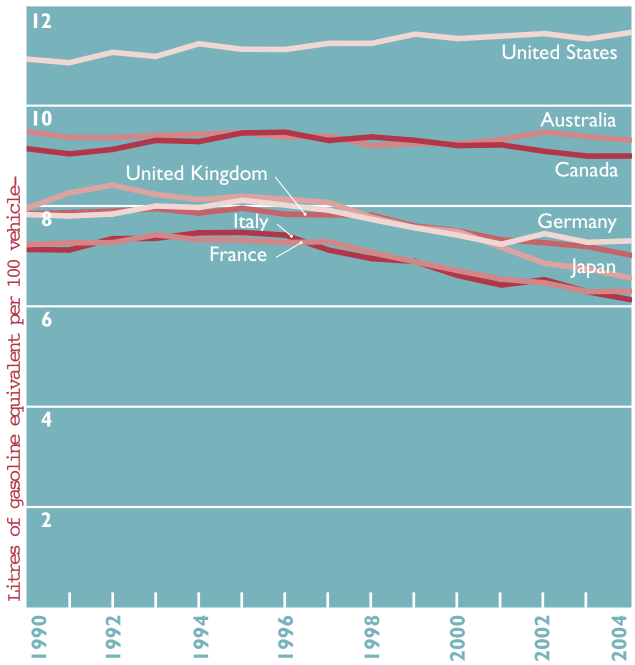



**Figure 4.2**
**Development of the specific energy use for new passenger cars in selected countries** Source: IEA[10]



In 2008, sales of vehicles with the lowest fuel efficiency experienced the largest decrease, due to the high gasoline prices. This indicates that high pricing of gasoline promotes the market share of fuel saving vehicles.

## Policy developments

Apart from the initiatives in the sector, several governments have taken policy initiatives to improve energy efficiency in transport. Japan, US and China already implemented regulatory standards.

In Japan, passenger cars are included in the Top-Runner programme; over the period 1995-2005, the average energy efficiency improvement was 2.1 percent per year. Apart from light duty vehicles, heavy duty vehicles are included in the Top-Runner approach, making Japan one of the few countries paying attention to this category. In this case, the improvement was 2.0 percent per year, much more than the expected 0.6 percent.

Since 2005, new passenger vehicles are subject to fuel economy standards in China. Regulatory maximum fuel consumption standards are set for 16 different weight classes. In 2008 and 2009, phase II of the programme will take effect, with higher standards. According to the China Automotive Technology & Research Center (CATARC), the overall passenger vehicle fuel efficiency improved with 9 percent over the period 2002-2006. Furthermore, China introduced taxation on vehicles, depending on the size of the engine, the larger the engine, the higher the tax on the vehicle.

The ACEA agreement is a voluntary agreement between the European Automobile Manufacturers Association (ACEA) and the European Commission to limit the amount of carbon dioxide emitted by passenger cars sold in Europe. Signed in 1998, the agreement aimed to reduce the $CO_2$ emission level of new passenger cars from 186 g/km of $CO_2$ in 1995 to an average of 140 g/km of $CO_2$ by 2008, corresponding to 5.8 l petrol/100 km or 5.25 l diesel/100 km.

Although the agreement led to significant reductions in specific energy use (see Figure 4.4), the agreement will most likely not achieve its target as only 160 g/km had been achieved by 2005. In 2007, the European Commission acknowledged the limited achievement of the ACEA agreement and introduced a proposal for legally-binding $CO_2$ limits. The ultimate EU target is to reach an average $CO_2$ emission of 120 g/km for all new passenger cars by 2012. A level of 130 g/km should be realised by improvements in the motor vehicle technology and another 10 g/km by using biofuels and other technological improvements.

To conclude, quite some progress can be seen in the area of passenger car policies, although the current efforts are limited to Japan, China, the US and the EU. It is important to recognise that passenger cars are only responsible for about half of the energy use in transportation. Special attention has to be paid to other areas, including freight transport, and air traffic, which requires international co-ordination because of their international character. Freight road transport is rarely included in regulatory standards.

**Figure 4.3**
**Hybrid car sales in the United States** Source: ADTA[42]

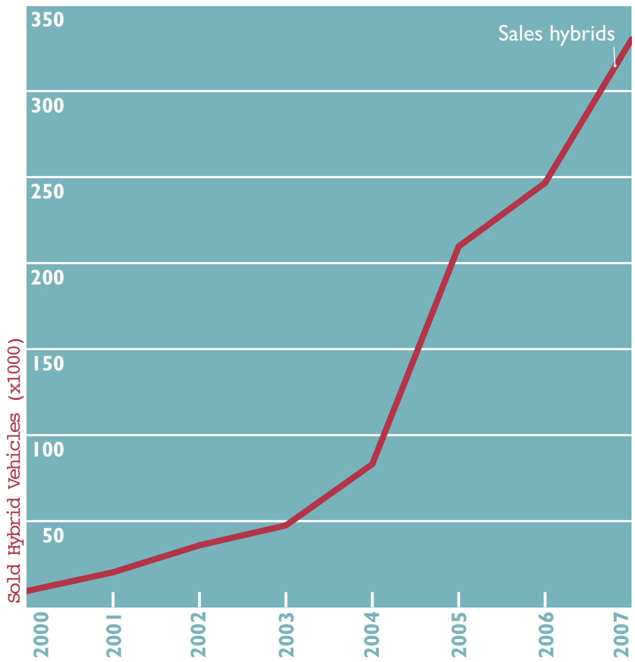
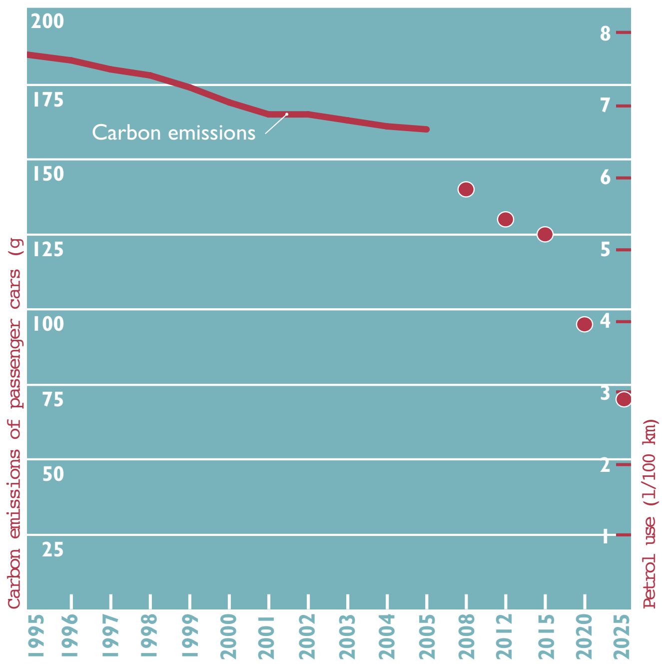



**Figure 4.4**
**Progress of the ACEA agreement, dots represent future EU targets** Source: ACEA[43]



## 5 – ENERGY EFFICIENCY IN AGRICULTURE

Although agriculture itself is responsible for less than 2 percent of the world energy use, the impact of the entire food production system is much larger. However, the energy efficiency in the food production chain is improving.

In some developing countries energy use in agriculture is much more important, up to more than 10 percent of the total energy use. Some policies have been introduced in these countries, for instance to improve the energy efficiency of irrigation pumps, but the overall attention for policy development and data collection is still limited.

In agriculture, energy is needed for a range of applications, ranging from irrigation to land cultivation and drying of products. In addition, energy is needed for fertilizers and further processing and storage of products. This indirect energy use is not included in agriculture statistics, but it is important to recognise that the entire food production system is larger than agriculture.

In the year 2005 the global energy use for agriculture amounted to 1.7 percent of the total primary energy use. Energy use in agriculture has a larger share of the total in countries like Zimbabwe (7 percent), Yemen (11 percent), Tajikistan (12 percent), Namibia (13 percent) and Jamaica (12 percent). In the G8+5 countries, the share of agriculture in total energy use is highest in Brazil (4 percent) and India (3 percent).

Energy use for agriculture hardly changed during the last five years for which data are available. Between 2000 and 2005 the agricultural energy use in Canada, France, Germany, Italy and UK decreased by less than 0.5 percent.

Canada and Russia have the highest agricultural energy use per capita, although Russia drastically became more efficient between 1990 and 2005, see Figure 5.1. In the other countries, per capita energy use is lower (between 1 and 3 GJ/capita).

Figure 5.2 depicts the energy use per hectare of agricultural land. It shows that especially Japan uses considerable energy per hectare of land (almost 30 GJ/ha in 2005). This is due to a relatively small amount of available agricultural land and a higher intensity of land use that comes with that. All other countries have an energy use that is equal to or lower than 11 GJ/ha. Especially US, Brazil, Mexico and South Africa have a very low primary energy use per hectare (less than 2 GJ/ha in 2005). China experienced the strongest growth, in energy use per capita and per hectare. The strongest absolute growth in energy use per hectare occurred in India, which has a much higher population density than China.

It must be stressed that, due to the limited share in total energy use, the attention paid to agriculture in energy statistics is limited. This means that the results in this chapter should be interpreted carefully.

**Figure 5.1**

**Primary energy use per capita for agriculture in the G8+5 countries** Source: IEA[47]

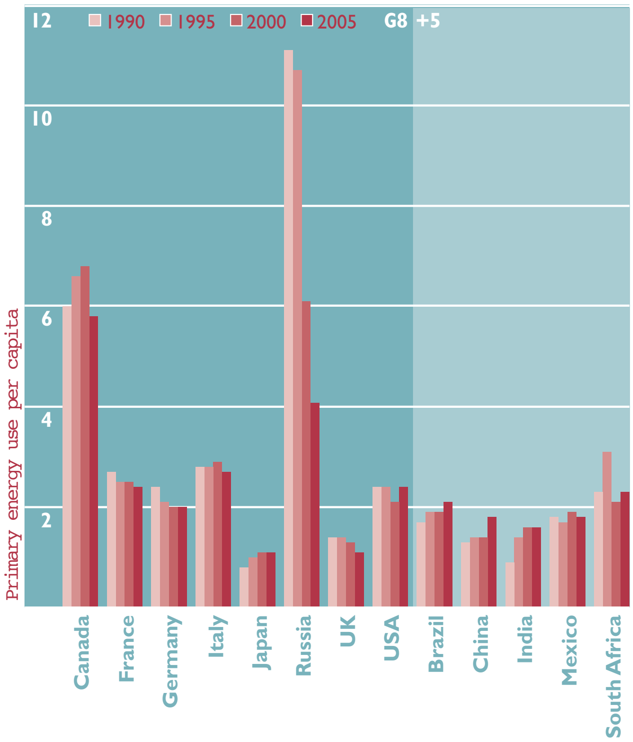
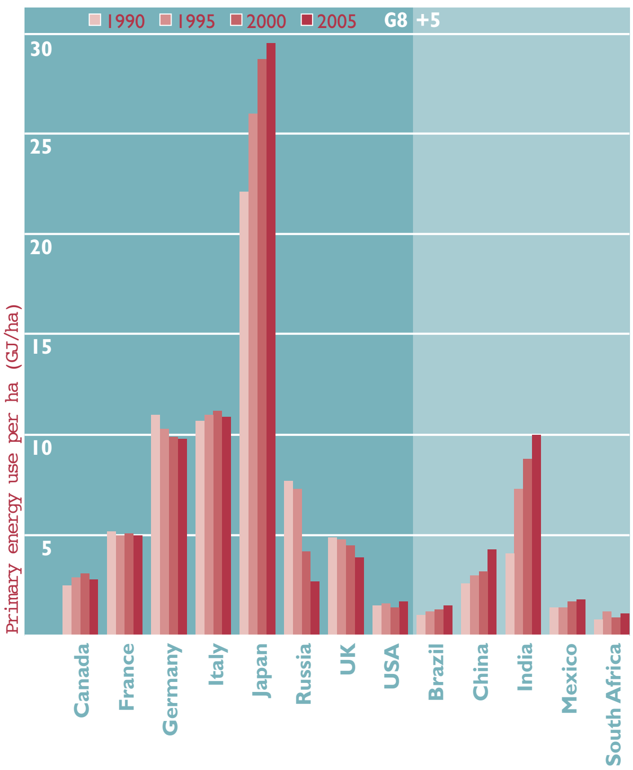



**Figure 5.2**

**Primary energy use per hectare of agricultural land in the G8+5 countries** Source IEA, FAOSTAT[48]



## Energy efficiency developments

Limited information is available on energy efficiency in agriculture. As one of the main aims of agriculture is to produce food, the energy use per unit of food-energy can be used as an aggregate indicator. Figure 5.3 shows a steady reduction of energy use per unit of food-energy produced. However, the energy use per unit of food-energy in the food system as a whole (including the food processing industry) did not fall. This is due to increased processing and a shift to a diet with a higher share of animal products. Figure 5.3 shows results for Europe, but the trend holds also for other countries at similar stages of development.

One of the most energy-intensive sectors within agriculture is greenhouse horticulture. An example for the Netherlands shows that the energy efficiency improved, by 3.4 percent per year, in the period between 2001 and 2006 (Figure 5.4). It is the objective of the sector, to improve the energy efficiency further by 6 percent per year until 2010[44]. This is made possible by technology innovations, like the closed greenhouse and the energy producing greenhouse[45].

In India the agriculture sector is the most electricity intensive sector, with a 27 percent share in total electricity consumption in 2000-2001. The main reason for this is the wide diffusion of electric water pumps, representing the second most energy intensive sector in Indian agriculture, after land preparation[46].

## Policy developments

Agriculture is not high on the agenda when it comes to energy efficiency policies. But there are some important exceptions to this rule. For example the Indian government makes efforts to improve irrigation systems (see box 5.1).

**Box 5.1 GOOD PRACTICE**

**Improvement of irrigation systems in India**[51]

- **The Indian government wants to raise the agricultural growth rate to 4 percent per year, as a means to reduce poverty. Better and more evenly distributed sources of irrigation must achieve this. Farmers prefer irrigation pumps as the most reliable source of irrigation.**
- **The government has promoted a programme for the deployment of solar photovoltaic water pumping systems during 1993-1994. The capital costs of these systems yet limited the diffusion of these units far below the initial target of 50.000 to just over 7000.**
- **In addition the government promoted the replacement of the electric pumps with ISI (Indian Standard) pumps that use 25 percent to 35 percent less energy.**

**Figure 5.3**
**Energy efficiency in total agriculture, expressed per calorie of food produced** Source: Ramirez (2005)[49]

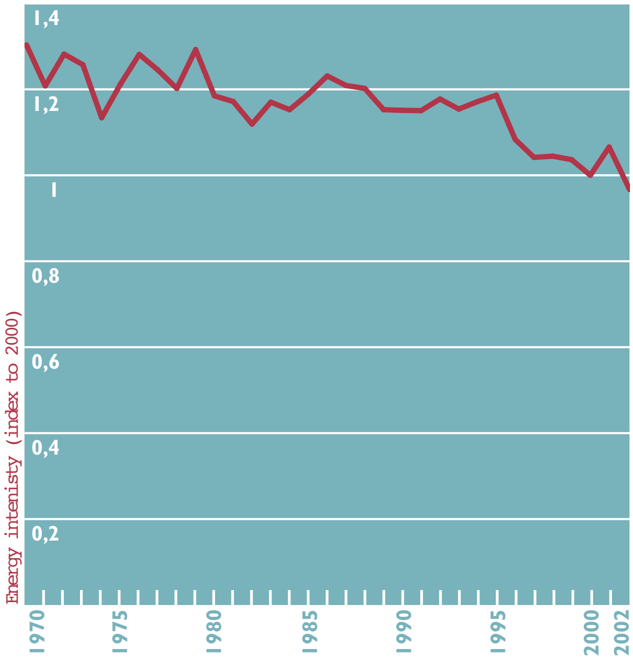
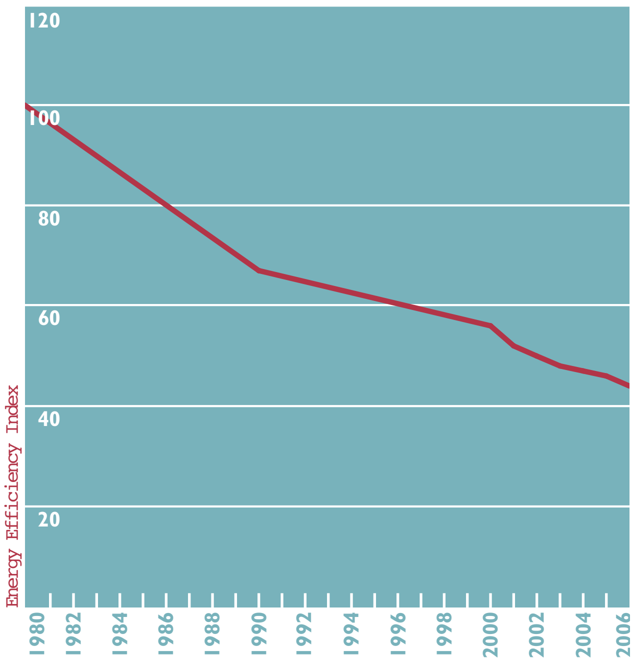



**Figure 5.4**
**Energy efficiency index of the greenhouse horticulture in the Netherlands (1980=100%)** Source: SenterNovem[50]



# 6 – ENERGY EFFICIENCY IN ENERGY SUPPLY

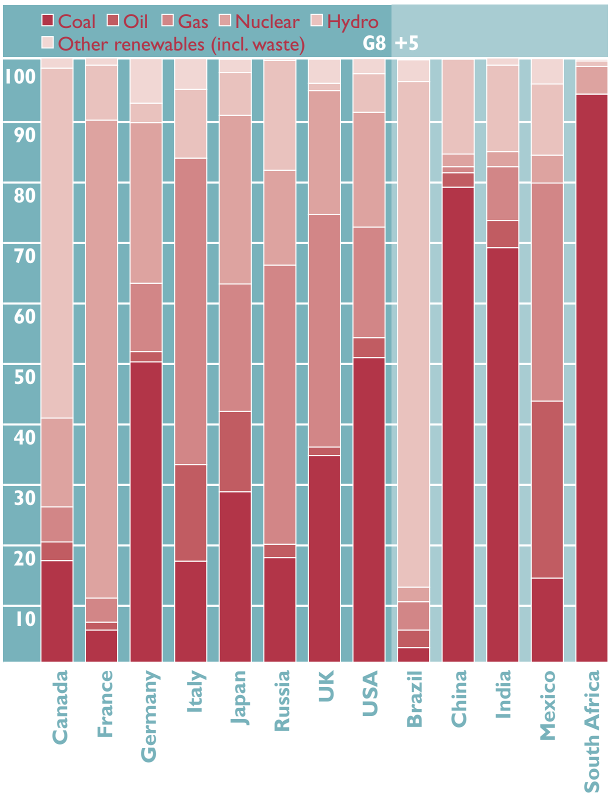
Electricity is the part of the energy consumption growing most rapidly throughout the world, highlighted by a 19 percent increase in the past five years. So it is interesting to have a closer look at the efficiency opportunities in fossil fuel power plants. At present, efficiencies vary widely by country, from about 30 percent for the least efficient countries up to 50 percent for the most efficient. These percentages mean that 50 to 70 percent of all primary energy is lost during the generation process. This in turn leaves room for further efficiency improvement.

The energy supply sector consists of a number of sub-sectors, including oil refineries and coking plants. The most important sector in terms of energy conversion losses is the electricity production sector. In the power sector, a wide range of options is available to reduce greenhouse gas emissions, including switching to fuels with lower carbon content, conversion to nuclear or renewables and energy efficiency improvement. This chapter will focus on energy efficiency improvement.

Worldwide, 35 percent of total primary energy supply is used to produce electricity. Figure 6.1 depicts the breakdown of electricity production in the G8+5 countries. Fossil fuels, especially coal and natural gas, are still dominant in most countries. This section focuses on fossil-fuel based electricity production.

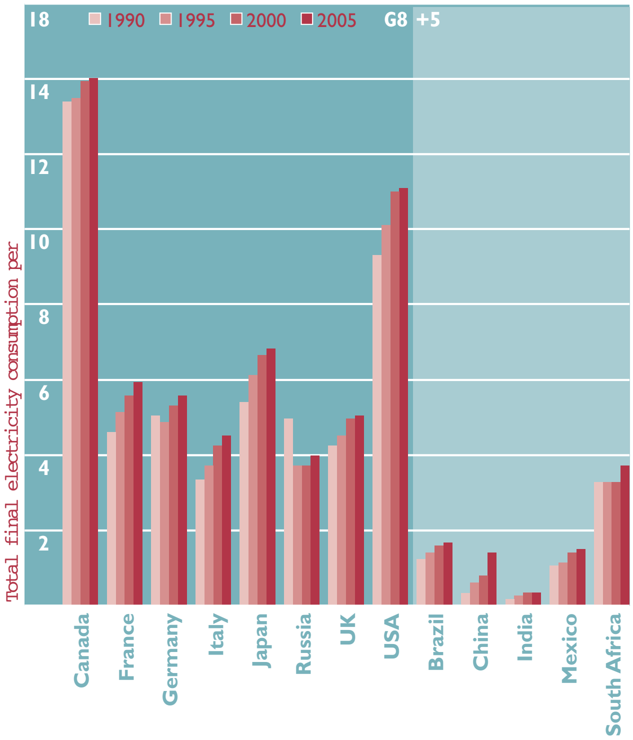
Worldwide electricity consumption grew at a rate of 3.6 percent per year in the last five years for which data is available, which is much stronger than the growth in total energy use

**Figure 6.1**
**Breakdown of electricity production into source categories for the G8+5 countries** Source: IEA




(2.4 percent per year). In all G8+5 countries, the electricity consumption per capita is growing. Figure 6.2 reveals the development of the electricity consumption per capita in the G8+5 countries. Notably, in absolute terms the growth per capita is high both in developed countries and in developing countries. In the past five years an average inhabitant of a G8 country added 250 kWh to the electricity consumption; an average inhabitant from a +5 country added 380 kWh. After a steady electricity consumption level in the period between 1990 and 2000, the electricity consumption in South Africa increased over the period 2000-2005 (2.8 percent per year). China and India experienced the most rapid annual growth between 2000 and 2005; 12.7 and 3.8 percent, respectively.

**Figure 6.2**
**Development of the electricity consumption per capita in the G8+5 countries** Source: IEA




## Energy efficiency developments

Around the world energy conversion efficiencies of fossil fuel power plants are gradually increasing. Average conversion efficiencies of coal-fired power plants increased over the past five years by 1.3 percentage points in the G8 countries, and 5 percentage points in the +5 countries (Figure 6.3). In effect, this increase has already resulted in a saving equivalent to twelve new power plants in G8 countries and 40 power plants in +5 countries. The major part of the electricity in China, India and South Africa is produced by coal-fired power plants (Figure 6.1). These countries experienced a growth in electricity demand (Figure 6.2), but the growth in fossil fuel (coal) demand was tempered by the realised conversion efficiency improvements.

**Figure 6.3**

**Development of the conversion efficiency of coal-fired power plants**[59]

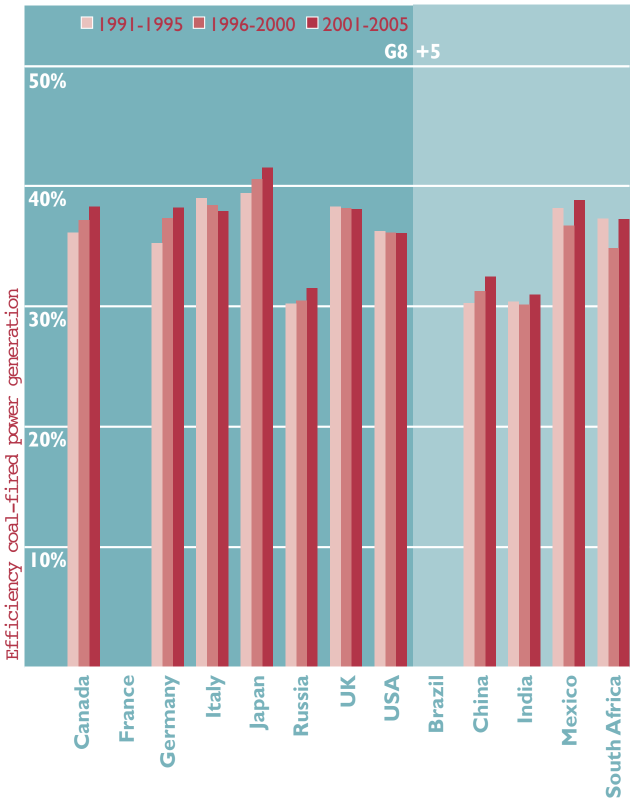
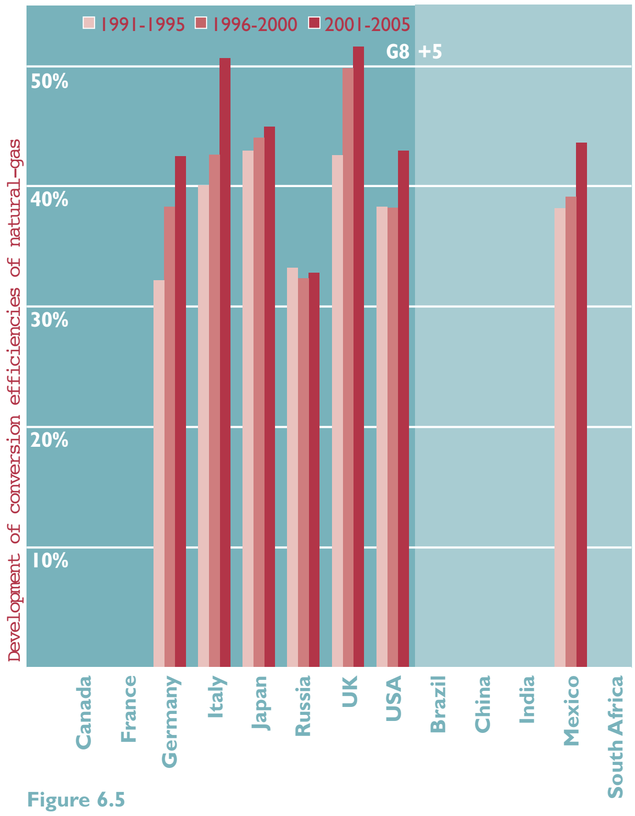



**Figure 6.4**

**Development of conversion efficiencies of natural-gas fired power plants** Source: IEA[60]



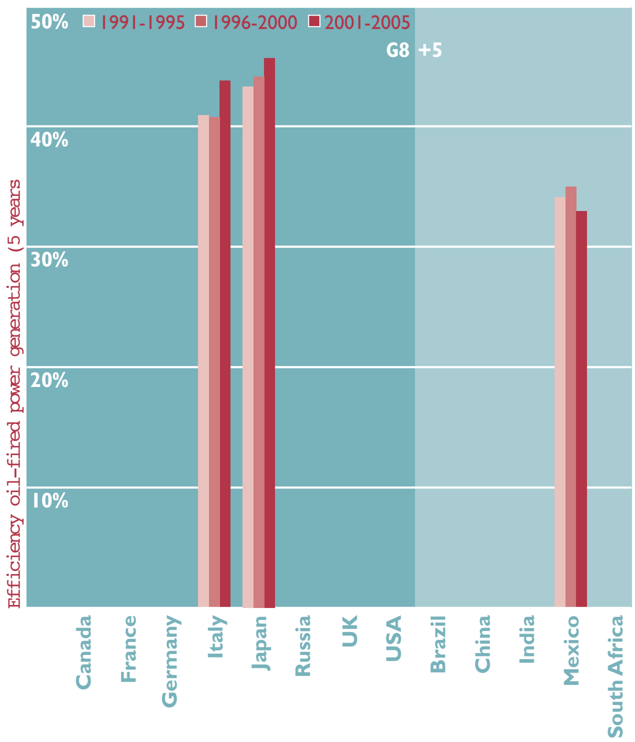

For natural-gas fired power plants the increase is even stronger: 8 percentage points in G8 countries and 12 percent-points in the +5 countries (Figure 6.4). This corresponds to a saving of 46 power plants in G8 countries and 7 power plants in +5 countries.

The highest efficiencies for coal-fired and oil-fired power plants are now found in Japan (more than 40 and 45 percent, see figure 6.3 and 6.5, respectively). In general, power plants in Japan have the highest efficiency. Natural gas-fired power plants have the highest efficiency in Italy and the UK. Plants in Russia, both coal-fired and natural gas-fired are performing the least efficient.

A significant part of the electric power is lost during transmission and distribution. These losses can be divided in technical and commercial losses. Technical losses are caused by resistance in power lines and conversion losses in transformers. Technical losses vary between 5 and 15 percent of the electricity production[52]. Commercial losses are caused by theft/illegal tapping, administrative errors, incorrect metering or unpaid bills. In 2005, 8.7 percent of the world- wide electricity production was lost, which was 1589 TWh, equivalent to the production of 440 power plants.

**Figure 6.5**

**Development of conversion efficiencies of oil-fired power plants for countries with a significant share of oil-fired electricity production** Source: IEA[61]



In Europe, around 5-8 percent of the electricity production is lost (about 1 percent commercial losses). Of the G8+5 countries, India has the highest percentage of losses, 25 percent, while Japan has the lowest percentage, 4.6 percent (in 2005)[53].

## Market and technology developments

The efficiencies of natural gas and coal fired power plants are expected to further improve in the coming years. At the moment the state-of-the art efficiency of natural gas fired power plants is 60 percent, but it is expected to increase to 65 percent in the near future[54]. The efficiency of coal-fired power plants is currently 46-47 percent, but that will improve to 48-52 percent in the coming years.[55]

If combined with the generation of heat, the overall efficiency of a power plant will increase considerably. In some countries the share of combined generation of heat and power (CHP) is considerable. Measured in gross electricity generation, the share of CHP was 13 percent in Germany and 9 percent in Italy in 2005. In addition, waste to energy CHP plants for district heating exist in Italy with overall efficiencies of 84 percent[56].

## Policy developments

One of the main policies affecting the power sector is greenhouse gas emission trading. The European Union started in 2005 with the first stage of the large-scale emission trading system (ETS). In the first phase (2005–2007) the system saw significant prices that dwindled later on. The system has influenced the power sector, but the impact was mainly on fuel choice (a shift from coal to natural gas). No discernible impact on power plant efficiencies has been found yet.

Although prices in the second phase of the EU ETS seem to be more stable, it is too early to predict the actual impact on conversion efficiencies of power plants.

With regards to CHP, significant support schemes exist in EU countries. A common EU Directive from 2004 requires all Member States to establish promotional schemes for high efficient CHP plants. Germany already issued a law in April 2002, putting in place a system of certification of CHP plants based on conversion efficiencies factors. The policy concerns a feed-in tariff for CHP-generated power, combined with an obligation for power suppliers to purchase this CHP power. A purchasing obligation is also the main instrument imposed on Italian and French system operators. The policy in UK for promoting CHP plants is mainly based on fiscal incentives.[57]

In order to reduce technical grid losses, Australia, New Zealand and China implemented Mandatory Minimum Efficiency Performance Standards (MEPS) for transformers, while Japan included transformers in the Top Runner Programme and the US and Europe developed voluntary standards. The US standards are scheduled to become mandatory in the near future[58].

# 7 – OVERALL DEVELOPMENTS

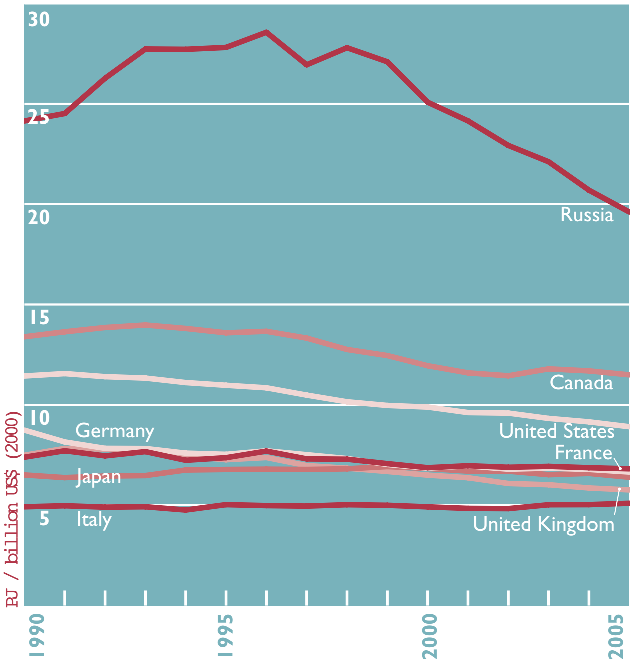
Energy intensities of most G8+5 economies are declining, but at slow pace. Only in Russia, a fast decline is observed, although absolute numbers remain high.

All over the world, many policies are in place and some of them prove to be very effective. Energy efficiency already represents large annual investments amounting to around 60 billion Euros[62] in recent years. But energy efficiency has not penetrated all sectors in all countries. A continuation of investments and policies development is required.

## Developments in energy intensity

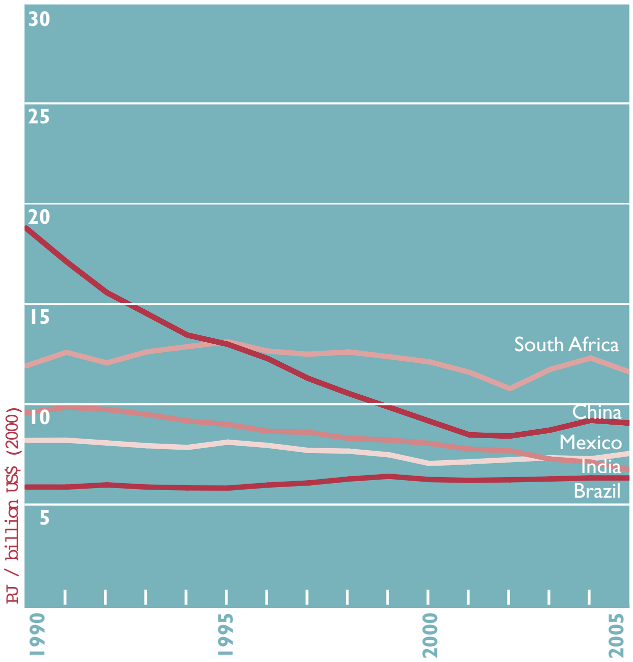
To get a quick impression of national developments, the 'energy intensity' is often used as an indicator. The energy intensity is defined as the ratio of the total primary energy supply over gross domestic product (GDP). Changes in energy intensity of a country are not only caused by changes in energy efficiency, but also by changes in economic structure. The development of the energy intensity of the G8+5 countries is depicted in Figures 7.1 and 7.2.

**Figure 7.1**
**Total primary energy supply per GDP in the period 1990-2005, for G8 countries** Source: IEA




For most of the countries the changes in energy intensity are relatively modest. China saw a rapid decline of the energy intensity in the 1990s, but in recent years, the energy intensity is more or less stable. Part of the explanation is a strong increase in recent years in production of basic materials, like steel, offsetting the overall increasing efficiency.

**Figure 7.2**
**Total primary energy supply per GDP in the period 1990-2005, for +5 countries** Source: IEA




Russia still shows a strong decline of the energy intensity, bearing in mind the high initial levels. The initial increase of energy intensity in Russia is explained by the fact that between 1990 and 1996, GDP decreased much faster than the total primary energy supply, resulting in an increase of the ratio. After 1996, both primary energy supply and GDP grew, but the GDP grew faster than the total primary energy supply, resulting in a decrease of the ratio.

## Development of the energy efficiency market

So far, strong efficiency improvements only occur for specific applications in specific countries, but the efforts have not yet spread to all sectors in all countries. Nevertheless, the achievements are substantial: energy efficiency improvement has lead to avoiding the construction of 1700 power plants worldwide.

Total annual investments are substantial: they are estimated to be 60 billion Euros in recent years, creating hundreds of thousands jobs[62]. The annual investments lead to a saving of energy costs of 25 billion per year.

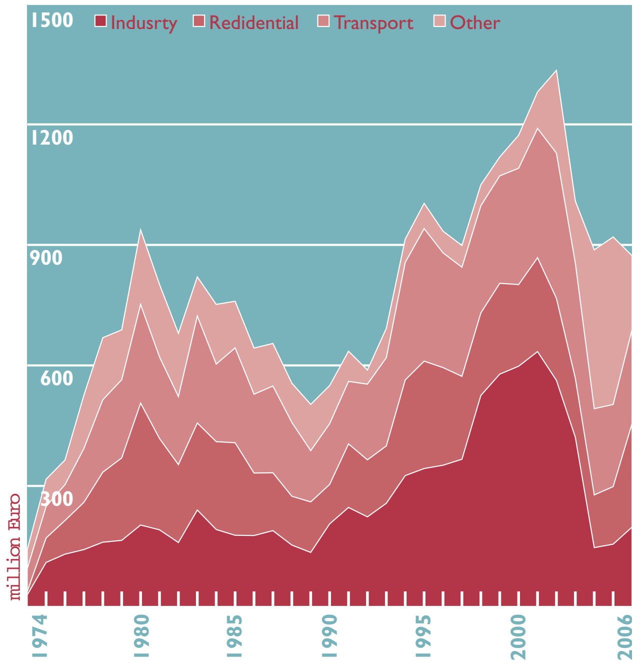
Recent years have shown strong increases in energy prices. Crude oil prices increased from 25 US$ per barrel in 2002 to 65 US$ per barrel in 2007. Partly in connection with the rise in oil prices and partly for other reasons, prices for all other energy carriers, like coal, natural gas and electricity, have also increased. As the short-term price elasticity of energy use is generally low, the impact of higher prices on the adoption of more energy-efficient technologies is still limited (note that many data in this report run only to 2006). However, it is likely that much stronger impacts of the elevated energy prices will be noticeable in the years to come.

## Technology development

The development of new technology is indispensible for further efficiency improvement in the long run. Governments usually stimulate this kind of energy efficiency innovation by financially supporting Research and Development (R&D). The development of R&D support by IEA countries is depicted in Figure 7.3. Energy efficiency R&D support has increased since 1990, but in recent years there has been a declining tendency. Note, however, that R&D statistics are not always complete.

The share of energy efficiency R&D support in the total of energy R&D support in IEA countries is modest at around 12 percent. Also in per capita terms the expenditure is limited at about 1 Euro per year.

**Figure 7.3**
**Development of energy efficiency R&D support in IEA countries** Source: IEA[63]




## Development of generic policies

The standard example of a generic policy, targeting more than one application or one technology, is an energy or carbon tax. Except for the automotive sector, where fuels are heavily taxed in many countries, taxes are still not very common. Only a few countries, like Denmark and the Netherlands, heavily tax small consumers. The UK and Denmark have a tax for industrial energy users (exemptions are possible if companies enter into voluntary agreements). The EU imposes minimum tax levels on all energy carriers, but the rate (equivalent to 1–5 Euros per tonne of $CO_2$) is not expected to have a significant impact on the energy use[65].

Much more common is the opposite of an energy tax, notably subsidies on energy use. The main reasons for energy subsidies are the security of supply, environmental improvement, economic benefits, employment and social benefits. An inventory from 2001 reveals that subsidies in the EU 15 for solid fuel, oil, gas and nuclear totalled more than 24 billion Euros, compared to around 5 billion Euros for renewables and even less for energy efficiency. This is rather contradictory to the priority allegedly given to energy efficiency and renewables[64]. Many developing countries subsidise electricity and other energy carriers as part of their social policies.

## International policy development

Mechanisms that stimulate energy efficiency in developing countries and economies in transition are the Clean Development Mechanism (CDM) and Joint Implementation (JI), both implemented as a result of the Kyoto Protocol. In total, there are 26 methodologies available for energy efficiency improvement projects. So far, 6 percent of all the projected carbon emissions reductions resulting from CDM projects are due to energy efficiency projects (Figure 7.4). Two important reasons can be identified for the relatively small contribution of energy efficiency projects in these mechanisms. The first is that energy efficiency projects are often small-scale projects, which makes them less attractive to project developers as the transaction costs become relatively high. The second is that monitoring requirements of energy efficiency projects are complicated.

Despite these difficulties, Figure 7.5 shows an increasing trend of registered energy efficiency projects in the period 2004-2007. World Bank estimations show a strong increase in market volume in 2007. Point Carbon reports a market share of new energy efficiency projects of 20 percent in that same year[64].

A new approach to tackle the issues of high transaction costs with small CDM projects is the so-called 'programmatic' CDM. These projects do not focus on individual projects, but instead on 'programmes' with implementation in multiple locations and in different points in time. Secondly the CDM executive Board is taking measures to increase the share of energy efficiency within the CDM. These developments may help increase the role of energy efficiency projects in the Clean Development Mechanism.

## Policy evaluation

In its 4th Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) concludes that "a wide variety of national policies and instruments are available to governments to create the incentives for mitigation action. Experience from implementation in various countries and sectors shows there are advantages and disadvantages for any given instrument."

**Figure7.4**

**The breakdown of registered CDM projects, as a share of Certified Emission Reduction (CER) units**

Source: UNEP Risø Centre[64]

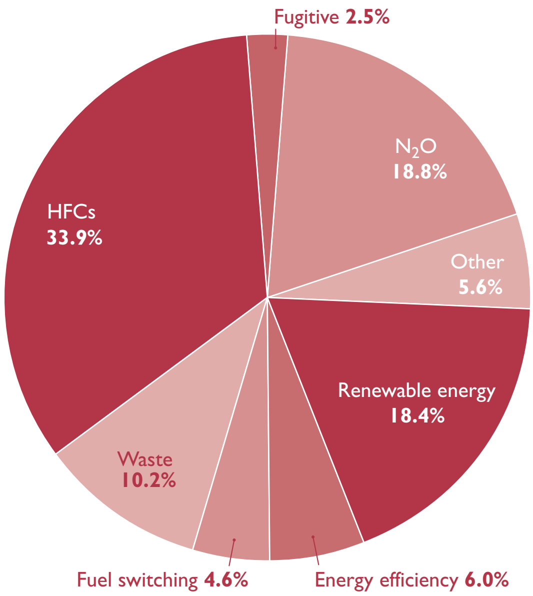
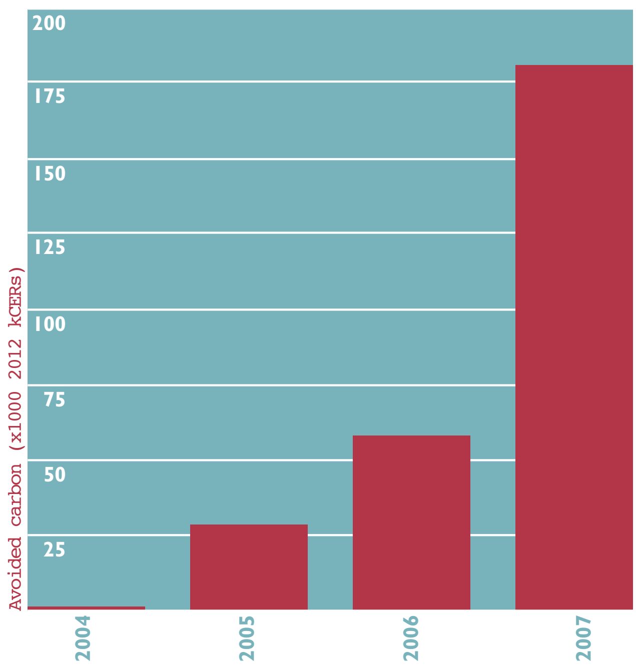



**Figure 7.5**

**Registered energy efficiency projects**

Source: UNEP Risø Centre

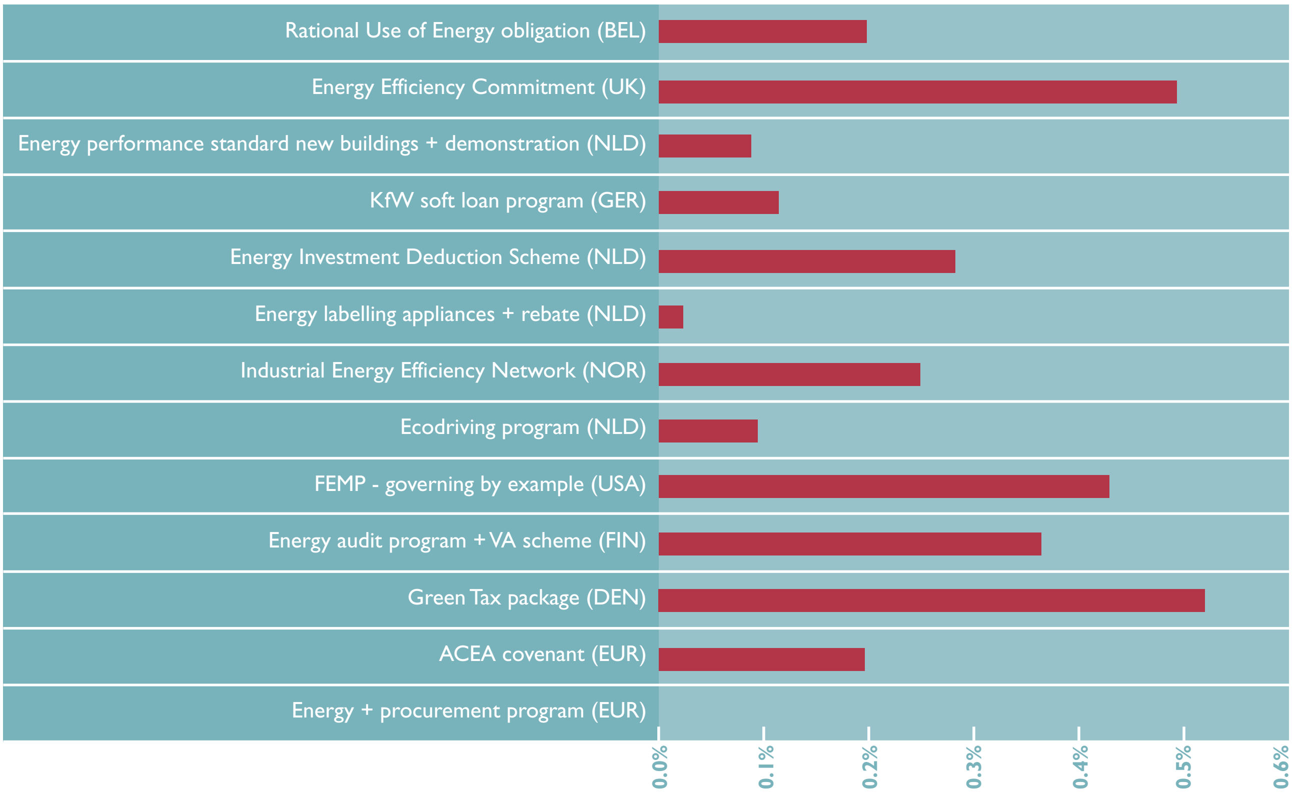


Further conclusions are that regulatory measures and standards may be preferable in many situations as taxes and charges may be politically difficult to implement. For emission trading systems the volume of allowed emissions determines their environmental effectiveness. Financial incentives are often critical to overcome barriers to the penetration of new technologies.

But in many situations, the effectiveness of policies for energy efficiency is not very well known. There is a clear need for better quantitative policy evaluations. An example of such a policy evaluation is shown in Figure 7.6. The figure shows that some policies can have a significant accelerating impact on the rate of energy efficiency improvement, although for other policies the impact is small or even negligible.

**Figure 7.6**

**Impact of a variety of policies expressed in percentage saving induced per year** Source: Ecofys



# 8 – THE ROLE OF INSTITUTIONS

All researched countries have established their particular institutions for supporting energy efficiency. The institutional support of energy efficiency is usually organised in three areas: strategy and policy making; programme development and coordination and research.

## Organisational structures

Generally, all countries differ in the way they have assigned responsibilities to particular institutions and have organised them in a working system. Systems range from being very simple to becoming more complex, employing small to large numbers of permanent staff. In this regard, Mexico and Ghana provide examples of the simplest institutional set-ups. Both countries have one Ministry of Energy and one implementing body, the National Commission for Energy Conservation (CONAE) in Mexico and the Energy Foundation in Ghana. The Ministry is responsible for strategies and policy planning while the implementing body takes care of promoting awareness, project financing and management.

In more complex systems like in the US or Japan, this basic approach is enhanced in three dimensions: specialisation, co-operation and capacity building.

*Specialisation* means that countries assign the duties of project management, financing and research to independent organisations such as agencies, funds and research centres. The specialisation can go beyond this, and in some countries there are various agencies, funds and research centres, which focus only on a particular issue or geographical region. This is especially found in large and federal countries like the US and India.

The dimension of *co-operation* describes the efforts of countries to create a platform between the various institutions and business organisations at the national and international level. This platform can be institutionalised via an independent co-ordinating body like REEEP at the worldwide scale or via other organisations with a more focused geographical mandate. Certain organisations improve their co-operation by setting up a special branch responsible for international co-operation, e.g. the New Energy Foundation in Japan.

The supporting institutions are only performing effectively if they are staffed with a proper number of adequately educated employees. Thus, the dimension of *capacity building* is an obvious tool for any country to improve its support for energy efficiency. Increasing the number of employees is the simplest method, while the improvement of skills and knowledge requires more efforts.

Leaving the national level and having a closer look at the individual institutions, it is observed how countries integrate energy efficiency issues in the organisational structure. A group of countries can be identified, which set up at least one unit within a particular ministry with exclusive focus on energy efficiency (e.g. Germany, Japan, US, Australia, and India).

**Figure 8.1**
**Decentralised: energy efficiency units at various ministries**

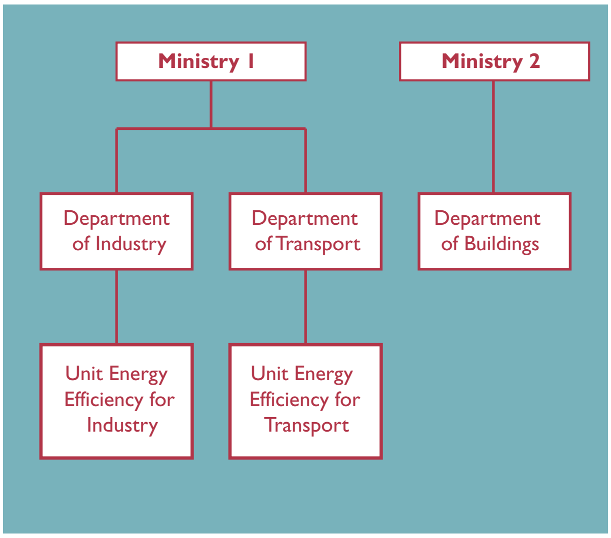
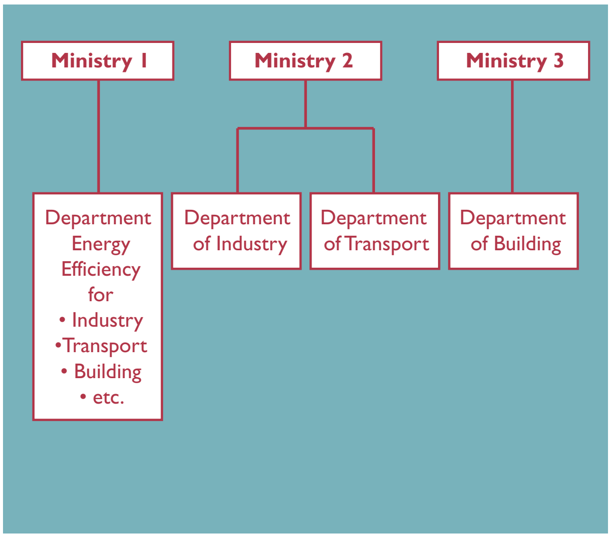



**Figure 8.2**
**Centralised: dedicated energy efficiency unit with sectoral tasks**



Another group of countries does not have a dedicated, special department or unit at all, and energy efficiency is treated only via sector policies.

The countries following the first approach can be further grouped according to the extent of tasks and fields the particular unit is responsible for. In India for example, there is an energy efficiency unit under the Ministry of Power, but the energy efficiency aspects of a particular sector are subject to the specific ministries. However, following this line, the Ministry of Textiles for example has no particular unit for energy efficiency, but the issue is dealt with via industrial research associations.

The German approach is very similar to this, with the difference that there are more energy efficiency units focusing on one sector in ministries responsible for environment, energy, industry and building.

The Australian approach is special from the point of view that it combines the centralised and decentralised approach. Vertically there are two key offices: the Department of the Environment Water, Heritage and the Arts and the Department of Resources, Energy and Tourism, which are both dealing with energy efficiency from the point of view of climate change, technology policy and energy. Their work is combined with the horizontal programme National Framework for Energy Efficiency, which is, according to organisation, "being developed co-operatively with the involvement of all government jurisdictions and key stakeholders."

A special characteristic of federal countries is that the institutional support for energy efficiency is much more complex than in non-federal ones. In this case policy making, implementation and research are dealt with at the federal, state and municipal levels as well. Thus all levels operate more or less independently, with the co-ordination depending on how the particular government translated the importance of energy efficiency into the organisational structure.

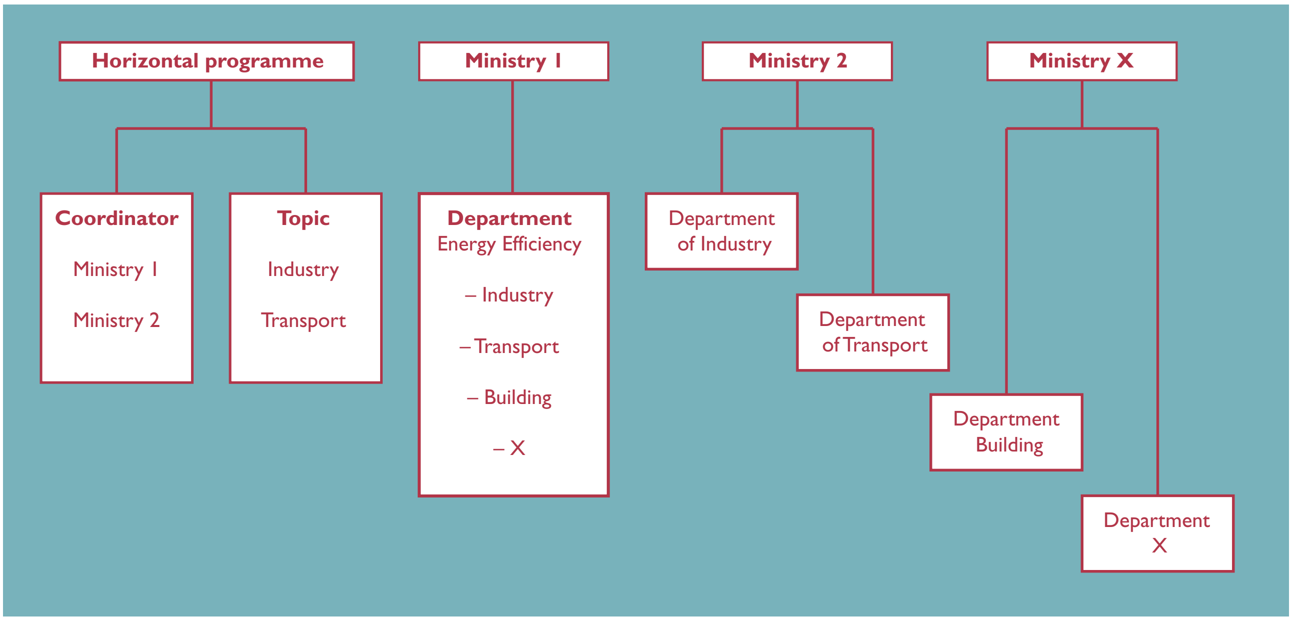
At the supra-national level, the European Commission is important to mention. In recent years the Commission has published its Action Plan on energy efficiency and has now elaborated this in a set of Directives that give guidance to the development of energy efficiency policies in the European Union (see chapter 9).

## Staff

When looking at ministries, the number of staff who are exclusively in charge of energy efficiency might seem to be small compared to the size of energy efficiency programmes that a country has initiated (e.g. Germany, France and Denmark). The number of employees varies strongly according to the type of job. At the strategic policy level the number of employees is between 1-7 per department or unit. The number of staff increases at the programme and project level, in some cases even to several hundreds. The majority of persons working on energy efficiency are employed by research institutes.

In spite of these general observations there are big differences between countries. Mexico and Ghana have a similar approach regarding the organisation of tasks. One ministry sets the

**Figure 8.3**
**Matrix organisation**



framework conditions and an independent body implements these policies. Having a closer look at the implementing bodies, one can see that the human resources of the National Commission for Energy Conservation in Mexico significantly outnumber those of the Energy Foundation in Ghana (98 vs. 7 persons).

Including the Danish Electricity Saving Trust into this analysis, it is surprising to see that it employs only 10 permanent employees. This figure is just slightly more than in Ghana, but the real number of people involved is considerably higher, since it is involving the specific expert know-how via outsourcing (see Box 8.1).

In Canada, a large number of staff are employed at the Office of Energy Efficiency (267), a situation which is also similar in Mexico. In the UK for the Energy Saving Trust employs 150; in India the Bureau of Energy Efficiency employs 40 and in Norway, the Enova SF employs 40.

### Conclusions

Countries with ambitious targets have set up independent management bodies, have created a network of research organisations, employed a large management staff and created a fund for financing programmes. The framework for operation of these institutions is set-up and controlled often by dedicated ministerial units. To promote higher energy efficiency improvement rates, more countries should establish dedicated institutions and/or allocate more resources to these institutions and networks.

**Box 8.1 GOOD PRACTICE**

**Danish outsourcing**

**Just like other countries the Danish Ministry of Transport and Energy established a fund for promoting and financing energy efficiency investments. The Danish approach is, however, different from those of other countries. The fund consists of only 10 permanent employees, who fulfil administrative and managerial tasks. The rest of the activities like project management, providing specific expert know-how are outsourced.**

## 9 – OUTLOOK

The potential for energy efficiency improvement can hardly be overrated. All sectors and all countries provide large opportunities that have yet been untapped. Although the progress until now has been limited – as we've seen in previous chapters – the prospects for rapid implementation of energy efficiency measures are splendid. Keeping the world energy use at the current level while maintaining economic growth is possible. However, this will require the ambitious adoption of existing and new energy-efficient technologies.

### Potential for energy efficiency improvement

The potential for energy efficiency improvement is significant in all sectors. Figures 9.1 and 9.2 indicate the potential for the year 2050 for both developed and developing countries. In both cases, business-as-usual economic growth projections are taken into account (2.7 percent annual growth until 2050).

Figures 9.1 and 9.2 show that for both developed and developing countries and all sectors, the potential is very substantial. For developed countries, tapping the total potential will lead to a net decrease in energy demand. For developing countries energy demand is likely to increase still, even with a strong pursuit of energy efficiency. For the world as a whole, energy use can stabilise.

**Figure 9.1**

**Potential for energy efficiency improvement in developed countries by sector** Source: Ecofys[67]

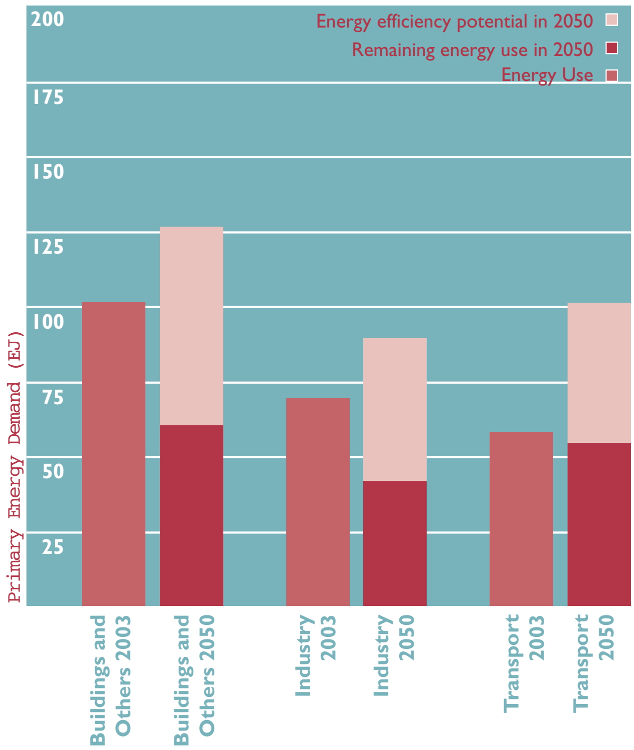
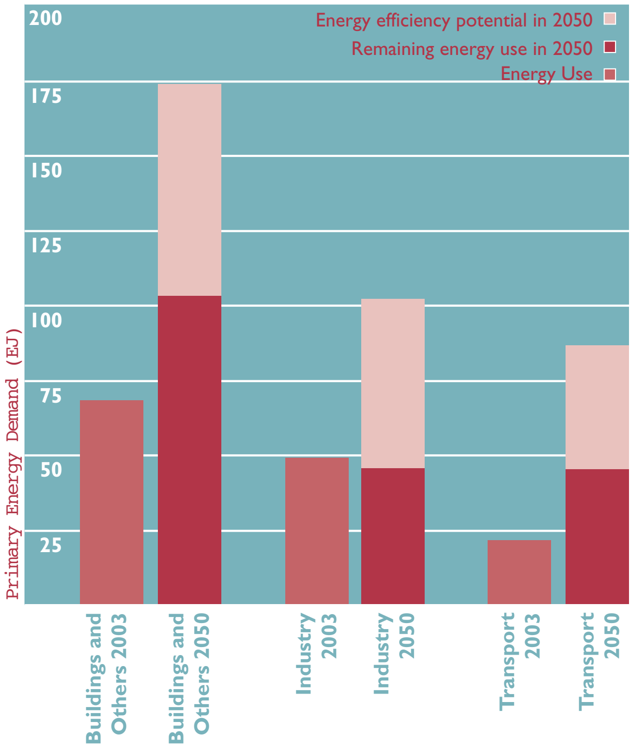


**Figure 9.2**
**Potential for energy efficiency improvement in developing countries by sector** Source: Ecofys




In the period until 2030 a substantial part of this potential (estimated 80 percent) can be realised with existing technologies. This does not mean that the potential comes for free: very significant efforts and investments by households, companies and other organisations are required to actually implement all energy-efficient technologies. All this requires support, facilities and incentives from government policies.

For achieving the potential foreseen by 2050, even more is needed: substantial investments in research, technological development and market introduction to bring a whole range of interesting new technologies to actual implementation potential for energy efficiency improvement. A recent study for the German Federal Environment Agency estimated that a worldwide annual investment, equivalent to 0.2 percent of the GDP is required to harvest the full technical potential of energy efficiency in 2050[68]. This investment will be lower if social and environmental costs and an increase in energy prices are included.

Harvesting the energy efficiency potential in 2050 will lead to an estimated annual emission reduction of 11 Gtons $CO_2$ in developed countries and 12 Gtons $CO_2$ in developing countries, with respect to a 'current policy' scenario. Energy savings are highest in the 'buildings and others' sector, reducing emissions by 5 Gtons $CO_2$ each in both developed and developing countries.

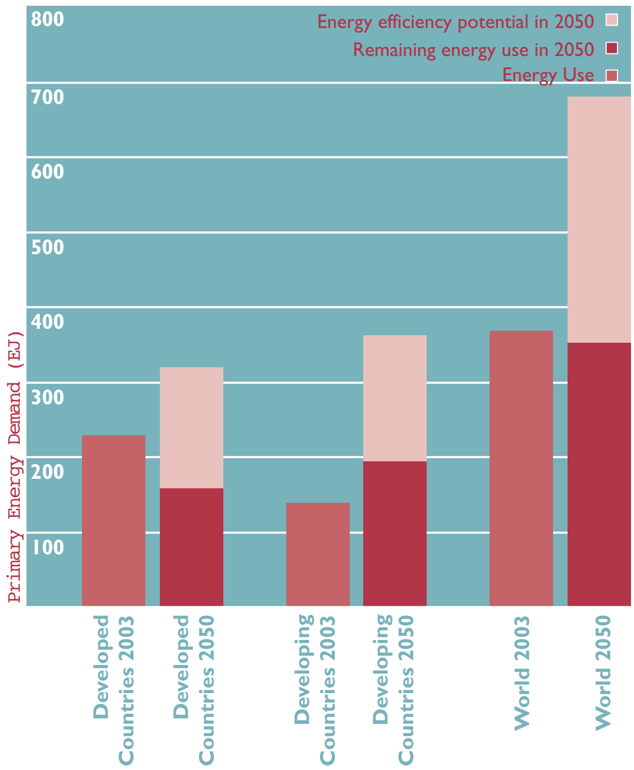
## Policy outlook

To date, only two regions in the world already have formulated economy-wide targets for overall energy efficiency improvement. China, in its 11th Five Year Plan, announced to reduce the energy use per unit of GDP by 20 percent between 2005 and 2010. The European Union wishes to reach an additional energy efficiency improvement of 20 percent by the year 2020 compared to 2005. Such broad efficiency targets require action from all sectors in the economy.

As concluded before, virtually all countries have policies in place for achieving higher energy efficiencies in certain sectors or technologies, but not many countries have strong policies throughout the economy.

The previous chapters showed a lot of experience with traditional policies. In recent years, new policies like energy performance standards for buildings, white certificate systems and emission trading systems have been added to the portfolio. These past accomplishments, experiments and lessons learned should make it easier to rapidly implement stronger policies. All in all, prospects for new initiatives from the private sector

**Figure 9.3**
**Total potential for energy efficiency improvement in developed countries, developing countries and for the world as a whole** Source: Ecofys



and from governments are good. There is a broadly shared vision that any energy strategy starts with energy efficiency as a key element. Climate change concerns are a key driver.

Possibly heading towards a Copenhagen mandate/agreement in 2009 – as a successor for the Kyoto Protocol – many countries will no doubt enhance their efforts even further. Meanwhile, many companies are embracing the concept of carbon neutrality, of which energy efficiency improvement again is a key measure.

But in addition to climate change concerns, also other drivers, like high energy prices and worries about the security of energy supply, are getting stronger. Also here, energy efficiency is a crucial part of the answer.

Box 9.1 **GOOD PRACTICE**

### EU Action Plan for Energy Efficiency

**The EU aims to save 20 percent of overall energy consumption by 2020, with respect to a business-as-usual scenario. The Action Plan for Energy Efficiency outlines a framework of policies and measures to realise this goal. The measures were presented in 2006 and are expected to be producing effects before 2013 and many even before 2010.**

**The Action Plan covers a broad range of policies and measures:**

- **The setting of dynamic energy performance requirements, for example by labelling equipment. Furthermore, minimum performance requirements for buildings are being implemented and strengthened (see chapter 2).**
- **Stimulating improvement in the efficiency of electricity generation (transformation efficiency and prevention of grid losses), for example by setting minimum binding efficiency requirements and the promotion of combined heat and power (CHP).**
- **Promotion of energy efficiency in the transport sector by involving the different stakeholders. Fuel efficiency is promoted by setting maximum levels of $CO_2$ emissions (in g $CO_2$/km, see chapter 4) and the strengthening of the EU requirements for labelling cars.**
- **Facilitating and designing financial measures (including tax measures) to stimulate the development and implementation of energy efficiency and to take away financial barriers to invest in energy efficiency (especially for small and medium enterprises). Energy efficiency investments are especially promoted in new Member States.**
- **Promoting rational energy use, for example by training and education of energy managers and the development of energy efficiency schemes.**
- **The 'Covenant of Mayors' was launched in 2008, constituting a network of mayors of the largest cities in Europe. Within this network cities can exchange and apply best practices to improve energy efficiency in the urban environments.**
- **The EU Commission developed an international framework agreement to promote energy efficiency world-wide, including Brazil, China, India, Japan, Russia and the United States. This promotion will also concern further collaboration with other international organisations, such as the United Nations, G8 and the World Bank.**

**A mid-term review of the Action Plan is planned in 2009.**

# APPENDIX ON METHODOLOGIES

**The Energy Efficiency Index (EEI)**
For sectors producing one product the specific energy consumption, a, of that product is the total energy use, E, divided by the production volume, V: a = E/V. In this case, the EEI is defined as the ratio of E and $E_{ref}$. $E_{ref}$ is the total energy consumption for the production in a reference country or year, or with a reference technique. For sectors where several types of products are produced (products 1,2…x) the following formula applies:

$$EEI = 100\ x\ \frac{E_{sector}}{E_{sector,\ ref}} = 100\ x\ \frac{E_{sector}}{a_{1,\ ref}\ V_1 + a_{2,\ ref} + \ldots + a_{x,\ ref} V_x}$$

where:

| | |
|---|---|
| $V_i$ | = the production volume for product x in a specific year/country |
| $a_{i,ref}$ | = the reference specific energy use for product x |
| Esector | = the total energy consumption of a sector in a specific year/country |
| $E_{sector,ref}$ | = the total energy consumption of a sector in a specific year/country |

For *Figure 3.3,* $E_{sector,ref}$ is calculated from the specific energy use of the best available technologies in the year 1990
For *Figure 5.4,* 1980 is used as a reference year.

**Primary energy**
(used in *Figures: 1.1, 2.1, 2.2, 2.3, 3.2, 4.1, 5.1* and *5.2*)
To calculate the primary energy the IEA balances were used[6].
The primary energy use for the different sectors (buildings, industry and agriculture) is calculated from the final energy consumption (FEC). The data on the FEC are specified per sector in the IEA balances. The FEC is broken into fuel consumption (FC) and electricity consumption (EC):

$$FC = FEC - EC$$

The EC is converted to the primary energy demand for electricity production by dividing it with the conversion factor (CF, for example: if the conversion efficiency is 40%, the conversion factor is 0.4). This number is added to FC. So to calculate the primary energy use, we use the formula:

$$Primary\ Energy\ Use = FC + EC/CF$$

The CF is the ratio of the Gross Power Generation and the fossil fuel input, taking into account distribution losses.
Since the primary energy use is calculated from the final energy consumption (TFC in the IEA balances), some categories ('Own Use', 'Coal Transformation') are not reflected in the presented quantity, while these categories are included in the Total Primary Energy Supply (TPES) in the IEA balances. Therefore the reported TPES values in the IEA balances are higher than the primary energy use presented in this report.

Population figures were retrieved from the IEA database[2], the numbers of hectares agricultural land were taken from the FAOSTAT 2006 – online database (agricultural land in 2005)[48].

## NOTES AND REFERENCES


1 IEA, Oil crises and climate challenges, 30 years of energy use in IEA countries, International Energy Agency (IEA), Paris, France, 2004

2 IEA, Indicators Database 1971-2005, International Energy Agency (IEA), Paris, France, 2007

3 IISI Committee of Economic Studies, Steel Statistical Yearbook 2007, International Iron and Steel Institute (IISI), Brussels, Belgium, 2007.
http://www.worldsteel.org/pictures/publicationfiles/SSY2007.pdf

4 International Road Federation, World Road Statistics, 2007: Figure calculated from the growth percentage of passenger cars in use in the G8+5 countries over the period 2000-2005 relative to the year 2000. A yearly weighted average for all G8+5 countries is then taken as the final value.

5 'Other' includes fishery.
1990-2005 calculations with data from: IEA, Energy balances of non-OECD countries, editions 1992-2007, International Energy Agency (IEA), Paris, France.
2006 and 2007 figures are estimated by using growth rates in primary energy consumption from: BP, Statistical Review of World Energy, http://www.bp.com/statisticalreview, last accessed 23 June 2008. These growth rates, 2.70% over 2006 and 2.36% over 2007, where applied to all sectors.
In the Appendix on methodologies it is explained how the primary energy was calculated.

6 Calculated with data from:
(unless indicated by an reference, the data represented in the charts are obtained/calculated from these sources)
IEA, Energy balances of non-OECD countries, editions 1992-2007, International Energy Agency (IEA), Paris, France
IEA, Energy balances of OECD countries, editions 1992-2007, International Energy Agency (IEA), Paris, France
In the Appendix on methodologies it is explained how the primary energy was calculated.

7 Phrase taken from: Green Paper on Energy Efficiency 'Doing More with Less', Office for Official Publications of the European Communities, Luxembourg, 2005.

8 See for example:
- World Energy Assessment (WEA), UNDP/UNDESA/WEC, UNDP, New York, 2000.
- Climate Change 2007 – Mitigation of Climate Change (Fourth Assessment Report of Working Group III of the Intergovernmental Panel on Climate Change (IPCC), see33

9 Energy efficiency improvement is not the only way to limit the energy use of total human activity. Two others are: 1) structural change – shifts to less energy-intensive activities (e.g. more growth in the service sector than in heavy industry) will dampen the growth of energy use in relation to GDP; 2) modal changes – changes in the way certain activities are carried out will have the same effect, these include for example: changing from passenger cars to public transport and producing steel out of scrap instead of primary ore.

10 IEA, Energy Use in the New Millennium: Trends in IEA Countries, International Energy Agency (IEA), Paris, France, 2007
Figure 2.4: Data for China refer to North China (Beijing region)

11 Office of Energy Efficiency (2007), Table 37: Appliance Stock by Appliance Type and Energy Source. Natural resources Canada. Available online at:
http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tablestrends2/res_ca_37_e_2.cfm?attr=0, last accessed 06 June 2008.

12 The Northwest Energy Efficiency Alliance: Northwest ENERGY STAR Lighting: Ten Years of Market Change, Californian Energy Commission workshop, 2007

13 IEA, Light's labour's lost, policies for energy-efficient lighting, International Energy Agency (IEA), Paris, France, 2006.
http://www.iea.org/textbase/nppdf/free/2006/light2006.pdf

14 LED = Light Emitting Diode

15 An average power plant is assumed to have a capacity of 600 MW and a load factor of 6000h/year, resulting in a annual production of 3600 GWh.
The amount of newly sold refrigerators in Japan is taken for the years 2002, 2003, 2005 and 2006 at Appliance Magazine.com:
http://www.appliancemagazine.com/editorial.php?article=522&zone=1&first=1 and
http://www.appliancemagazine.com/editorial.php?article=1735&zone=1&first=1 last accessed on 13 June 2008. For the years 1991-2001 and 2004 the amount of newly refrigerators sold is assumed to be 4.5 million/year, as in year 2006. An average refrigerator capacity of 200 litres is assumed.

16 Lebot, B.: European Union: Cumulative experience from a mixture of voluntary & mandatory policy approaches, IEA Workshop on Energy Efficiency Standards and Labelling, Bangalore, 2004.
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