Energy Efficiency Policies around the World: Review and Evaluation

World Energy Council 2008

Promoting the sustainable supply and use of energy for the greatest benefit of all

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General Secretary of the WEC service
On Energy Efficiency Policy
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Ce rapport a été effectué sous le patronage du Comité des Programmes du Conseil Mondial de l'Energie. Plus de 70 comités nationaux et équipes nationales ont participé efficacement et activement au bon déroulement de cette étude, particulièrement en répondant au questionnaire sur les politiques et mesures nationales d'efficacité énergétique. Nous voudrions adresser nos remerciements à tous les experts sans qui le travail n'aurait pu être accompli. Cette étude a également bénéficier de la contribution de plus de 100 experts lors de 3 séminaires régionaux (Bangkok en Asie, Abuja en Afrique et Paris en Europe) et d'un séminaire général. Ces contributions ont certainement contribué à étendre la couverture géographique, et surtout à davantage refléter les spécificités régionales de la mise en oeuvre des politiques d'efficacité énergétique. .

Nous tenons à remercier l'équipe de coordination technique d'ENERDATA qui nous a aidé à élaborer des indicateurs homogènes pour le rapport et à synthétiser l'enquête, et plus particulièrement B. Lapillonne, rédacteur du rapport, Nathalie Desbrosses, responsable des indicateurs, et Nathalie Bellia pour son assistance dans la préparation du rapport.Nous voudrions également remercier les auteurs des études de cas incluses dans ce rapport pour leur grande expertise sur la comparaison internationale de l'évaluation des politiques d'efficacité énergétique : Diana Ürge-Vorsatz et ses collègues (Central European University), Philippe Menanteau (LEPI-EPE), Wolfgang Eichhammer (Fraunhofer/ISI), Romain Molitor (Trafico), et Eoin Lees. Notre remerciement va aussi à Elena Nekhaev du Secrétariat de la WEC qui nous a beaucoup encouragés et conseillés dans notre travail.

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Foreword

The World Energy Council (WEC) technical service on *Energy Efficiency Policies and Indicators* is a joint project between the WEC and ADEME and has been running for more than a decade under the chairmanship of François Moisan.

As the Chairman of the Programme Committee that oversees this service, I have closely followed its progress over the past three years. The service focuses on the evaluation of energy efficiency trends around the world and the interaction between energy efficiency policies and energy efficiency performance of national economies.

The main long-term drivers of energy efficiency policies are; security of energy supply, efficiency of national economies, environmental concerns, including global warming and, in developing countries, investment constraints on the energy supply side.

The enormous potential of energy efficiency improvements at all stages of energy production and use is widely recognised, but realising this potential remains a global challenge.

I would like to thank the Committee Chair François Moisan and his colleagues from ADEME and ENERDATA for their dedication and hard work, the participating WEC Member Committees, and the international partner organisations APERC and OLADE for supporting this important project.

Evolvement of a more energy efficient global economy is the first step on the path towards sustainable energy development, and, like all first steps, is not without its risks, however, the experience WEC has accumulated in this domain will ensure a smooth process.

Ron Wood

Chairman of the WEC Programme Committee

Summary

This study is aiming to describe and evaluate energy efficiency trends and policies. While ADEME coordinated the project, the study was carried out over three years with contributions from more than 70 countries in addition to the technical assistance of ENERDATA.

The first objective of the study is to identify recent trends in energy efficiency performance in selected countries and regions at macro and regional levels. A selection of indicators is analysed and compared for that purpose. The methodology used is directly adapted from the European Commission project on energy efficiency indicators, ODYSSEE (ADEME/EnR/EIE Project).

The second objective is to describe and evaluate energy efficiency policies carried out in a sample of countries throughout the world. A survey was carried out in more than 70 countries and is focused on five policy measures, whose evaluation was completed in five detailed case studies prepared by selected experts: mandatory energy audits, ESCO's, energy incentives for cars, energy efficiency obligation for energy utilities, and the package of measures for solar water heaters.

Beyond a review of energy efficiency measures already implemented, the survey aimed to pinpoint the most interesting experiences and draw some conclusions on advantages and drawbacks of different policies. In particular, the study aimed to identify policy measures proven to be most effective, in order to make recommendations for countries embarking on energy demand management policies.

The Kyoto Protocol objectives, and more recently, concerns about security of energy supply have enhanced the importance given to energy efficiency policies. Almost all OECD countries now implement new measures adapted to their own national circumstances. Given a broad geographical coverage, the report provides a comprehensive and valuable source of information. The correlation between indicators and policy measures represents an original approach to energy efficiency evaluation. Non-OECD countries are implementing regulations to prevent an accelerating increase in electricity demand; Apart from the main role played by market instruments (voluntary agreements, labels, information dissemination), regulatory measures are still effective where the market fails to give appropriate signals e.g. (buildings, appliances, etc).

The recent experience in the context of high energy prices should be of great interest for the design of new, efficient policies. Transport remains the sector where experience is weakest. Urban air quality is a strong argument for developing new technologies and instruments but technology alone cannot provide a definitive solution if the infrastructure is not designed for sustainable mobility.

The project not only contributes to the ongoing information exchange helping to remove barriers to energy efficiency improvements, and to increase the transparency of policy and measures between countries.

Résumé

Cette étude avait pour but de décrire les tendances de l'efficacité énergétique au travers de multiples indicateurs et d'évaluer les politiques d'efficacité énergétique mises en oeuvre. Cette étude a été menée durant les trois dernières années avec l'assistance technique d'ENERDATA s.a. et les contributions de plus de 70 pays.

Le premier objectif de cette étude est de décrire et expliquer les tendances des performances d'efficacité énergétique dans ces pays. Dans ce but une sélection d'indicateurs sont analysés et comparés. La méthodologie utilisée est directement adaptée du projet européen sur les indicateurs d'efficacité énergétique, ODYSSEE (projet ADEME/EnR/EIE).

Le second objectif est de décrire et évaluer les politiques d'efficacité énergétique mises en oeuvre dans un échantillon de pays au niveau mondial. Dans ce but, une enquête a été effectuée dans 70 pays, représentatifs de toutes les régions du monde. L'enquête s'est concentrée sur 5 types de mesures, dont l'évaluation a été complétée par des études de cas détaillées préparées par des experts. Au-delà d'une description des mesures mises en oeuvre, le but de l'enquête est de repérer les expériences les plus intéressantes et d'en tirer des conclusions sur leurs avantages et limites. En particulier, l'étude vise à identifier les mesures qui se sont révélées les plus efficaces pour faire des recommandations pour les pays les moins avancés dans les politiques de maîtrise de leur consommation.

Les objectifs du protocole de Kyoto et, plus récemment, les contraintes sur l'offre ont renforcé la priorité donnée aux politiques d'efficacité énergétique. Presque tous les pays de l'OCDE ont mis en œuvre de nouveaux instruments adaptés à leurs caractéristiques nationales. Ce rapport, avec sa couverture très large des pays et son niveau de mise à jour, fournit une source d'information exhaustive et de haute qualité. La tentative d'associer les indicateurs aux politiques constitue une approche originale d'évaluation de l'efficacité énergétique. Les pays non OCDE sont en train d'instaurer un certain nombre de réglementations pour prévenir une augmentation trop forte de leur demande d'électricité : malgré un rôle croissant des instruments dits de marché (accords volontaires, label, information, dissémination), les mesures réglementaires sont toujours utilisées quand les mécanismes de marché sont insuffisants pour donner le "bon" signal aux consommateurs (bâtiments, équipements électroménagers).

L'expérience acquise ces dernières années dans un contexte de prix élevés de l'énergie devrait être particulièrement intéressante pour concevoir de nouvelles politiques efficaces. Les transports demeurent le secteur où l'expérience est la moins importante. La qualité de l'air dans les villes est un argument fort pour développer de nouvelles technologies et politiques, mais la technologie ne peut pas résoudre tous les problèmes si les infrastructures ne sont pas conçus pour une mobilité soutenable.

1. Introduction

1.1 Objectives and content of the report

This report presents the results of a three-year study on "Energy Efficiency Policies" co-ordinated by ADEME with the technical assistance of ENERDATA and contributions from more than 70 WEC member countries. The study was aimed at monitoring energy efficiency trends through various indicators and evaluating energy efficiency policies. The report provides updated information and expands the range of countries covered in previous reports prepared by ADEME/WEC for the last four Congresses held by the World Energy Council in Tokyo (1995), Houston (1998), Buenos Aires (2001) and Sydney (2004).

The first objective of the study was to identify and explain trends in energy efficiency performance in selected countries and regions. For that purpose, a selection of indicators was analysed and compared. The methodology used is directly adapted from the European project on energy efficiency indicators, ODYSSEE[2].

The second objective was to describe and evaluate energy efficiency policies using a sample of countries throughout the world. For that purpose, a survey was carried out in over 70 countries. The survey focused on five policy measures, where evaluation was completed in detailed case studies prepared by selected experts. Beyond a description of measures already implemented, the study aimed to identify the most effective proven policy measures.

This report consists of two main parts: a review of the energy efficiency progress achieved around the world (Chapter 2) and the evaluation of energy efficiency policies and measures (Chapter 3). In the final chapter (Chapter 4) conclusions and recommendations are summarised to help the reader learn from the experiences of the most advanced countries, in terms of energy efficiency policies. Two annexes complement this evaluation. Annex 1 presents country case studies on selected policy measures: ESCO's, energy efficiency obligations for energy utilities, energy incentives for cars, mandatory energy audits, and the package of measures for solar water heaters. Annex 2 presents the synthesis of the worldwide survey on energy efficiency policy and measures.

Given its broad geographical coverage, the report provides a comprehensive and valuable source of information. The methodology of relating energy efficiency indicators to policy measures represents an original approach to the evaluation of these policies.

1.2 Why is energy efficiency an important issue?

The Kyoto Protocol objectives and more recently, emerging constraints on energy supply have raised the importance given to energy efficiency policies. Almost all OECD countries and an increasing number of non-OECD countries are using new or updated instruments adapted to national circumstances. Apart from a major role of market instruments (voluntary agreements, labels, information dissemination etc), regulatory measures are also widely implemented where the market fails to give the right signals (buildings, appliances etc).

In developing countries, energy efficiency is an important issue, too but often with different driving forces compared to industrialised countries. In developing countries, the need to reduce greenhouse gas emissions and local pollution is less of a priority: alleviating the financial burden of oil imports, reducing energy investment requirement, and making the best use of existing supply capacities to improve the access to energy are more important drivers.

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[2] Project on energy efficiency indicators co-ordinated by ADEME and supported by the Energy Intelligence for Europe Agency, EnR and all energy efficiency agencies in Europe and their representatives (30 countries).

Following the steep increase in oil price since 2003[3], the cost of oil imports has soared, with severe consequences for economic growth of the poorest countries. Any efficiency improvement in oil consuming sectors will result in direct benefits to the balance of trade of oil importing countries.

Improving energy efficiency, for instance in electricity use, will have two benefits:

Supply more consumers with the same electricity production capacity, which is often the main constraint in many countries of Africa and Asia.

Slow down the electricity demand growth, and reduce the investment needed for the expansion of the electricity sector; this is especially important in countries with high growth of the electricity demand, such as China and many South East Asian countries.

The focus of this report is on the evaluation of energy efficiency policies and trends. What is meant by "energy efficiency"?

1.3 Definition and Scope of Energy Efficiency

Energy efficiency improvements refer to a reduction in the energy used for a given service (heating, lighting, etc.) or level of activity. The reduction in the energy consumption is usually associated with technological changes, but not always since it can also result from better organisation and management or improved economic conditions in the sector ("non-technical factors").

In some cases, because of financial constraints imposed by high energy prices, consumers may decrease their energy consumption through a reduction in their energy services (e.g. reduction of comfort temperature; in car mileage). Such reductions do not necessarily result in increased overall energy efficiency of the economy, and are easily reversible. They should not be associated with energy efficiency.

To economists, energy efficiency has a broader meaning: it encompasses all changes that result in decreasing the amount of energy used to produce one unit of economic activity (e.g. the energy used per unit of GDP or value added). Energy efficiency is associated with economic efficiency and includes technological, behavioural and economic changes.

Energy efficiency is first of all a matter of individual behaviour and reflects the rationale of energy consumers. Avoiding unnecessary consumption of energy or choosing the most appropriate equipment to reduce the cost of the energy helps to decrease individual energy consumption without decreasing individual welfare.

Avoiding unnecessary consumption is certainly a matter of individual behaviour, but it is also, often, a matter of appropriate equipment: thermal regulation of room temperature, or automatic de-activation of lights in unoccupied hotel rooms are good examples of how equipment can reduce the influence of individual behaviour.

1.4 Energy Efficiency Policies and Measures

Any cost related decision concerning energy efficiency, at the individual level, is based, more or less, on a trade-off between the immediate cost and the future decrease in energy expenses expected from increased efficiency. The higher the energy price, observed or expected, the more attractive are the energy efficient solutions.

Making a "good" investment decision, for domestic appliances or industrial devices, from the energy efficiency viewpoint, certainly relies on a sound economic rationale. Good price signals are necessary.

[3] Almost a tripling between the beginning of 2003 (26 US$/bbl for the Brent) and August 2006 (73 US$/bbl); since then the price is around 60 US$/bbl, which still twice higher than in 2003.

In market economies, where most energy prices to final consumers are deregulated, prices should normally reflect fairly accurately the supply costs. However, for several reasons, they often reflect only a part of the overall costs of fuels and electricity. They include none, or just a few, environmental externalities and long run marginal development costs.

As a result, decisions made by final consumers when purchasing equipment or making an energy efficient investment (e.g. retrofitting of dwelling) often do not reflect the drive towards global economic optimisation, creating a gap between the actual achievements in energy efficiency and what could be achieved through an accurate price system accounting for all costs involved.

Taxation is the usual means used by governments to reduce or suppress price distortions at the consumer level. In that sense, taxation is always complementary to energy efficiency policies and measures. It is hardly just a component of these policies and measures because of its much broader socio-economic aspects, but it certainly determines the effectiveness of policies and measures.

Clear price signals alone are not enough to achieve a rationalisation of energy use. Indeed certain conditions are required to remove the usual barriers to energy efficiency and to develop and structure the market for efficient equipment and devices:

- The availability of efficient appliances and production devices;
- The availability of good information for consumers about such equipment and devices; and,
- The availability of technical, commercial and financial services when necessary.

Policy measures are therefore necessary in market economies to reinforce the role of energy prices, firstly to create the appropriate market conditions for efficient equipment, secondly to drive consumer choice towards the most cost effective solutions. They also aim at alleviating the recognised failures in market mechanisms.

Three major sources of failures in market mechanisms are often pinpointed to justify the implementation of policy measures:

The information is either missing or partial, and cannot be improved at acceptable cost;

Decision-makers for energy efficiency investments (in buildings, appliances, equipment, etc.) are not always the final users who have to pay the heating or cooling bills: the overall cost of energy service is not transparent to the market;

Financial constraints faced by individual consumers are often more severe than what is actually revealed by national discount rates or long term interest rates, resulting in a preference for short term profitability. This often leads consumers to over-emphasise the immediate cost of equipment and devices, which usually does not benefit the selection of efficient equipment or devices. Implicit discount rates in industry are over 20% compared to less than 10% for public discount rates, and 4-6% for long-term interest rates.

Energy efficiency policy and measures ("non-price measures") are therefore necessary to complement the role of prices. The main objective of measures is to create the necessary conditions to speed up the development and the deployment of market efficient equipment, through:

- Information for and communication with final consumers;
- Risk sharing with producers and distributors;
- R&D and dissemination of expertise in the field of energy efficiency;
- Deployment of specific financing mechanisms;
- Regulation of appliances and equipment, or for consumers.

Energy efficiency policy is therefore considered here in a broad sense. It includes all public interventions ("policy measures") aiming at improving the energy efficiency of a country, through adequate pricing, institutional setting, regulation and economic or fiscal incentives.

Information and communication measures have two main targets:

- To increase the awareness of final consumers about the individual and national benefits of energy efficiency;
- To open the range of possible options for technical decisions to be made by final consumers and make the overall costs of all options transparent.

Sharing the economic risk with the producers and distributors of energy efficient equipment and devices can take several forms: loans, subsidies, tax credits, etc. The main objective is to overcome the commercial barriers raised by the developers of efficient equipment and devices.

Supporting R&D and dissemination costs from public funds and channelling any government set price created by advanced energy efficient technologies, equipment and devices to the private sector, aims at speeding up the penetration of efficient equipment and devices and decreasing their costs on the market.

Introducing specific financing mechanisms has two objectives:

- For consumers, to reduce the market imbalance (due to financial constraints) between cost- effective solutions with high investment / low operating costs (energy efficient), on the one side, and low investment / high operating costs (less efficient) on the other side;
- For suppliers, to help implement production or distribution activities in the field of energy efficient products and services.

Regulations aim at removing from the market the least efficient appliances, equipment and buildings and introduce mandatory actions for consumers that should indirectly improve energy efficiency (e.g. maintenance, reporting, auditing).

Chapter 3 reviews various types of measures and discusses conditions for their implementation, as well as their use in the various world regions.

1.5 Energy Efficiency Policies Evaluation

Why is evaluation necessary?

Energy efficiency policies and measures are not free. Whatever policy structure and implementation scheme, whatever the measures taken, there is a cost to the taxpayer.

As a general rule, energy efficiency policies and measures are economically sound if the macro-economic benefits of increased energy efficiency achieved by these policies and measures outweigh the overall cost to the taxpayers. The bigger the difference between the benefit and the cost, the more attractive and effective are the policies and measures.

Evaluating energy efficiency policies and measures is necessary to ensure that public funds are well used. The evaluation can be done at two levels:

- From the taxpayer viewpoint: the public cost involved in the policies and measures.
- From the macro-economic viewpoint: the benefit resulting from the actual progress in energy efficiency achieved through the policies and measures.

Why tracking energy efficiency at the macro level is not an easy task?

Insulating a house makes it obviously more energy efficient from an engineering point of view: less energy is consumed for the same comfort. However, this technical improvement at the micro-level may be not visible at the macro-level - the whole stock of dwellings - if, at the same time, more houses are built, dwellings get larger, more appliances are used and/or if the comfort is improved.

The same applies to industry: each factory can decrease its energy consumption per unit of output with more energy efficient technologies, but this may not be seen at the level of the industrial sector if there is at the same time an increase in the production or a higher growth in the production of energy intensive industries.

Energy efficiency is not just a technical matter, it is also a matter of efficient services: making a phone call instead of a personal visit, using public transport instead of a car, recycling bottles, reducing heat at night, using timber instead of concrete for house construction, all this results in a decrease in energy consumption for identical or similar services. Again, such improvements at the micro-level may not be directly visible at the macro-level. Assessing energy efficiency also means measuring the overall impact of all the improvements at the micro-level on the evolution of energy consumption

Of course, assessing energy efficiency from a policy view point does not mean reviewing each particular dwelling or factory; but it certainly means estimating, or measuring, how much all these improvements at the micro-level did contribute to the actual evolution of the energy consumption in the various sectors, and for the whole country.

Several difficulties emerge when assessing energy efficiency progress. First, from a conceptual viewpoint, energy efficiency is at the same time both a pure economic concept (similar to that of productivity) and a political concept (the result of energy efficiency policy); the boundary between these two concepts is never clear.

Secondly, from a methodological viewpoint, it is difficult to separate out the various causes behind observed actual energy efficiency improvement: more energy efficient socio-economic structures, price setting, results of sectoral policy measures; etc. A good illustration is the example of cars. How to measure the energy efficiency of cars: in terms of technology, drivers' behaviour, or pattern of use?

Energy efficiency indicators designed and calculated in this study aim at developing solutions to these difficulties, in three ways:

- Overall macro-economic indicators tend to reconcile the macro-economic and political concepts of energy efficiency, measuring separately the main components of the overall energy intensity of the GDP: those linked to the structure of the economy and those linked to sectoral energy efficiencies;

- Sectoral indicators aim first at reconciling the economic appraisal of energy efficiency in the sectors with the technical appraisal of efficiency improvements in dwellings, vehicles, industrial processes, etc., and second at relating these technical appraisals to the evaluation of actual energy savings, from which economic benefits can be estimated;

- Comparative country indicators, based on comparable data set, aim at allowing comparison across countries to highlight, in energy efficiency achievements, those which can be attributed to differences in policies and measures and to taxation and pricing policies.

2. Energy Efficiency Trends

2.1 Introduction

This chapter reviews recent energy efficiency trends by world region based on a set of homogeneous energy efficiency indicators covering the period 1980–2006, with a greater focus on the last sixteen years (1990-2006). All indicators include biomass, as many OECD countries are now promoting the use of biomass to reduce emissions of greenhouse gases and as biomass is still a dominant source of energy in many developing countries.

The data used for the calculation of the energy efficiency indicators were taken from ENERDATA world energy database[4]. This database relies on harmonised data from international organisations (International Energy Agency/IEA, EUROSTAT, World Bank, Asian Development Bank, IMF), from industry associations (Cedigaz for gas, IISI for steel, IRF for transport, for instance), as well as from national energy ministries and utilities. It provides a consistent coverage of the world energy consumption, split by main regions, and is kept up-to-date to take into account the most recent trends. Some of the more detailed indicators were taken for European Union (EU) countries from the ODYSSEE database[5].

The indicator trends are presented for seven world regions. Because of its size and diversity, Asia is split into four sub-regions and a few major countries:

- ***Europe*** (EU, Albania, Bosnia, Croatia, Iceland, Macedonia, Norway, Serbia, Switzerland, and Turkey)
- ***CIS***[6]
- ***North America*** (USA, Canada)
- ***Latin America***
- ***Asia:***
  - China
  - India
  - Asia and Pacific OECD (Japan, Korea, Australia, New Zealand)
  - Other Asia (ASEAN, other South Asia)
- ***Africa***
- ***Middle East***

This chapter begins with a presentation of the indicators at the level of the whole economy and at the level of economic sectors. Then a comparison of energy efficiency trends across the various world regions is presented: first, the overall energy efficiency trends, and then the trends by sector (industry, transport, households, and services).

Particular attention is given to the relationship between energy efficiency achievements (as assessed from the indicators) on the one hand and economic development (in particular the role of structural changes in the economy) and energy efficiency policies on the other hand.

[4] For more information, see www.enerdata.fr

[5] The ODYSSEE database has been developed since 1990 at the EU level as a joint project with participation of ADEME (coordinator), the Energy Intelligence for Europe programme of the European Commission and all EU energy efficiency agencies; EnR, the network of energy efficiency agencies, also supports the project. For more information, see www.odyssee-indicators.org.

[6] CIS (Commonwealth of Independent States) includes countries of the former Soviet Union excluding the Baltic states (i.e. Estonia, Latvia and Lithuania)

2.2 Energy Efficiency Indicators

The energy efficiency indicators considered here are designed to monitor changes in energy efficiency and to allow cross-country comparisons of various energy efficiency situations. Two types of indicators are considered for the description of energy efficiency: economic and techno-economic ratios.

Economic ratios, referred to as **energy intensities**, are defined as ratios between energy consumption, measured in energy units - tonnes of oil equivalent/(toe) - and indicators of economic activity, measured in monetary units at constant prices (gross domestic product (GDP), value added, etc. Intensities are used each time energy efficiency is measured at a high level of aggregation, i.e. at the level of the whole economy or a sector. To make these energy intensities more comparable, they are all converted to purchasing power parities at 1995 prices and parities, unless otherwise specified (see **Box 2**).

Techno-economic ratios are calculated at a disaggregated level (by sub-sector or end-use) by relating energy consumption to an indicator of activity measured in physical terms (tonnes of steel, number of passenger-kilometres, etc.) or to a consumption unit (e.g. per vehicle, dwelling, etc.). These techno-economic ratios are called **unit consumption.**

To allow a meaningful comparison of energy efficiency between countries, these indicators are based on common definitions; in particular with respect to the definition of energy consumption[7]. The indicators calculated in this study are available by country on the WEC web site (**www.worldenergy.org**).

Box 2: Energy intensities at purchasing power parities

GDP and value added data for all regions are converted at purchasing power parities to reflect differences in general price levels.[8] Using purchasing power parities rates ("ppp" in short) instead of exchange rates increases the value of GDP in regions with a low cost of living, and therefore decreases their energy intensities[9] (Figure 2.1).

Energy intensities at purchasing power parities are more relevant as they relate the energy consumption to the real level of economic activity. The use of purchasing power parities greatly improves the comparability of energy intensities between regions with different levels of economic development, as it narrows the gap between regions, compared to the use of exchange rates.

The intensities are measured at constant prices and exchange rates[10]: therefore, the use of purchasing power parities changes the magnitude of the indicators but does not affect the trends.

2.3 Overall Energy Efficiency Performance

A general indication of energy efficiency performance is given by the **primary energy intensity**, which relates the total energy consumption of the region or country to its GDP.

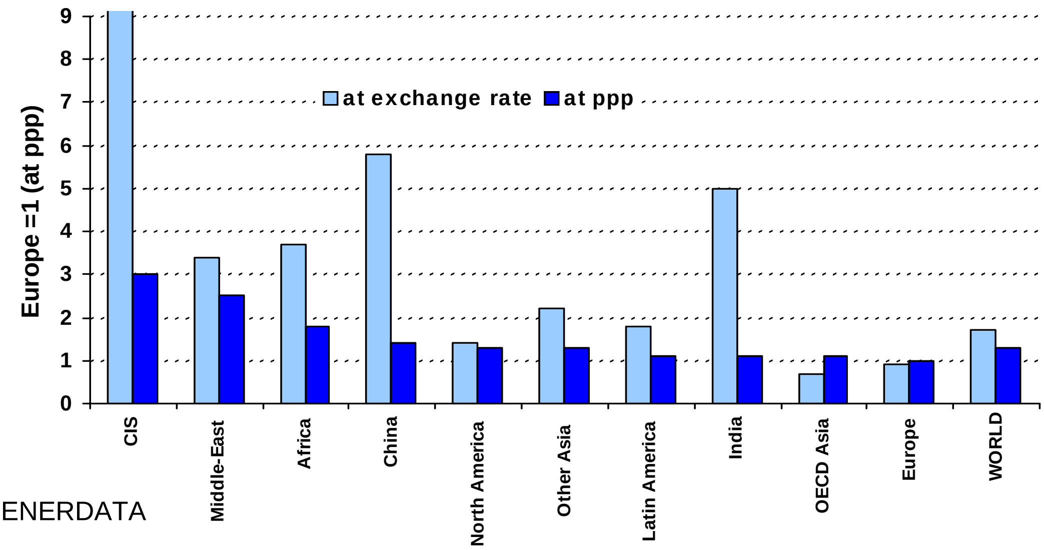
[7] Electricity is converted to toe according to the IEA methodology: 0.26 toe/ MWh for nuclear;
0.086 toe/MWh (3.6 GJ) for hydro, wind and electricity consumption; 0.86 toe/MW for geothermal. Biomass is included in energy consumption figures. Non-energy uses are excluded from final energy consumption.

[8] The purchasing power parities by country come from the World Bank. The GDP of each region at purchasing power parities is then calculated as the sum of countries in the region.

[9] On average, for non-OECD countries the GDP at purchasing power parities is 2.7 times higher than if it is expressed at exchange rates (factor 3 for CIS and 2.3 for China)

[10] At 1995 prices and exchange rates following the World Bank

Figure 2.1 Primary Energy Intensity at purchasing power parities vs exchange rates



Source: ENERDATA

Primary energy intensity measures how much energy is required by each country or region to generate one unit of GDP. It is therefore more an indicator of "energy productivity" than a true indicator of efficiency from a technical viewpoint. Its level reflects the nature of the economic activity (the "economic structure"), the structure of the energy mix, the climate, and the technical energy efficiency. Trends in energy intensities are influenced by changes in the economic and industrial activities of the country ("structural changes"), the energy mix, and the efficiency of end-use equipment and buildings.

The energy intensity is generally considered a reliable indicator as it is calculated using basic statistics. However, its interpretation is sometimes questionable for countries where part of their economic activity is informal (i.e. not accounted by the GDP) and where the use of traditional fuels is significant, as their consumption is not usually well monitored.

The ODYSSEE project is using an alternative indicator, called ODEX (ODYSSEE index), which replaces the overall energy intensity to monitor energy efficiency trends in the EU[11].

ODEX aggregates energy efficiency trends by sub-sector (or end-uses or transport mode), measured in physical units, in a single indicator by main sector (industry, households, transport and services) and for the economy as a whole[12]. ODEX by sector provides alternative indicators for energy intensities (industry and transport) or unit consumption (per dwelling for households) to describe the overall trends by sector.

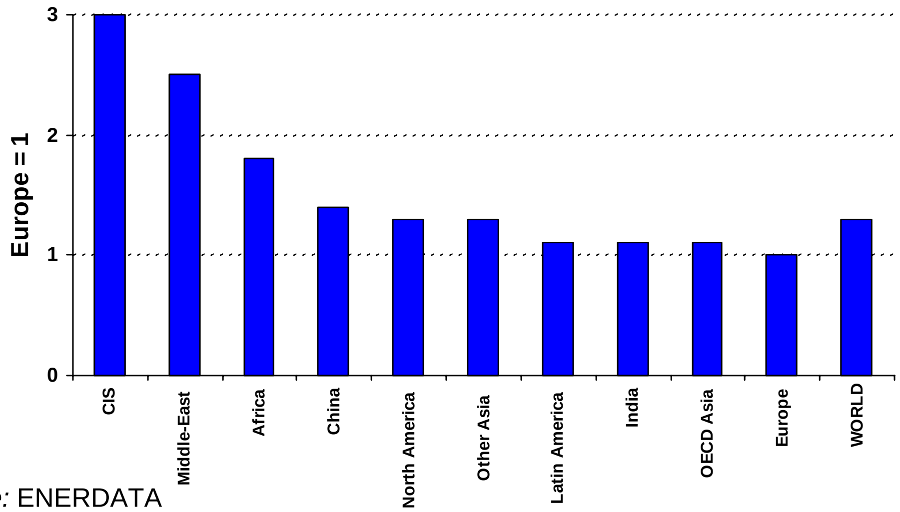
Tripling the energy intensity levels among world regions

The CIS uses three times more primary energy per unit of GDP than Europe, the world region with the lowest energy intensity (**Figure 2.2**). OECD Asia & Pacific, India and Latin America are close to the European level (about 10% higher); North America and Other Asia stand at the same level as the world average with an energy intensity of 30% higher than Europe. China's energy intensity is 40% above the average of Europe. High energy intensities in countries of the CIS and Middle East, can be attributed to various factors: lower energy efficiency, dominant role of energy intensive industries, and low energy prices.

[11] See www.odyssee-indicators.org.

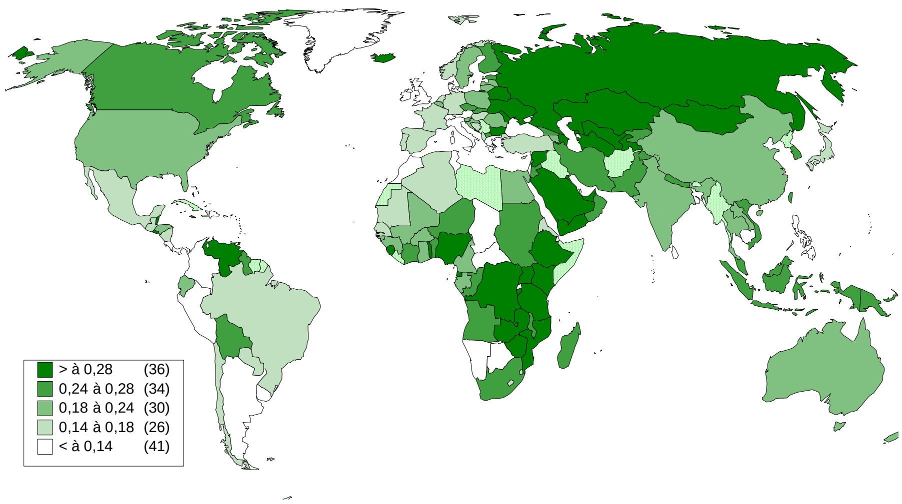
[12] ODEX by sector is calculated from unit consumption indices by sub-sector, weighted by the share of each sub-sector in the energy consumption. As indices are used, different units can be used to better assess energy efficiency (e.g. toe/dwelling, kWh/appliance). A value of 85 for ODEX means a 15 % efficiency improvement.

Figure 2.2: Primary energy intensity by world region (2006)
Intensité énergétique primaire par région du monde



Source: ENERDATA

Figure 2.3: Primary energy intensity by country (2006)[13]
Intensité énergétique primaire par pays



Source: ENERDATA

[13] Energy intensities in koe/US$95 at purchasing power parities; the range of energy intensities corresponding to the different colours have been selected so as to have groups of countries of similar size.

In most world regions the amount of energy used per unit GDP is decreasing steadily: 1.6% p.a. on average at the world level between 1990 and 2006 (1.4% without China)

The primary energy intensity demonstrates a decreasing trend in most regions, as a result of the combined effect of higher energy prices[14], energy conservation programmes and more recently CO_2 abatement policies, and other economic factors, such as the tertiarisation of the economies. There is even acceleration in energy intensity decrease since 2000, except a deceleration in energy intensity in Europe, China and Other Asia. In 2006, there is a strong reduction in the energy intensity almost everywhere due to the high oil prices. The Middle East is the only region where energy consumption has always been increasing faster than GDP. This energy intensity increase is however slowing down over time (**Figure 2.4**).

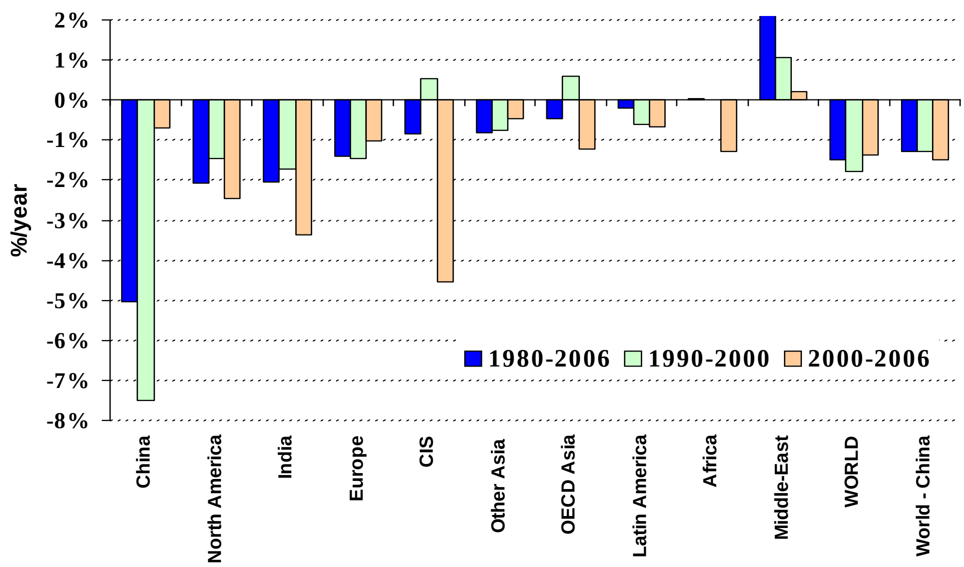
China, which had the highest energy intensity level in 1980, experienced the strongest improvement in energy productivity around 5% p.a. on average (and even 7.5% p.a. between 1990 and 2000).

As a result, China's energy intensity is now slightly above the world average level, whereas it was 80% higher in 1990.

This great improvement in China's energy productivity is the result of various factors: more efficient use of coal, switch from coal to oil, industry restructuring (rapid growth of equipment manufacturing industries) and higher energy prices. Their respective influences are however difficult to quantify. After 2000, the decreasing trend has slowed down significantly, to slightly less than 1% p.a.[15].

At the world level, the energy intensity decreased by 1.6% p.a. on average between 1990 and 2006.

Figure 2.4: Variation of primary energy intensity by world region
Variation de l'intensité énergétique primaire par région du monde



Source: ENERDATA.

[14] Following the second oil shock, between 1979 and 1985, and since 2000, and particularly since 2005.

[15] In 2006, however the energy intensity reduction was much higher due to the high oil price levels.

The reduction was more rapid between 1990 and 2000 (1.8% p.a.) than after 2000 (1.4% p.a.), mainly because of China: the acceleration over the nineties improvement is mainly due to China. Without China, the reduction between 1990 and 2000 is 1.3% p.a., i.e. the same as during the 1980's[16]. Since 2000, the improvement in energy productivity increased to 1.4% p.a. at the world level if China is excluded, because of the higher oil price in 2005 and 2006.

Higher GDP for less energy resulting in large energy savings at the world level

Energy productivity improvements in most regions resulted in large energy and CO_2 emission savings, estimated at 8.7 Gtoe and 20Gt CO_2 respectively in 2006 (**Figure 2.5**). If the energy intensities of each region had remained at their 1980 level, world energy consumption would have been 8.7 Gtoe higher in 2006 (i.e. 40% higher). Compared to 1990 technologies and economic structure (i.e. at 1990 intensities), the energy savings in 2006 are estimated at 4.4 Gtoe (half of which in China, 20% in North America and 10% in Europe) and the CO_2 savings at 10Gt.

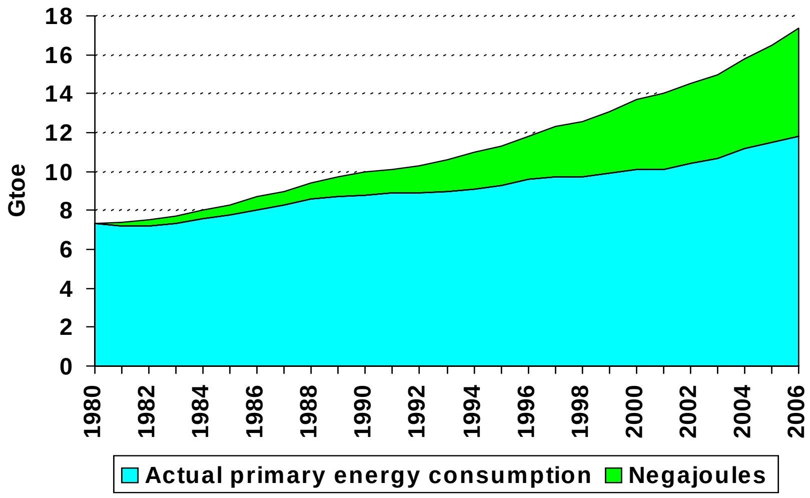
About 70 countries in the world have increased their energy productivity by more than 1% p.a. (i.e. with a decrease of their energy intensity below 1% p.a./year) (**Figure 2.6**). In about 30 countries, on the other hand, the energy productivity is decreasing (mainly in the Middle East, South Europe, Africa and Latin America).

In developing regions, the energy intensity is decreasing slower if biomass is excluded

If biomass is excluded (**Figure 2.7**), the situation looks different for developing regions e.g. Latin America, Other Asia, or the decrease is weaker e.g. China, India, or the increase is stronger e.g. Africa. The total primary intensity (including biomass) always changes more rapidly than the primary intensity of conventional energies[17] because of the traditional fuels substitution by modern energies.

Figure 2.5: Energy savings from energy intensity decrease at world level

Economies d'énergie au niveau mondial

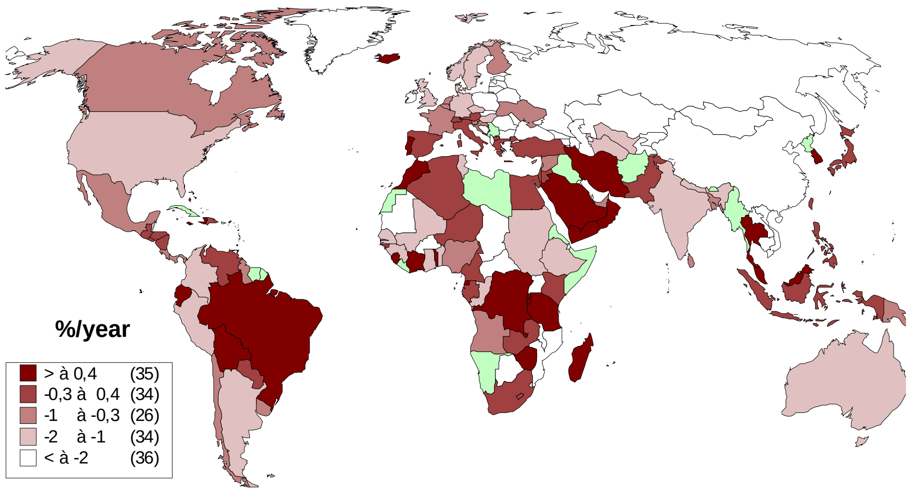


Source: ENERDATA

[16] The average rate of intensity reduction at world level was 1.3% p.a. on average between 1980 and 1990 and.1.5% p.a. between 1980 and 2006.

[17] Oil, coal, gas and electricity

Figure 2.6: Primary energy intensity trends by country (1990-2006) (%/year)
Intensité énergétique primaire par pays



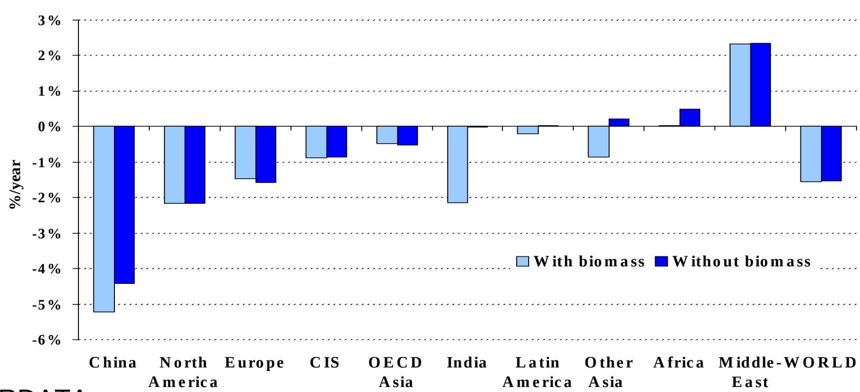
Source: ENERDATA

For most developed regions (Europe, North America, CIS, Asia & Pacific OECD), a reverse trend can be observed: the primary intensity including biomass decreases less rapidly than the primary intensity of conventional energies, mainly because of a broader use of biomass in these regions. At world level, these two opposite trends offset each other and both intensities experience almost the same decrease.

About 20% of end-use efficiency improvements are offset by higher conversion losses

To assess the energy efficiency of a country at the end-use level better, the **final energy intensity** is a more appropriate indicator: it corresponds to the energy consumed per unit of GDP by final consumers for energy using applications, excluding consumption and losses in energy conversion (power plants, refineries, etc.) and non-energy uses.

Figure 2.7: Primary energy intensity with and without biomass (1980-2006)
Intensité énergétique primaire (avec et sans biomasse)



Source: ENERDATA

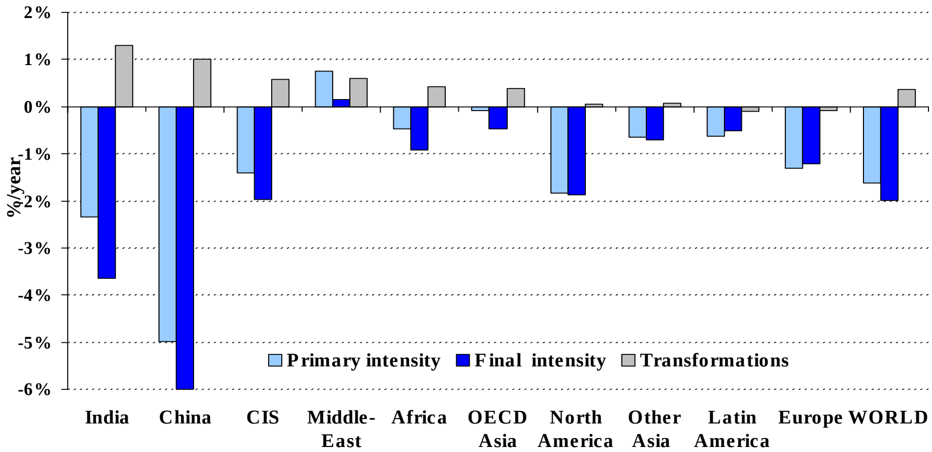
The final energy intensity at the world level decreases less than the primary energy intensity (2% p.a. against 1.6% p.a.). This is also true in almost all world regions, except in Europe and Latin America (**Figure 2.8**). Reductions in the energy intensity are larger at the final consumer level than at the level of the whole economy[18]. This is a result of growing losses in energy conversion. This factor partially offsets energy efficiency improvements at the final consumer level in regions with declining trends. At the world level, 20% of the energy productivity gain at the final consumer level was offset, by increasing losses in energy conversion (80% in OECD Asia & Pacific, 50% in Africa, 36% in India and 30% in CIS).

As a large share of the energy used (or lost) in energy conversion can be attributed to the electricity sector, increasing energy losses can be explained by two factors:

- Increasing share of thermal electricity (almost everywhere) or nuclear (in Europe, Japan and North America) in the electricity generation mix which led to a decrease in the average efficiency of electricity generation[19]. The recent development of gas combined cycle plants, wind and cogeneration had already reversed the trend in Western Europe. At the world level, the share of nuclear increased from 9% of total electricity generation in 1980 to 15% in 2006; over the same period the share of hydro decreased from 21% to 17%.

- Increasing share of electricity in final consumption, as a result of economic and industrial development, from 10% in 1980 to 16% at present at world level[20], implies increased losses in the electricity sector, unless the additional electricity is supplied by hydro, wind or imports.

Figure 2.8: Variation of primary and final energy intensity (1990-2006)
Variation de l'intensité primaire et finale



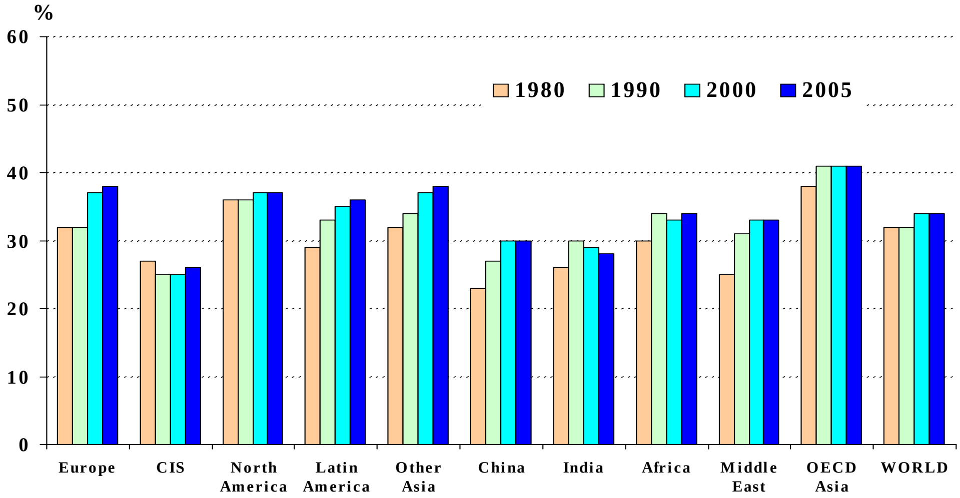
Source: ENERDATA

[18] When the intensity is increasing, the primary intensity increases faster than the final energy intensity.

[19] The electricity produced is converted in energy units (toe) on the basis of their average efficiency, which varies from 33% for nuclear power plants to 100% for hydro plants, and to 30% to 40% for thermal power plants

[20] For all regions, the total increase over this period is around 6 percentage points, except in the CIS (3 points) and China (11 points).

Figure 2.9: Trends in the average efficiency of thermal power production
Variation du rendement moyen des centrales thermiques



Source: **ENERDATA**

In Europe and Latin America, an opposite trend is taking place, due to the recent development of gas combined cycle plants, wind and cogeneration, especially in Europe.

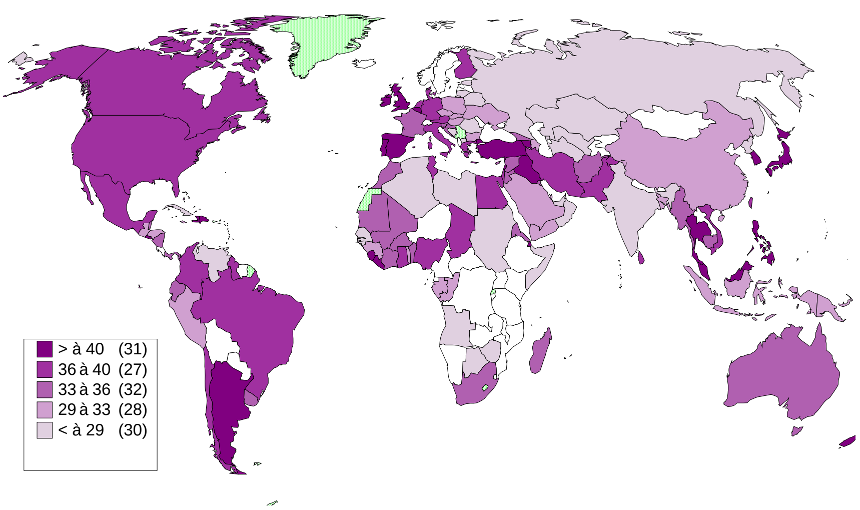
Energy efficiency of thermal power generation is improving slowly at world level

Energy efficiency of thermal power generation improved by 2% only since 1990 at world level (**Figure 2.9**); from 32% in 1990 to 34% in 2005. This is far below the EU average of 40% or the EU best practice (Spain with 46% due to a high penetration of gas combined cycle power plants).

If all world regions had the same energy efficiency performance as the EU average, 420 Mtoe of fuel would have been saved in 2006, avoiding 1.3 Gt of CO_2 emissions. The amount of savings would even reach 770 Mtoe or 2.4 Gt CO_2 if all thermal power plants had the Spanish performance.

About 30 countries in the world have an average efficiency of thermal power generation above 40% and about the same number in the range between 35 and 40% (**Figure 2.10**).

Figure 2.10: Average efficiency of thermal power production by country (%) (2006)
Rendement moyen des centrales thermiques



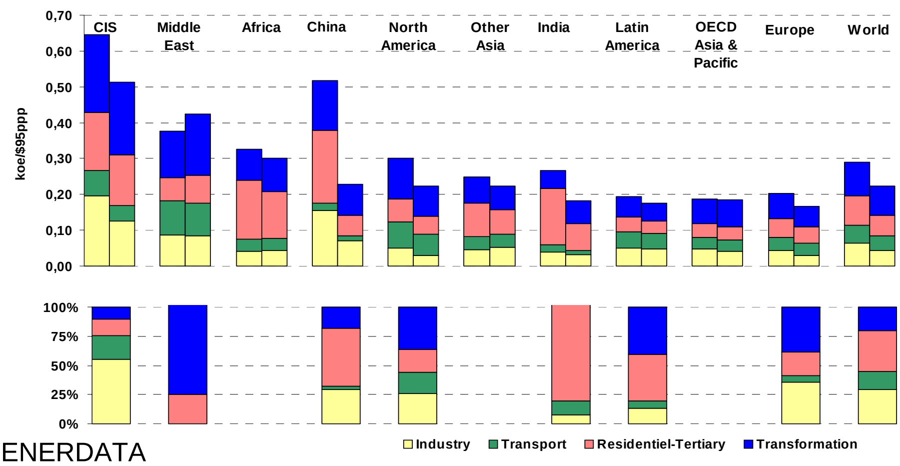
Source: ENERDATA

The sectors behind the decrease in the primary energy intensity vary across the region

Evaluation of the primary intensity by sector shows how each sector contributed to the variation in primary energy intensity (**Figure 2.11**).

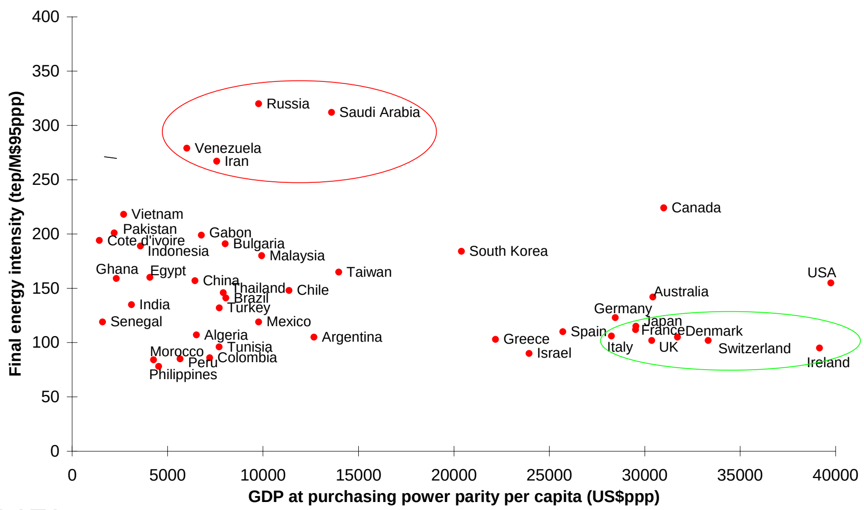
The energy intensity reduction in the industrial sector is clearly visible in industrialised countries. In emerging countries and regions, households is the main sector driving the reduction in energy intensity, because of the substitutions of modern and more efficient by traditional fuels.

Figure 2.11: Primary energy intensity by sector (1990 and 2006)[21] Intensité primaire par secteur



Source: ENERDATA

Figure 2.12: Final energy intensity and GDP per capita (2006) Intensité finale et PIB par habitant



Source: ENERDATA

[21] Some regions are not shown as the different sectors have opposite influence on the energy intensity variation.

In the Middle East, the transformation sector explains most of the increase in the energy intensity due to the rapid development of electricity uses (e.g. air-conditioning) and the fact that electricity production is 100% thermal.

At the world level, households and industry account for two thirds of the reduction of the energy intensity (35 and 30%, respectively). Surprisingly, transport has had a lower influence on energy intensity trends, probably because of the large increase in the price of motor fuels and slower consumption growth in recent years, which brought it in line with the GDP.

There are significant discrepancies in final energy intensity at the same level of economic development

Energy importing OECD countries demonstrate the lowest final energy intensity (**Figure 2.12**). Oil producing countries have the highest intensities.

For a given level of economic development, final energy intensities vary significantly**:** up to 2 times for energy importing countries and up to 3 times if large energy producers are included (e.g. Russia, Saudi Arabia, Venezuela or Iran). For energy importing countries, several factors explain such large discrepancies: different price levels, difference in the structure of the economic activity, energy supply mix, importance of energy efficiency policies etc. In particular, former centrally planned economies in Europe and the CIS, that historically had low and subsidised energy prices, usually have high energy intensities, because of low efficiency of buildings and end-use equipment.

Final intensities are generally decreasing with economic development and converging

Final energy intensities are decreasing in economically developing energy importing countries, as well as in OECD countries with significant energy resources (e.g. USA, Canada, Australia) (**Figure 2.13**). Several factors can explain this trend: higher prices for energy importers, saturation in some end-uses in the most developed OECD countries, effects of energy efficiency and climate change policies that are the strongest in energy importing countries and start to have an impact, mainly at the State level in USA, Canada and Australia. Final energy intensities are however increasing in non-OECD oil producing countries and, to a lesser extent, in some countries with significant energy resources (e.g. Thailand, Brazil).

Figure 2.13: Trends in final energy intensity and GDP per capita (1990-2006)
Variations de l'intensité finale et PIB par habitant

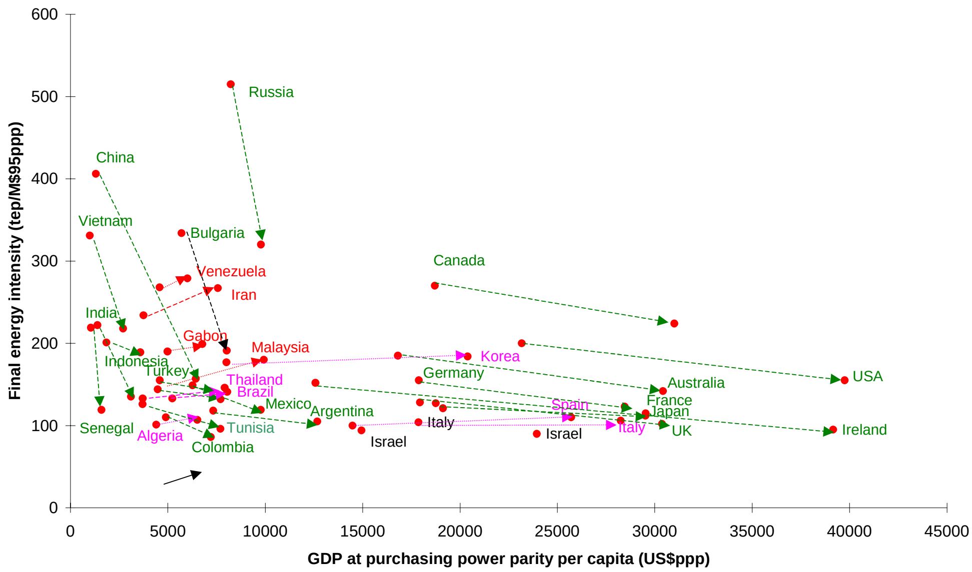
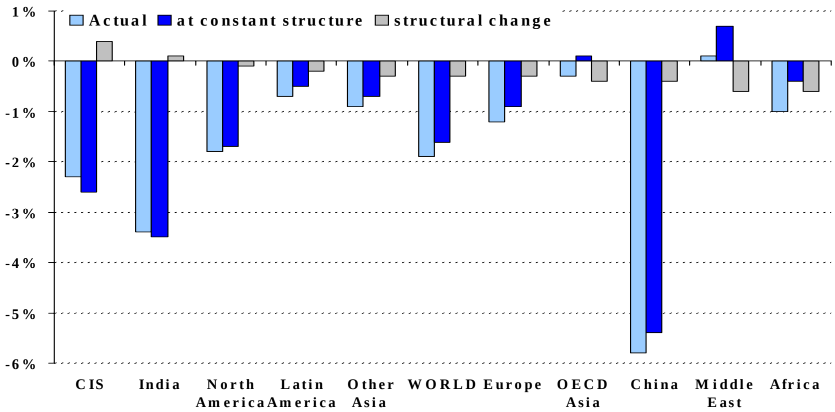


Figure 2.14: Role of structural changes in the GDP (1990-2006)
Rôle des changements structurels dans le PIB



Source: ENERDATA

In a long-term trend, energy intensities follow a "bell curve", generally with developing countries to the left, with increasing intensities, and developed countries on the right side, with decreasing and converging values.

Changes in economic structure also influence final energy intensities: services require six times less energy inputs per unit of value added than industry

Overall energy intensities, whether primary or final, capture all the factors that contribute to changes in the amount of energy required to produce one unit of GDP, including technical, managerial and economic factors. In this sense, changes in the economic structure contribute to variations in overall energy intensities, although they are not generally the result of energy efficiency policies. For example, all things being equal, the tertiarisation of the economy will decrease total energy intensities, as the energy intensity of industry is six times higher than that of the service sector at world level. In other words, it requires six times more energy to produce one unit of activity in industry compared to the service sector.

In OECD countries, the difference in these intensities is around 4.5 to 6 depending on the region. In non-OECD countries it is even higher, around or above10. The effect of structural changes is especially important in countries with rapid economic growth.

The share of industry in the GDP varies from 20% in North America, to 25% in Europe, India and Africa, around 30% for the world average, Latin America, OECD Asia and Pacific and around 60% in China. The share of services is about 20% in China, around 50% in Latin America, CIS, India, and at world level, 60% in Europe and OECD Asia & Pacific and 75% for North American countries.

In order to monitor better energy efficiency trends in relation to energy pricing and energy management policies, it is necessary to exclude the influence of structural changes. This is achieved by calculating **energy intensity at constant GDP structure**, i.e. assuming a constant share of agriculture, industry and services in the GDP as well as a constant share of the private households consumption in the GDP[22].

The difference between the actual evolution of the final energy intensity with that at constant economic structure shows the influence of structural changes on the economy (Figure 2.14).

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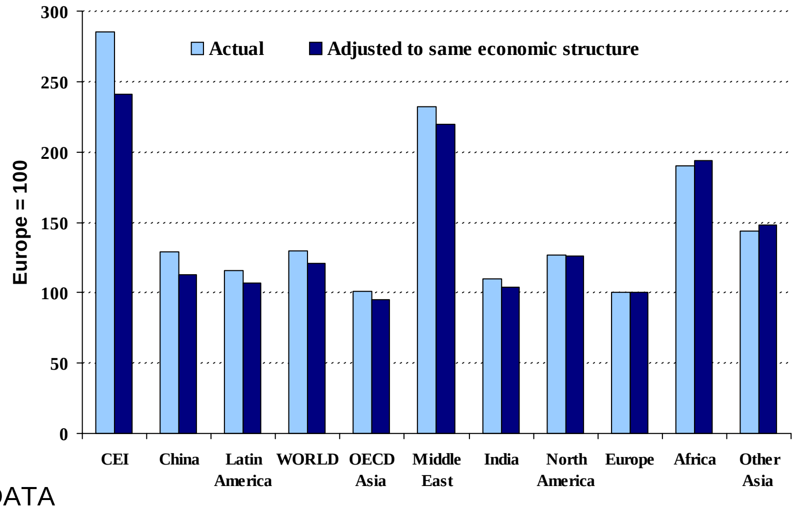
22 Final energy intensity at constant GDP structure is an imaginative value calculated assuming that the GDP structure by main sector (agriculture, industry, services) as well as the private consumption share in the GDP are unchanged from the base year, only taking into account the actual variation in the energy intensity of each sector (i.e. energy consumption over value added for agriculture, industry and services, and energy consumption over private consumption for households). In ODYSSEE, the calculation for European countries considers a constant structure of industrial sectors, which was not possible in this study due to data limitations on industry consumption and value added by industry sub-sector by world region (www.odyssee-indicators.org).

Figure 2.15: Final energy intensity adjusted at same economic structure (2006)
Intensité finale ajustée à la même structure économique



Source: ENERDATA

The intensity at constant GDP structure can be considered as a better indicator to capture trends in energy productivity than the usual energy intensity.

For most regions, the final intensity at constant structure decreased less than the final energy intensity. This means that part of the energy intensity reduction (i.e. part of the energy productivity improvement) was due to an increasing share of services in the GDP, the less energy intensive sector. In Africa for instance, structural changes explain about two third of the decrease in the final energy intensity between 1990 and 2006. In Latin America and other Asia, about one fourth of the reduction can be attributed to structural changes and in Europe 20%. In OECD countries, structural changes had a limited impact over the period as most of these changes took place in the 1980s. In CIS and India, there was an opposite but marginal trend: as a result, the actual energy productivity reduction is slightly higher than shown previously. It should be also be pointed out that, the most important economic restructuring was in industry and has not been measured in this study (probably most important in China).

Energy intensity should be compared at the same GDP structure

Differences in GDP structure among countries and regions will affect their relative energy intensity levels. For instance, a region with a high share of industry in its GDP, all other things being equal, will have higher energy intensity than other regions. To improve the comparisons among countries and regions, final energy intensities can be adjusted to the same GDP structure[23] (Figure 2.15). The adjustment is particularly significant in non-OECD countries with a higher contribution of industry to the GDP, compared to Europe.

2.4 Industry

The energy intensity of industry decreased significantly in OECD countries and China, with a slow down or even a reverse trend since 1990

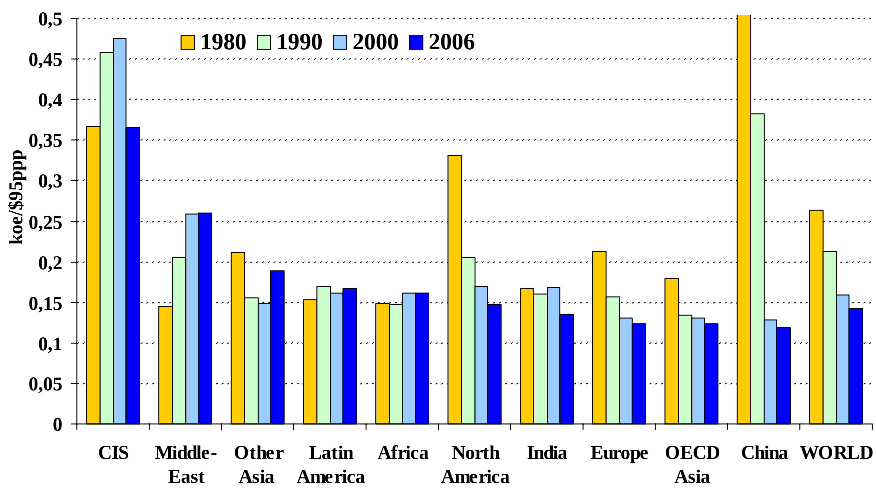
Since 1980, the general trend in industry in Europe, OECD Asia & Pacific, North America, China and India is a decrease in the energy required per unit of value added (industrial intensity) (**Figure 2.16**).

[23] The average GDP structure of Europe was taken as a reference. This choice does not affect the relative adjustment of countries and regions. The regions are ranked according to the magnitude of the adjustment.

For Europe, and North America, this reduction in industrial energy intensity slowed since 2000 and was even reversed for OECD Asia & Pacific.

In the other regions, the energy intensity remained almost stable, implying an energy consumption growth in industry in line with the level of activity.

Figure 2.16: Energy intensity of industry
Intensité énergétique de l'industrie

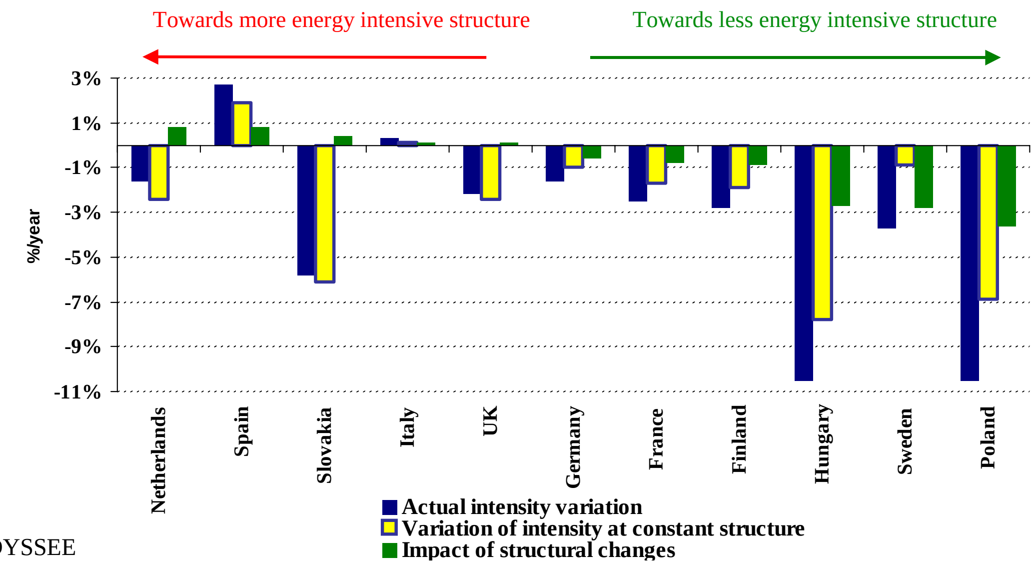


Source: ENERDATA.

The CIS and the Middle East experienced an increase in the energy intensity of industry until 2000.

The energy intensity levels of OECD Asia & Pacific, Europe and China are converging; India and North America are also getting close to these levels.

Figure 2.17: Energy intensity trends in industry: role of structural changes
Intensité énergétique de l'industrie : impact des changements de structure



Source: ODYSSEE

The influence of structural changes on the manufacturing sector moves in different directions depending on the countries

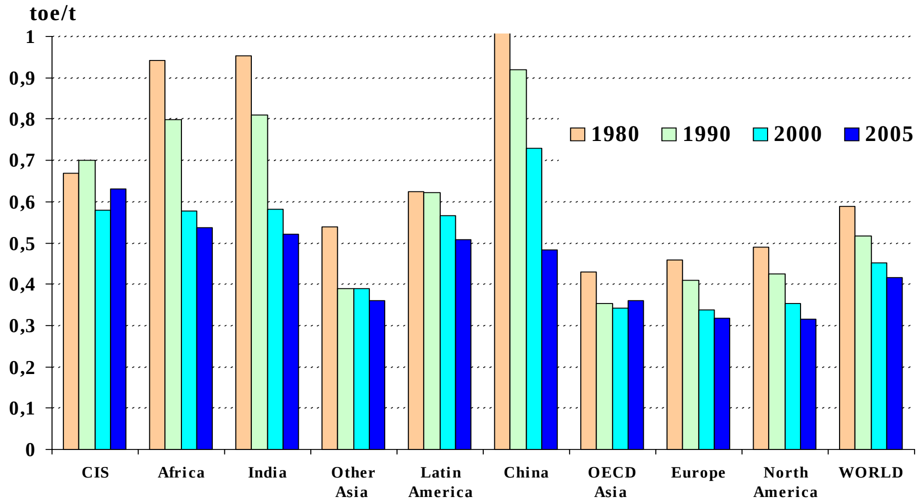
In countries that have experienced an increasing role of energy intensive sub-sectors of industry (e.g. steel, cement), for example the Netherlands, Slovakia or to a lesser extent UK, the actual improvement in energy productivity, as measured by the energy intensity at constant structure, appears to be greater than that due to the decrease in the intensity of manufacturing (**Figure 2.17**)[24].

In most other EU countries, especially in Scandinavian and Baltic countries e.g. Sweden, Finland, Denmark, Lithuania, Estonia, and Latvia or in Hungary, France, Germany, Poland and the Czech Republic, the shift in industrial structure has moved in the other direction, towards less energy intensive industries (e.g. electronic goods, light chemicals)[25]. In such cases, part of the decrease in energy intensity of manufacturing is due to structural changes. In other words, the intensity decrease overstates the actual improvement in energy productivity. In Poland, Hungary, Finland or France for example, about one third of the decrease in energy intensity since the mid nineties was due to changes in the structure of the manufacturing industry (**Figure 2.17**).

Convergence in energy consumption for energy intensive products

In energy intensive industries, the general trend points toward a reduction in the energy consumption per tonne of output, as observed for steel (**Figure 2.18**). Given the importance of steel in the energy balance of industry, this trend partly explains the overall improvement in energy productivity outlined above. There is a convergence in the most developed countries, whereas, in other countries, the situation is more diverse, due to differences in production processes and products. Europe and North America have the lowest average specific consumption (0.32 toe/t of crude steel). In the CIS, this specific consumption is twice higher and emerging countries about 60-70% higher, but the progress is generally greater in these countries.

Figure 2.18: Variation of the energy consumption per tonne of steel
Variation de la consommation unitaire moyenne de l'acier.

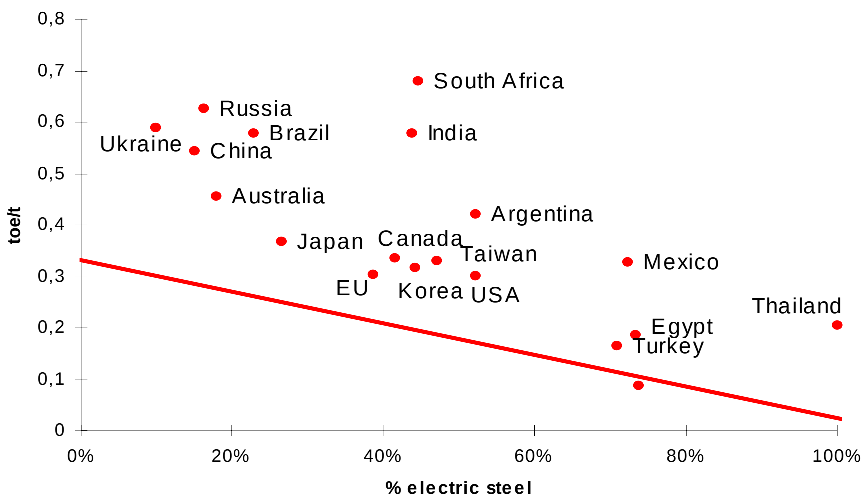


Source: ENERDATA

[24] See reports on EU countries at www.odyssee-indicators.org

[25] Such structural changes were particularly important in most OECD countries between 1980 and 1990 (e.g. Japan) and probably now in China.

Figure 2.19: Energy consumption per ton of steel as a function of process mix
Consommation unitaire par tonne d'acier en fonction de la part des procédés



Source: Enerdata

The rapid reduction in the energy consumption per tonne of steel is the result of two factors: energy efficiency improvements and an increasing share of electric steel production, the least energy intensive process compared to the oxygen blast furnace. At world level, 34% of the steel was produced through the electric process in 2005, up from 28% in 1990. In some countries, negotiated agreements between industry associations and the government on targets for energy efficiency improvements explain part of the results achieved.

To really compare countries' energy efficiency performance in steel production, it is necessary to account for the differences in the process. Countries with 100% production from electricity will have, all other things being equal, much lower specific energy consumption than countries with a large proportion of steel produced with the energy intensive oxygen process. **Figure 2.19** indicates for a selection of countries the average consumption per tonne of steel in relation to the share of the electric process.

Only groups of countries with a similar process mix can be compared: for instance, South Africa, India, Korea and Taiwan, with Korea turning out to have the best performance, or China, Russia and Australia, with Australia with the lowest specific consumption. The graph also displays the best practice (red line): the distance of each country to this best practice gives an estimate of the potential of energy efficiency improvement that can be achieved with the existing process mix. An additional potential of reduction in the specific consumption could be achieved by increasing the share of the electric process.

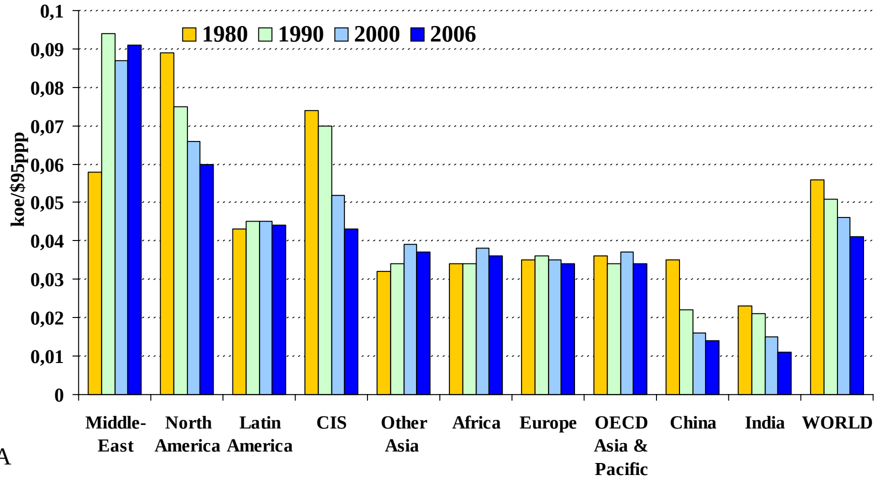
2.5 Transport

In transport great disparities exist among regions in the energy intensity trends; certain interesting signals in some OECD countries with a stabilisation of transport energy use

The energy intensity of the transport sector[26] appears to be quite similar in Europe, OECD Asia and Pacific and other Asia, while North America's stand at a level 75% higher (**Figure 2.20**). In China and India, because of the still low car ownership, the energy intensity is low compared to the other regions.

[26] There is no good indicator to reflect the overall efficiency trends in the transport sector, mainly because of the difficulty of separating out the energy used by different modes of transport, especially for road transport. The most common indicator is the energy consumed in transport per unit of GDP, as transport activities take place in all sectors. In the ODYSSEE project for Europe, an alternative indicator is used, combining in a single index the energy efficiency trends by mode (ODEX) (see www.odyssee.indicators.org).

Figure 2.20: Energy intensity of transport
Intensité énergétique du transport

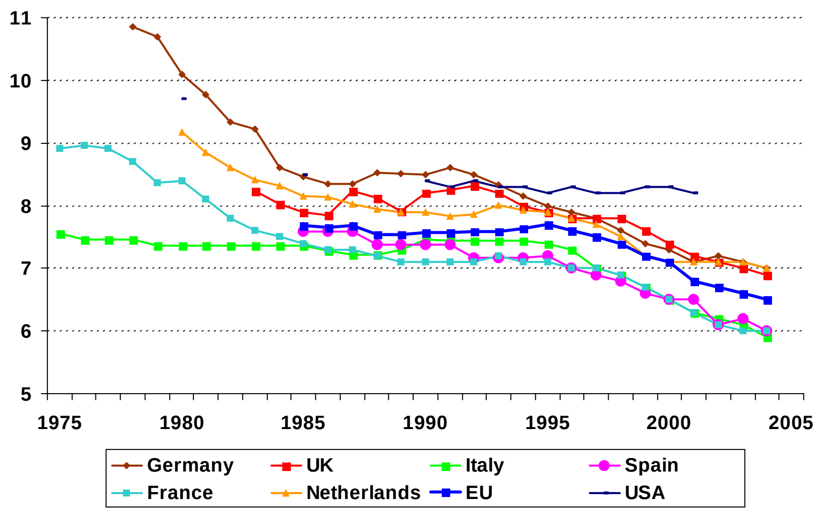


Source: ENERDATA

North America and CIS are among the few regions where the energy consumption of transport is growing much slower than the GDP. In North America, the reduction in the fuel economy of new cars, following the implementation of the CAFE standards[27], and the already high energy intensity explain this situation.

In Europe, the energy intensity of transport has been decreasing only slightly since 1990. In OECD, Asia & Pacific, there was hardly any reduction at all. This is not in line with the improvement of the energy efficiency of vehicles (25-30% in Europe since 1973) and the policy measures implemented[29] (**Figure 2.21**).

Figure 2.21: Specific consumption of new cars (litres/100km)[28]
Consommation spécifique des automobiles neuves



Source: Odyssee

[27]The average fuel economy of new cars improved by almost 40% between 1973 and 1993 (it was about twice higher than in Europe in 1973).

[28] Test values

[29]For instance the agreement between the European Commission and association of cars manufacturers (ACEA, JAMA, KAMA) and measures in urban transport in relation to environmental protection.

In fact, other factors have offset these technical improvements: growing traffic jams, behavioural factors (e.g. a shift to bigger cars, use of air conditioning) and continuous shift to road for the transport of goods. Since 2000, some countries demonstrated a stabilisation in the energy consumption by the transport sector (e.g. Japan or France) or even a decrease (Germany),

In Latin America, Africa and Other Asia, the energy intensity of transport has been increasing until 2000, because of the increasing ownership of cars and motorcycles, and the use of roads to transport goods instead of water or rail. Higher oil prices have, however, reversed that trend everywhere in recent years. In China and South Asia, the growth of the energy consumption of transport is slower than the GDP because of a slower increase in car ownership and the dominant role of rail transport for the transport of goods.

2.6 Household and Service Sectors

The diverse patterns of energy consumption for thermal uses (cooking, space and water heating) among world regions make any comparison between regions fairly meaningless. The following evaluation of energy trends in these sectors will therefore focus on electricity only.

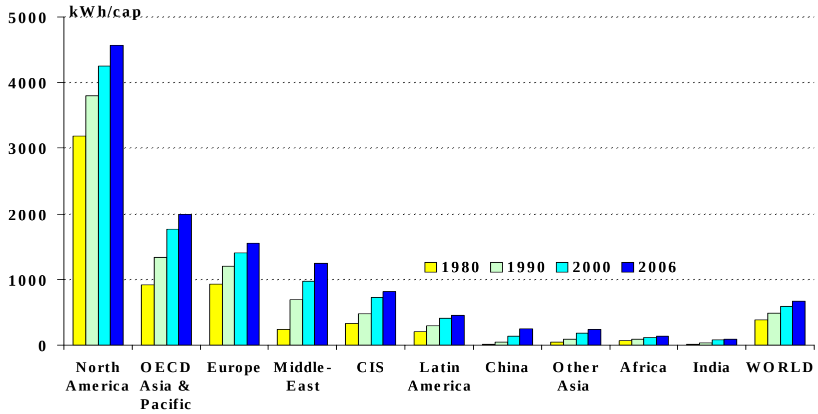
The household electricity consumption per capita is rising and showing diverse trends

The average consumption of electricity per capita in households is very diverse in developed regions depending on the level of ownership of electrical appliances and the importance of electric space heating (**Figure 2.22**). It varies from a value of around 1500 kWh/capita for European countries[30], to around 2000 kWh in OECD Asia & Pacific, and is around 4500 kWh in North America, i.e. three times the value for Europe.

Such a comparison would be more relevant if it only included captive uses (i.e. without space heating and other thermal uses, such as cooking or water heating). However, the poor availability of data on the consumption of electricity by end-use limits the possibilities for such comparisons.

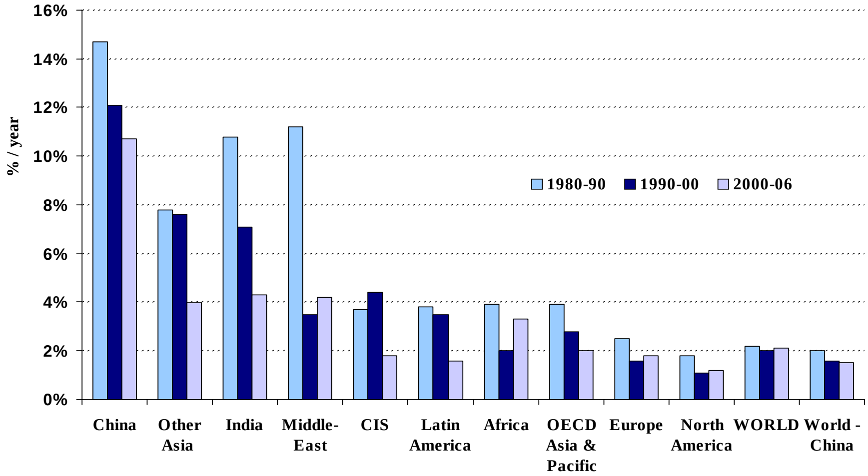
Developing regions have much lower values of per capita consumption as part of the population does not have access to electricity and the ownership of large appliances (e.g. refrigerators, washing machines, and air conditioning) is less common. Per capita consumption of households is 16 times lower in India than in Europe, 3.5 times lower in China and Other Asia, 11 times lower in Africa.

Figure 2.22: Household electricity consumption per capita
Consommation d'électricité des ménages par habitant



Source: ENERDATA

Figure 2.23: Variations in the household electricity consumption per capita
Variation de la consommation d'électricité des ménages par habitant

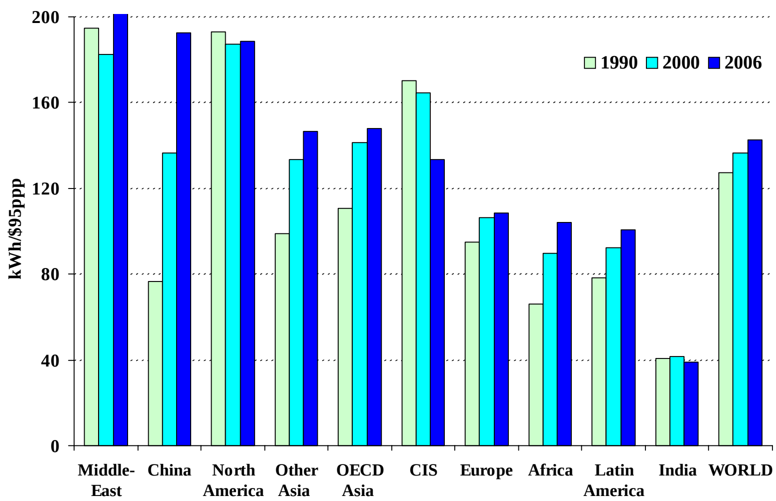


Source: ENERDATA

In India, and Africa less than half of the population has presently access to electricity[31]. In all regions, consumption per capita is increasing. The growth is the most rapid in Asia: above 10% p.a. in China and around 4% p.a. in India and other Asia. It is more moderate in Europe, North America and OECD Asia & Pacific, compared to other regions, but is still between 1 and 2% p.a.

This general growth is slowing down in most regions (**Figure 2.23**). In developed regions, this is the result of both certain saturation in the appliances ownership and the effect of the policies implemented to improve the energy efficiency performance of electrical appliances (labelling, efficiency standards)[32].

Figure 2.24: Electricity intensity in the service sector
Intensité électrique des services



Source: ENERDATA

[30] In EU new member countries from the Baltic region and Central and Eastern Europe, the average is twice lower than the average for Europe

[31] Around 50% in India and 40% in Africa in 2006 (source Enerdata)

[32] See below 3.4

In Europe and North America, however the electricity consumption of households is increasing slightly faster since 2000. This may be due to the growing numbers of new appliances, such as IT devices, linked to the development of internet and new telecommunications types, as well as a spread of new equipment, such as air conditioning in Europe. In addition, the policy measures have been focusing only on part of the household electric appliances (usually the largest ones)[33]. In emerging regions, the efficiency policies probably also play a part in explaining this slow down.

The electricity intensity of the service sector is increasing

In developing countries, the main source of energy used in the services sector (public administration, commerce and other service activities) is electricity. Therefore, as for the household sector, the indicators considered here focus on electricity. The quantity of electricity required to generate one unit of value added (the electricity intensity) is increasing in most regions, especially in less industrialised regions in which the service sector is expanding rapidly, and in countries with air conditioning requirements (e.g. China, Other Asia) (**Figure 2.24**). In North America, a region with a high energy intensity level, the ratio is rather stable.

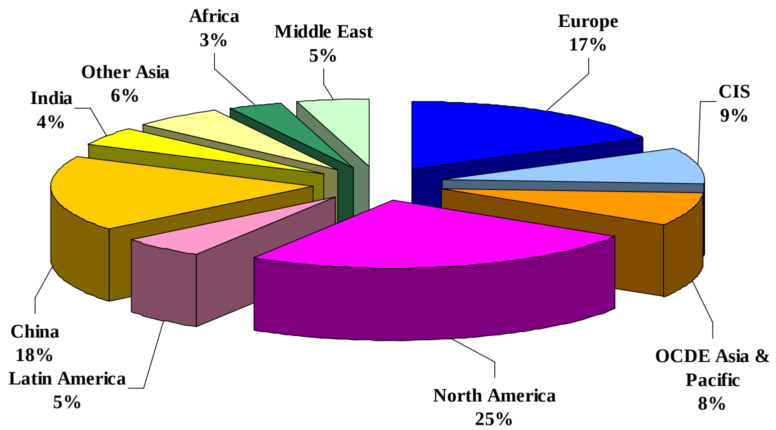
2.7 CO_2 Emissions from Energy Combustion

One fifth of the world's population accounts for about 60% of world CO_2 emissions

Developed regions are the largest emitters of CO_2 from energy combustion (Figure 2.25). North America, Europe, CIS, Asia & Pacific OECD together account for 54% of the total world CO_2 emissions whereas they represent only one fifth of the world population. China is the main emitter in the developing regions with 19% of total emissions.

CO_2 emissions from energy combustion doubled since 1990 in non OECD Asia

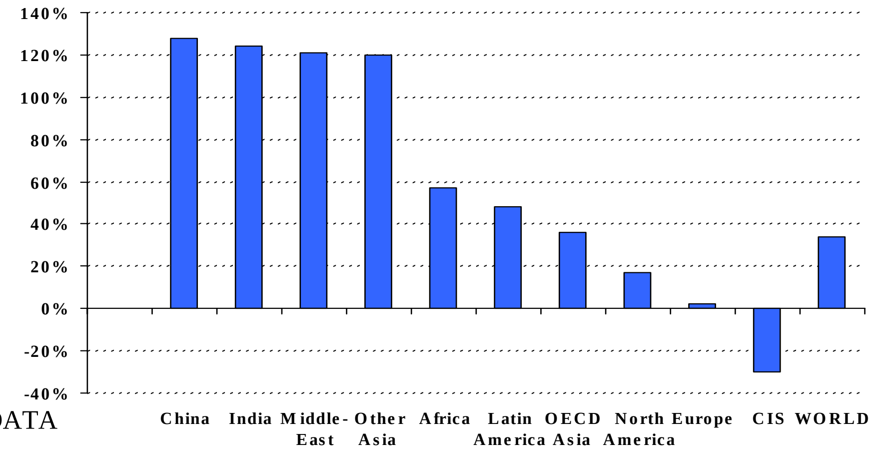
Figure 2.25: Distribution of world CO2 emissions from energy use (2006)
Répartition des émissions de CO2 mondiales liées à la combustion



Source: ENERDATA

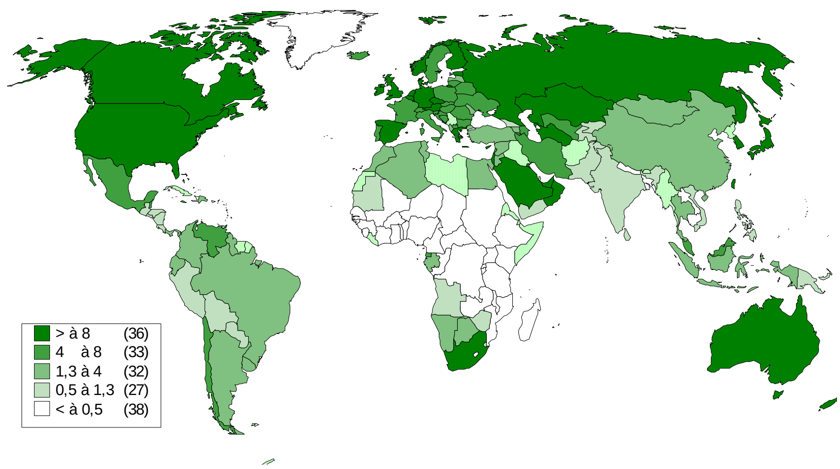
[33] In the EU, the six large appliances targeted by the EU Directives and voluntary agreements with equipment manufacturers account for a decreasing share of the total electricity consumption for electrical appliances and lighting: 45 % in 2004 down from 54 % in 1990. In contrast, the share of all other appliances, including air conditioning reached 38 % in 2004 up from 27 % in 1990 (see www.odyssee-indicators.org).

Figure 2.26: Variations of CO_2 emissions from energy use (1990-2006)
Variation des émissions de CO_2 liées à la combustion



Source: ENERDATA

Figure 2.27: CO_2 emissions per capita (2006) (t CO_2)
Emissions de CO_2 par habitant



Source: ENERDATA

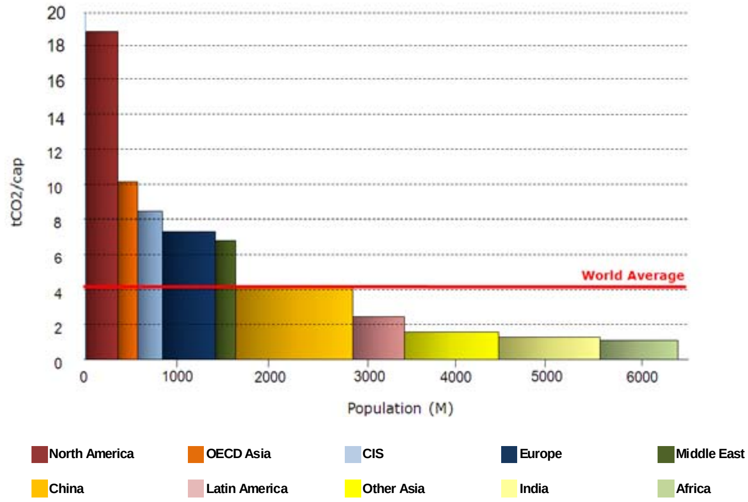
Trends in CO_2 emissions vary significantly between countries (**Figure 2.26**). Developing countries with high economic growth have registered a doubling in their CO_2 emissions (India, Middle East, Other Asia and China). Europe managed to almost stabilise its emissions, partly because of the climate change policies. North America and OECD Asia & Pacific experienced a growth in their emissions (36% and 17%), as climate policies have been weaker in some of the countries (e.g. USA and Australia).

The decrease in emissions in the CIS is due to the sharp contraction of their economies in the 90's.

Since 1998, their emissions are however strongly increasing (+ 9%). As a result of these trends, world CO_2 emissions from energy use are 34% higher in 2006 than in 1990.

CO_2 emissions per capita vary greatly among countries

Figure 2.28: CO2 emissions per capita
Emissions de CO2 par habitant



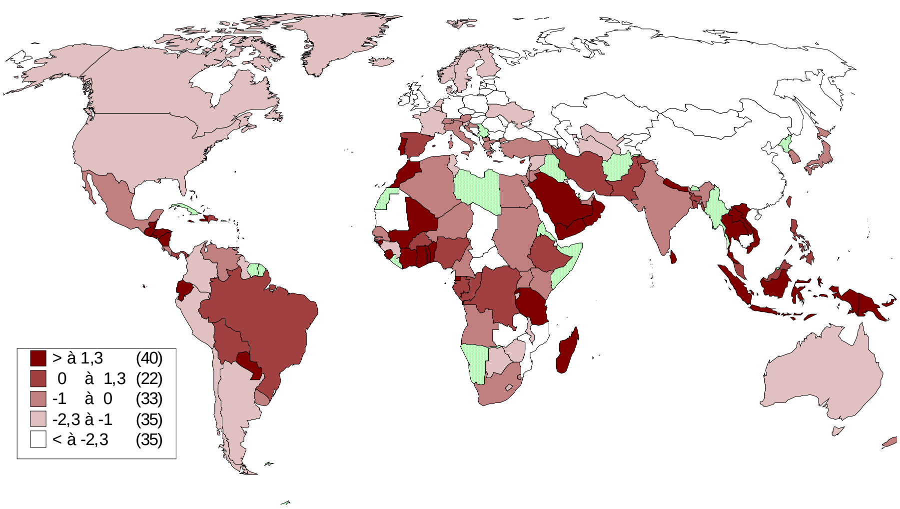
Source: ENERDATA

About 40% of countries in the world have a level of emissions per capita above 4t CO_2, i.e. the world average of the countries in the range of 4-8t and half above 8 t (**Figure 2.27**). Countries with the highest emissions usually have abundant energy resources[1].

A moderate increase of CO_2 emissions per capita

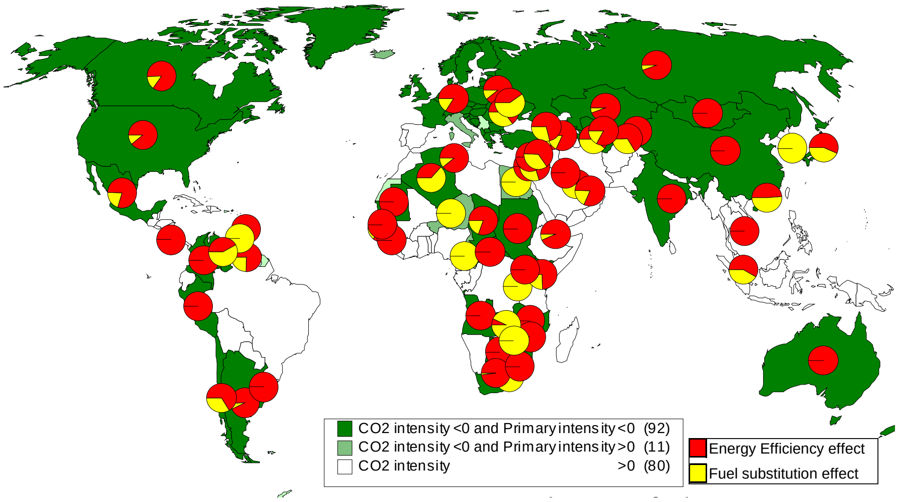
At world level, CO_2 emissions per capita increased only moderately (+5% since 1990). Without China, there is even a slight decrease. This is the result of two opposite trends: a rise of CO_2 emissions per capita in most regions, on the one hand and a decrease in Europe, CIS and to a lesser extent in North America, on the other hand.

Figure 2.29: Variation in CO2 intensity (1990-2006) (%/year)
Variation de l'intensité en CO2



[1] e.g. Kuwait, Bahrain, Emirates, USA, Australia,

Figure 2.30: Impact of fuel substitutions on the CO2 intensity variation[34]
Effet des substitutions d'énergie sur la variation de l'intensité en CO2



CO_2 emissions per capita are very diverse. Around 1t CO_2 in the less developed regions (Africa and India), 1.5 t in other Asia, slightly under 4 t in China, around 7-8 t for Europe, CIS, and the Middle East, close to 10 t in Asia & Pacific OECD and near 19t in North America (**Figure 2.28**). The largest growth took place in Asia and the Middle East, due to the high economic growth.

CO_2 emissions generally increase less rapidly than the economic activity

CO_2 emissions from energy use increase slower than economic activity in most world regions, except in the Middle East, in OECD Asia & Pacific and Other Asia, and in about two thirds of the countries in the world (**Figure 2.29**).

Energy productivity improvements: main driver of reduction in CO2 intensities

Two main factors contribute to decrease the CO_2 intensity of the GDP: energy productivity improvement on the one hand, and a change to energy sources with lower CO_2 emission factors (e.g. gas, renewables, nuclear). In about half of the countries, both the CO_2 intensity and primary energy intensity are decreasing and most of the reduction in the CO_2 intensity is driven by energy productivity improvements: fuel substitutions played a minor role (Figure 2.30). At world level, all the reduction is due to energy productivity improvements.

Canada, Saudi Arabia, Russia and Kazakhstan.
[34] Source: ENERDATA ; variation over 1990-2005

3. Evaluation of Energy Efficiency Policies and Measures

3.1 Introduction

This evaluation covers the impact of selected energy efficiency policy measures around the world to find answers to the following questions. What is the importance of energy efficiency measures? What are the priorities? What are the trends? Which measures are being favoured? What are the innovative measures? What are the results? Which measures are cost effective?

Based on a comprehensive global survey, the evaluation also draws on five in-depth case studies prepared by experts. The following measures were selected as they are widely implemented and are known to be effective; in addition, they complement the set of measures already evaluated in previous reports[35]:

- Mandatory energy audits
- Energy Service Companies (ESCO's)
- Energy incentives for cars
- Energy efficiency obligation for energy utilities, and
- Package of measures for solar water heaters.

Five experts were requested to prepare a comprehensive evaluation of these five types of instruments. Each of the experts prepared a core report of between 10 and 50 pages, completed with concrete examples of country experiences ("country case studies"). These reports have been assembled and condensed to be included in this chapter in the review of the different measures[36].

The full set of country case studies is included in Annex 1 of this report.

The survey[37] of energy efficiency policy measures covers a total of 76 countries, representative of all world regions (Figure 3.1):

- **32 from Europe**: 25 countries from the European Union (EU), plus Croatia, Iceland, Norway, Russia, Serbia, Switzerland and Turkey;
- **Nine from America** (Argentina, Brazil, Canada, Chile, Colombia, Mexico, Peru, the United States, Venezuela ;);
- **17 from Asia and the Pacific** (Australia, China and Hong Kong separately, India, Indonesia, Japan, Malaysia, Mongolia, Myanmar, New Zealand, Philippines, Republic of Korea, Singapore, Sri Lanka, Thailand, Vietnam);
- **12 from Africa** (Algeria, Botswana, Egypt, Ghana, Guinea, Guinea Bissau, Kenya, Morocco, Nigeria, South Africa, Tunisia);
- **Six from the Middle East** (Iran, Israel, Jordan, Kuwait, Lebanon, Syria).

The surveyed countries represent altogether 83% of the world energy consumption (100% for North America and Western Europe, 68% of Latin America, 73% of Asia, 54% of Africa and 44% of the Middle East). In the sample, 43 countries do not belong to OECD: this sample therefore gives a good representation of non-OECD countries. Among the 29 OECD countries, seven countries are outside Europe (in America, Asia & Pacific).

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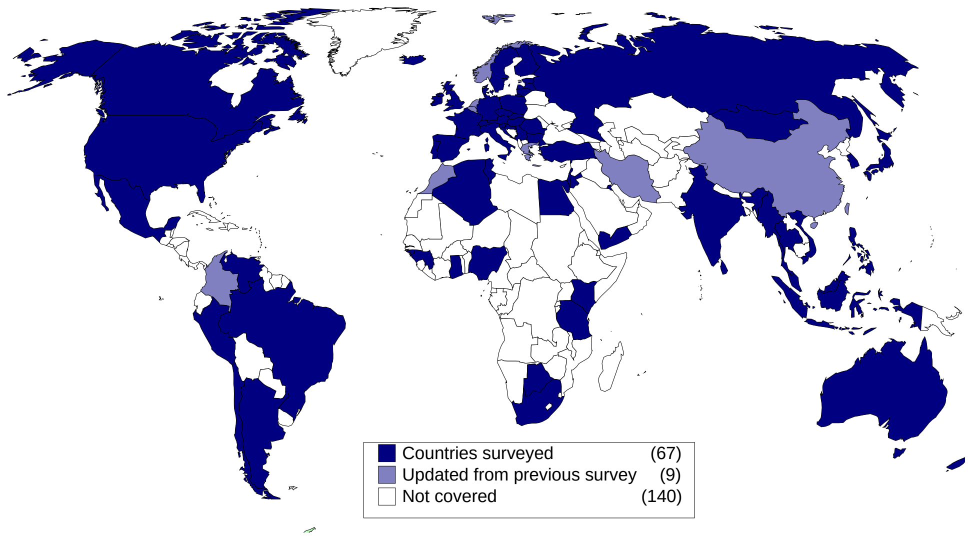
[35] The following measures have already been evaluated in the previous reports: building codes, energy audits, labelling and standards of electrical appliances, fiscal measure for cars and motor fuels, economic and fiscal incentives, voluntary/sectoral agreements, local energy information centres, new energy efficiency financing schemes, packages of P&M 's.

[36] The full reports of the experts are available on the WEC web site: http://www.worldenergy.org/wec-geis/wec_info/work_programme2004/tech/seep/reports.asp

[37] The survey is based on a questionnaire designed by ADEME and Enerdata. It was sent by the WEC to all WEC member committees and the survey was further completed by a mailing to the ADEME network of energy efficiency agencies in the EU 25, in North Africa, and in some OECD countries. In total 100 countries were contacted, 67 countries answered directly and 9 countries were completed by Enerdata using additional sources. The survey was spread over 2006 and 2007, with the synthesis given in Annex 2 updated up to June 2007.

Figure 3.1: Countries covered by the WEC Survey on Energy Efficiency Policies



The survey covers institutional aspects, as well as existing regulations and financial measures. It also covers with a greater focus the selected energy efficiency policy measures mentioned above. The measures considered in the survey are organised as follows[38]:

- **Institutions and programmes**
  - Institutions: agencies (national, regional and local), Ministry department
  - National programmes of energy efficiency, and GHG abatement[39] and law
- **Regulations (by sector)**
  - Efficiency standards for new buildings
  - Minimum efficiency standards and labels for household electrical appliances
  - Other mandatory regulations: energy managers, energy consumption reporting, energy savings and maintenance
- **Financial measures (by sector)**
  - Subsidies for investments and audits, soft loans
  - Fiscal measures: tax credit, accelerate depreciation, tax reduction on energy saving equipment
- **Selected measures**
  - Audits
  - ESCO's
  - Incentives for cars
  - Measures for solar water heaters
  - Energy efficiency obligations for utilities

The results of the survey are summarised in this report and presented by graphs, which show the degree of implementation of the measures in the world geographical regions: Europe, America, Asia (including Oceania), Africa and Middle East[40]. The results of the survey are given with all the detail by country/economy in various tables in **Annex 2.**

Although energy pricing is an important component of energy efficiency policies, pricing was only partly addressed in the survey[41]. Adequate pricing is a necessary condition for promoting energy efficiency. The first step of any energy efficiency

[38] Measures to promote renewable energies and fuel substitution were not included. R&D activities, although important in the long term, are also excluded from the survey, as they are less important in developing countries.

[39] National programmes with quantitative targets

[40] The percentages shown in the different graphs only apply to the countries that have responded to the survey: they are not an exact average of each region, except for Europe where the rate of answers was quite good. The countries are in addition not weighted according to their energy consumption.

[41] Mainly in the case studies on car incentives for motor fuels

policy should be to adjust energy prices in order to give correct signals to consumers, whilst maintaining incentives for behaviour changes or to acquire energy efficient equipment and technologies. Energy producing countries often maintain low domestic prices, which lead to intensive energy uses, as was seen previously by the high and increasing energy intensities in these countries. A reduction in the subsidies could save energy that could be sold at a much higher price on the international market and bring benefits to these economies. Many energy importing non OECD countries are also protecting their consumers from increase in the oil prices by maintaining subsidised prices for some fuels, which has a negative impact on public budgets, especially in the recent years with soaring oil prices.

Adequate pricing means establishing consumer energy prices that reflect the cost of energy supply, i.e. the long-term marginal cost for electricity, the long-term price of oil products on international markets for fossil fuels. Although most energy planners agree with such objectives, they often face reluctance and opposition from decision-makers outside the energy sector, who fear public resistance and the impact of energy price corrections on the consumer price index. Also, energy is a basic good for which a low price is a condition for low-income households' access. This makes actual price adjustments slow or impossible in many developing countries, especially in the household sector.

This part of the report is organised in different sections as follows:

- Institutions and programmes;
- Regulations;
- Financial incentives;
- Mandatory audits;
- ESCO's;
- Incentives for cars;
- Package of measures: for solar water heaters;
- Energy efficiency obligations for energy utilities
- Other measures.

3.2 Institutions and Programmes

There are two main questions related to institutional aspects of energy efficiency policies and their implementation. Firstly, are public energy efficiency agencies necessary to sustain national efforts to improve energy efficiency? Secondly, is it necessary to have strong institutionalisation of energy efficiency measures, through an energy efficiency law or a national programme approved by the parliament?

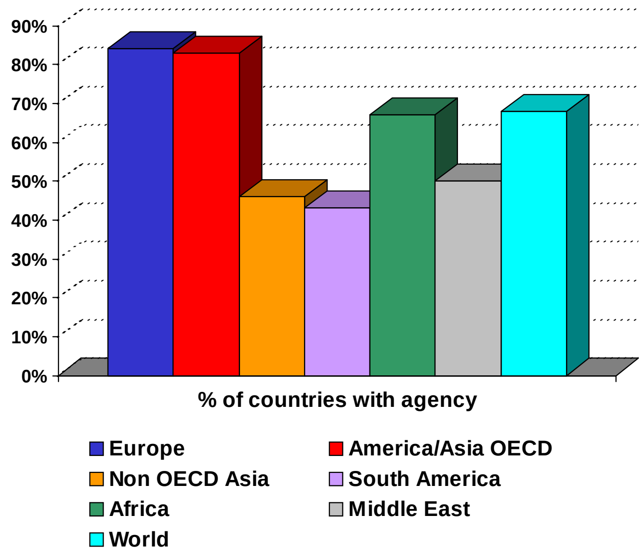
3.2.1 Energy efficiency agency

Two thirds of the surveyed countries have set up a national energy efficiency agency

Energy efficiency programmes usually require a dedicated technical body able to reach remote and varied energy consumers. Some measures, such as energy pricing or the introduction of international standards may however be implemented without a specific energy efficiency institution.

About two thirds of the surveyed countries have a national energy efficiency agency and over 90% a Ministry department dedicated to energy efficiency (**Figure 3.2**). An energy efficiency agency is defined here as a body with strong technical skills, dedicated to implementing the national energy efficiency policy, as well as in some cases the environmental policy (see **Annex 2**). Such agencies are usually separated from ministries, but may be part of a Ministry, as in Denmark, Canada, the US or the Philippines. In Europe, most of the countries have a national energy efficiency agency; several countries have created a new agency since 2000, such as Germany and Norway. In some countries, these agencies also cover environmental issues (e.g. France, the Netherlands). Energy efficiency agencies are increasingly recognised in the EU as necessary instruments to foster energy efficiency policies. The European Commission has recently set up a new agency dealing with the management of EU programmes on energy efficiency and renewables, the Intelligent Energy Executive Agency (IEEA)

Figure 3.2: Countries with an energy efficiency agency[42]
Pays avec une agence d'efficacité énergétique



Source: WEC/ADEME Survey

Energy efficiency agencies have the mission and capabilities, first of all, to design, implement and evaluate programmes and measures, to contract a range of stakeholders, such as companies, local authorities, or NGOs and, finally, to ensure coordination with higher or lower levels of authorities (international, national, regional and local). These agencies are usually public institutions funded by the State budget, and in developing countries are often supported by overseas technical assistance funds. In a few countries, part of the budget is based on a tax on energy (e.g. Norway) and some countries have set up agencies with private sector participation (e.g. Morocco, Portugal), whilst others are expecting their agency to operate as a partially private body that has to earn income.

In countries with a federal or decentralised structure, such as Spain, Germany, Belgium, the US and Canada, energy efficiency agencies have been set up by regional administrations. In addition, many countries have set up local or regional agencies43. In addition, many EU countries have set up local or regional agencies, very often through the Energy Intelligence for Europe programme44 of the European Commission that provides funding to the agencies. As a result, there are presently about 600 local or regional agencies in the EU. These regional and local agencies aim at providing more targeted measures, as they are closer to consumers and better able to take into account regional circumstances (climate, energy resources, etc.). Local information centres that many countries have set up complement them. The EU now has about 800 information centres and agencies dealing with energy efficiency. At world level, half of the countries have local or regional agencies.

The primary objective of all these institutions is to provide technical expertise to governments and consumers, something that cannot always be found in existing institutions. The poor quality of energy efficiency equipment and services is often seen as an obstacle to their good diffusion. Energy agencies can play a role in that field by certifying those which have the required quality. Government ministries do not, in general, have the required expertise to carry out all the activities of energy agencies.

[42] Based on the sample of countries surveyed; Mexico is included in America/Asia OECD. Europe includes Russia and Turkey.
[43] In some countries with a national energy agency, regional offices have been set up (e.g. ADEME in France with 28 offices, or ARCE in Romania with 16 branches).
[44] Or previously the SAVE programme.

Another important function of energy efficiency agencies is to act as a promoter of energy efficiency vis-à-vis energy companies. Electric utilities, although very active in some countries, are above all in the business of selling electricity and thus do not necessarily have a strong interest in energy efficiency over the long-term, especially in the context of a growing competition. There is, therefore, a need for agencies to deal with energy efficiency on a long-term basis.

Yet another function of energy efficiency agencies is to act as a coordinator of all governmental initiatives in the field of energy efficiency to avoid scattered and uncoordinated actions by different ministries. In particular, the veto of such agencies has proved very useful in negotiating sectoral agreements with groups of consumers or equipment producers to reach specific targets for efficiency improvements.

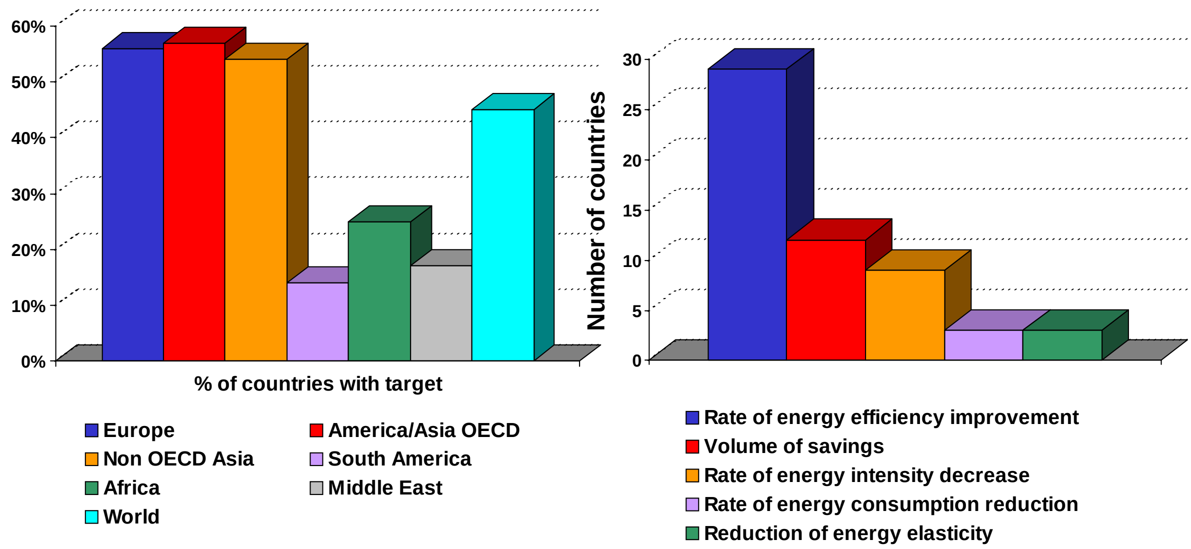
In countries that receive aid from international development assistance programmes, such agencies can in addition act as the national counterpart with whom donors negotiate the implementation of financial packages for energy efficiency. More generally, such agencies can be the counterpart to financial institutions to develop new funding schemes.

The fact that most countries have set up an energy efficiency agency is in a way an empirical justification of their usefulness.

3.2.2 National energy efficiency programmes and laws with quantitative targets

Increasingly, countries adopt national energy efficiency programme with quantitative targets46, with generally yearly monitoring requirement: this is now the case in slightly less than half of the surveyed countries and around 55% in OECD and non OECD Asia (Figure 3.3, left). The EU, not since recently an official target of energy efficiency improvement of 1% p.a. between 2008 and 2016 (9% cumulated in 2016) and 20% by 202047. These programmes are either purely devoted to

Figure 3.3: Countries with quantitative target and mode of expression of the targets[45]
Pays avec des objectifs quantifiés et mode d'expression des objectifs



Source: WEC/ADEME Survey

[45] Quantitative targets in their national energy efficiency programmes. Based on the sample of countries surveyed; Mexico included in America/Asia OECD; Russia and Turkey included in Europe. The new EU target of 1%/year of the Energy Service Directive to be achieved by EU countries is generally not reflected in the survey, as the Directive started to be implemented in 2007.

[46] The same also applies to programmes of CO_2 emission abatement with targets of CO_2 savings that exist in most Annex 1 countries (see Annex 2).

[47] This target is included in a new EU Directive, known as the Energy Service Directive. In addition, a target of

energy efficiency or combined with programmes for greenhouse gas reduction or promotion of renewables (in most EU countries)48. In some countries, such as Brazil, Colombia, India, the Philippines and Peru, an energy efficiency law has been adopted only recently (since 2000). Such laws and programmes ensure a certain continuity of public efforts and a better co-ordination of the various actions and measures.

The targets are expressed in different ways depending on the country. The target may refer first of all to a rate of energy savings or efficiency improvement, which is the most popular target used in about 30 countries (**Figure 3.3,** right). This is the case of all EU countries with the Energy Service Directive49, New Zealand, Japan, and Vietnam. In some countries, such targets only apply to a specific sector (e.g. buildings in Sweden, households in UK, or the energy sector in Mongolia).

The second type of targets considered by some countries is to achieve a specified energy saving (in GWh or Mtoe). This is the case of Spain, France, Italy, UK, Norway, Iran, Sri Lanka, Philippines, Thailand, Algeria, Morocco, and Tunisia.

In other countries, the objective is to achieve a specified rate of decrease of the energy intensity (usually in %/year or as a percentage over a period). France, Germany, Bulgaria, The Czech Republic, Hungary, Russia, China, Taiwan China and Tunisia are examples of countries with a target on the energy intensity.

Some countries have chosen to achieve a rate of reduction in the energy consumption (%) (e.g. Finland, Switzerland, Korea). Finally, and this is more recent, the target is to lower the value of the energy consumption elasticity to the GDP50 to a target value (e.g. Estonia, Thailand, Indonesia). Some countries have even set up different targets (e.g. France, Spain).

3.3 Regulations

Regulation is usually introduced when it is recognised that market failures would not allow economic instruments alone to reach the objective of the energy or environmental policy. In general, regulations impose minimum efficiency standards by law and/or governmental decree, or introduce energy efficient practices (technical and behavioural/managerial), as well as providing systematic information to consumers (e.g. energy audits, labels).

Regulations can be set at the national level, at the level of a group of countries (e.g. the case of Directives in the EU), or at the level of a sub-national region inside a federal country (e.g. US). There are also other regulations which are not specifically targeted at energy efficiency, but which can nonetheless influence (e.g. speed limits, maximum weight of trucks).

3.3.1 Regulations for Buildings

Most European countries have set up mandatory energy efficiency standards for new dwellings and service sector buildings. A new Directive on the energy performance of buildings introduce now in all EU countries harmonised standards for new buildings and make mandatory buildings certificates for the sale or rent of dwellings51.

In half of the other OECD countries in Asia and America, there are mandatory and in the other half voluntary standards (**Figure 3.4**). Some non-OECD

20% energy savings by 2020 is included in the Energy Efficiency Action Plan presented in 2007.

[48] See Annex 2 for the content and target of the programmes by country.

[49] The Netherlands, Slovenia and Spain had their own energy saving target before the Directive.

[50] This elasticity measures the relative variation of the energy consumption growth and the economic growth; an elasticity of 1 means that the energy consumption will grow at the same pace as the GDP. This type of target is equivalent to a target on the energy intensity but may be easier to communicate.

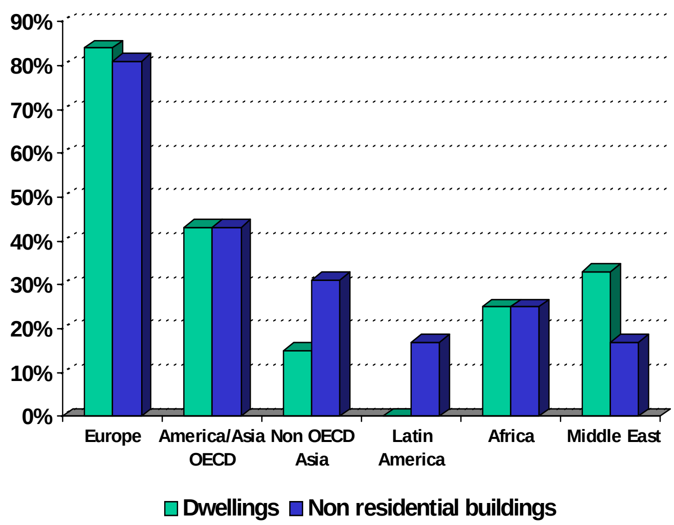
[51] Building certificates enable the buyer to access information on the energy consumption of the dwelling he is going to buy or to rent. These certificates have some similarities with the labelling of electrical appliances, but are more complex.

countries outside Europe have recently established mandatory or voluntary standards for service buildings: Singapore and the Philippines were among the first, followed by Algeria, Malaysia, Egypt and Syria for instance. In most countries, standards exist for both dwellings and service sector buildings, except in Africa and in Asia where most often standards only apply to non-residential buildings52.

The situation in these two regions is explained by the fact that commercial buildings account for the largest share of energy consumption. Altogether, about 50% of the countries surveyed had mandatory or voluntary standards for new non-residential buildings.

Thermal building codes have been changing over time from simple standards on building components to more complex standards, including for the most advanced countries energy performance standard53. These performance standards consider the whole building as a system and also include building equipment such as heating and air conditioning systems, ventilation, water heaters, and in some countries even pumps and elevators (maximum energy consumption per m3 or m2/year). Most building codes now are performance based (e.g. present standards in California, Germany and France, or the EU building Directive). These types of standards can be implemented jointly with standards on specific equipment or materials (insulation, windows, boilers), in order to ensure the use of the most efficient equipment in the retrofitting of existing buildings (e.g. France).

Figure 3.4: Countries with efficiency standards on new buildings
Pays ayant des normes sur les bâtiments neufs



Source: WEC/ADEME Survey

[52] There are of course some exceptions, such as China, Egypt and Algeria, which have also implemented standards for dwellings.

[53] Building standards can be basically classified in four categories (see 2001 WEC report on energy efficiency): i) maximum heat transfer through individual building components (e.g. walls, roof, windows) (k or U values in terms of W/m^2K); ii) limit on the overall heat transfer through the building envelope; iii) limitation of heating/cooling demand (taking into account the contribution from ventilation losses, passive solar gains

Revisions in thermal building codes have become increasingly regular. For instance, over the past 30 years, standards have been reinforced three or four times in most EU-15 countries, including some very recent revisions, and independent from the oil price level. The effort is not finished yet, as most EU countries have improved their standards since the year 2000. In addition, the new EU building directive has for the first time provided for a mandatory revision every five years.

The cumulative energy savings achieved for new dwellings, compared to dwellings built before the first oil shock, is about 60% on average in the EU[54]. The additional savings that are targeted with future revisions in the standards are also impressive, at 20-30%.

Relatively few countries have carried out evaluations of their building codes. According to the few studies available, it seems that the actual energy performance of new buildings is below what could be expected from the building regulations. This can be explained by behavioural factors (such as higher indoor temperatures, more rooms heated, or longer heating period over the year) and by a non-compliance with the building regulation[55].

Only a few countries have estimated the additional costs that each round of new building codes has caused. Nevertheless, from the few results available, the additional costs are limited to a few percentage points, if any at all.

Measures on buildings focused so far on new buildings. As new buildings represent a small share of the existing stock[56], building standards can only have a slow impact on the short term, which however becomes significant in the long-term. A more recent trend is to extend regulations to existing buildings and impose the introduction of energy efficiency certificates for existing buildings; each time there is a change of tenant or a sale. Such a measure was introduced in Denmark some years ago (1999) and extended recently to all EU countries with the Directive on Buildings (generally in 2006 or 2007). These certificates enable the buyer to obtain information about the energy consumption of the dwelling they are going to buy or rent.

3.3.2 Labelling and Efficiency Standards for Household Electrical Appliances57

To slow down or even reverse the trend in the electricity consumption of households, many countries have introduced labelling programmes and minimum energy performance standards for a selection of electrical appliances. Most countries first focused on refrigerators, along with air conditioners in certain countries, since they account for a large part of the household electricity consumption (in Europe, 20-30% depending on the country). Now these measures cover a greater number of equipment: lighting, washing machines, dryers, dishwashers and water heaters.

Labelling programmes are designed to provide consumers with information, which enables them to compare the energy efficiency of the different appliances on sale. They aim at modifying the selection criteria of consumers by drawing their attention to the energy consumption of household appliances. Labelling programmes however cannot sufficiently transform the market and are usually completed by minimum performance standards in the great majority of countries.

The aim of performance standards is to improve the energy efficiency of new appliances either by imposing a minimum energy efficiency rating to remove the least efficient products from the market, Minimum Energy Performance Standards (MEPS), or by requiring sales-weighted average energy efficiency improvements as "target values" e.g. "Top Runner Programme” in Japan. Target values are more flexible as they allow the sale of less

and internal heat sources) (maximum demand per m3 or m2); iv) energy performance standards

[54] Source Odyssee project www.odyssee-indicators.org

[55] According to a survey in Germany, energy savings achieved in recent dwellings are only 35% compared to dwellings built before the first regulations, whereas they should be 70% according to the building standards.

[56] Around 1% in industrialised countries, more in emerging countries.

[57] This section is based on a case study prepared for the project by P Menanteau from IEPE for the 2004 report.

efficient equipment provided other models with a higher efficiency rating are also offered for sale.

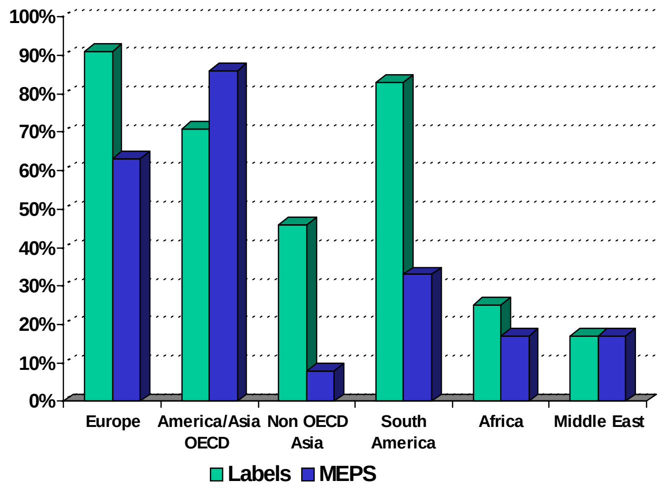
As an alternative to the regulatory process, make use of agreements with appliance manufacturers (voluntary or negotiated), which also improve the energy efficiency of appliances (e.g. agreements with CECED for washing machines in the EU58). Some countries even moved from unsuccessful voluntary agreements to MEPS (e.g. Brazil). Voluntary agreements can be an effective alternative to minimum energy efficiency standards.

Since they have the support of manufacturers, they can be implemented more rapidly than regulations.

Standards are necessary to remove certain inefficient but inexpensive products from the market, which labelling programmes alone cannot do. They are also needed in areas where the selection criteria of consumers totally exclude energy efficiency (television sets for example), or when the economic stakes for the consumer are very limited. Basically, labelling stimulates technological innovation and the introduction of new more efficient products, while standards effect the gradual removal from the market of the least energy efficient appliances.

Mandatory labelling for several electrical appliances exists in all EU countries based on the

Figure 3.5 : Use of labels and standards for refrigerators[60]



Source: WEC Survey

Nevertheless, their effectiveness is still dependent on the precise requirements corresponding to genuine additional efforts from industry59.

same regulations (EU Directives). They include refrigerators and freezers, washing machines, dishwashers and lamps. In OECD Asia and America, about 70% of the countries studied have implemented labels for refrigerators (**Figure 3.5**). In Africa, the Middle East and non-OECD Asia, labels are not widespread: they exist for refrigerators in less than 20% of the surveyed countries. Unlike Europe, labels are not always mandatory; however, regulations have proven more effective since they require manufacturers to put labels on all appliances and not just on the most energy efficient ones. Depending on climatic conditions, labelling programmes also concern air conditioners, which are often among the first appliances to be labelled. In most developing countries, second hand

[58] Commitment by CECED (European Committee of Domestic Equipment Manufacturers) to reduce by 20% the average consumption of washing machine over 1994-2000 (from 0.30 to 0.24 kWh/kg). Similar agreements have since been signed in the EU for dishwashers, electric water heaters, TVs and VCRs in standby mode.

[59] For more information on voluntary agreement, see the 2004 WEC report on energy efficiency.

[60] Percentage of countries with labels or MEPS (Mandatory Energy Performance Standards).

appliances account for a large market share of the appliances sold, which reduces the impact of labelling normally restricted to new appliances.

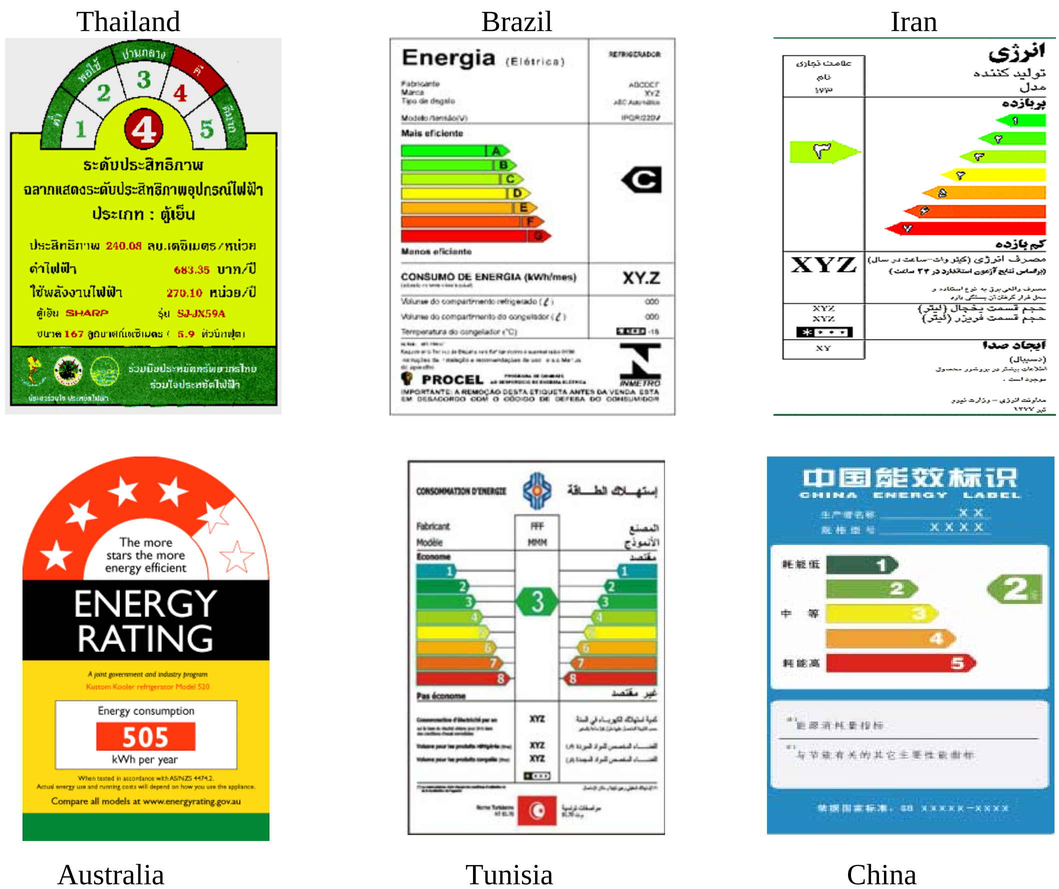
In Europe, about 60% of the countries have standards for refrigerators61, which is about the same order of magnitude as in Asia. In OECD America and Asia, a higher proportion of the countries surveyed have such standards (over 80%); in addition, MEPS are imposed on a larger number of appliances (about 12 different types of appliances on average and up to 30 in Canada)62.

Labelling programmes introduced in developing countries are based on the experience of OECD countries and use models that have already been proven: the European label has been used as a model in Brazil, Tunisia, China and Iran, while labels introduced in Thailand and Korea are based on the Australian model **(Figure 3.6**).

Labelling programmes and performance standards are effective instruments, which enable authorities to benefit from low-cost energy savings, consumers to spend less on electricity, and manufacturers to improve their products and become more competitive against imported, less efficient products. As shown by various studies, the increased use of more efficient appliances did not result in a price increase for the consumers, as producers were able to adapt and to benefit from the increased sales (“learning effect”).

In Europe, about 60% of the countries have

Figure 3.6: Examples of energy labels



61 A EU directive defined mandatory energy efficiency standards since 1999 for refrigerators and freezers.

62 See Annex 2

standards for refrigerators[63], which is about the same order of magnitude as in Asia. In OECD America and Asia, a higher proportion of the countries surveyed have such standards (over 80%); in addition, MEPS are imposed on a larger number of appliances (about 12 different types of appliances on average and up to 30 in Canada)[64].

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The European and Australian programmes are considered successful. In the EU for instance, there was a rapid increase in the market share of the most energy efficient appliances. Sales of refrigerators in Class A increased from less than 5% of total sales in 1995 to 23 % in 2000 and 61% in 2005; in addition, 19% of refrigerators sold in 2005 were in the two new more efficient classes (A+ and A++). For washing machines, the progress was even more rapid (1% in 1996, 38% in 2000 and 90% in 2005). Labelling has resulted in market transformation that can be attributed both to the increased interest of consumers in energy efficiency and to changes in the models made available by manufacturers, as well as to other accompanying measures (rebates, information campaigns[65]). The effect of labelling was reinforced by the progressive introduction of MEPS for refrigerators and by the agreement with CECED for washing machines. In anticipation of standards, manufacturers withdrew their less efficient models that had become hard to sell and introduced new more efficient designs to meet new demand and to differentiate themselves from their competitors. The average energy consumption of refrigerators fell from 370 kWh/year in 1990 to around 300 kWh/yr.[66]

In the US, minimum performance standards for the energy efficiency of household appliances also had a large impact[67]. For instance, the average consumption for cold appliances has decreased from 1726 kWh/year in 1972 to 490 kWh today, although this decline has not followed a steady curve. The periods during which energy efficiency ratings improved correspond most to periods when new or reinforced standards were introduced while little or no improvement was observed for the periods in between.

To be effective, labelling programmes and performance standards must be open-ended, i.e. regularly revised and upgraded. In the US, changes in the energy efficiency of cold appliances clearly show that energy efficiency improves as a result of new standards but then stabilizes. Faced with new standards, manufacturers adapt the appliances available so that they meet the new minimum requirements, but there are no incentives for them to go beyond what is required if no stricter standards have been planned for the future. For these types of programme, where labels play a secondary role, it is essential to reinforce standards at regular intervals as a way of stimulating technical progress and ensuring a steady improvement in energy efficiency.

In the case of the European and Australian programmes, the balance between energy labels and standards has played a vital role. The requirements are not as strict as they are in the US, but labelling acts as an incentive for manufacturers to differentiate themselves from their competitors and stimulates the introduction of new, more efficient models. However, there is no longer any incentive to innovate when all the models are in the best efficiency classes (Australian experience) or when most of the models on the market have been endorsed with a label (Energy Star programme in the US).

[63] A EU directive defined mandatory energy efficiency standards since 1999 for refrigerators and freezers.
[64] See Annex 2
[65] The different penetration of level A appliances in the EU is to a large extent due to the existence of accompanying measures, with the Netherlands recording a penetration much higher than the EU average.
[66] Source Odyssee project www.odyssee-indicators.org
[67] The progress is more spectacular than in Europe, since appliances were less efficient at the outset and regulations older.

In this respect, the "Top Runner" programme has the particular advantage of making the definition of new targets easier. As the most efficient appliances on the market at a given time are used to set the future standards, there is no need for extensive market or techno-economic analysis to set the minimum energy efficiency standards. With this type of approach, the preparatory work can be shortened and the negotiations between manufacturers and public authorities facilitated as the target corresponds to existing appliances that are already available on the market. Presently, the Top-Runner programme covers 18 energy intensive products, including main household appliances and passenger cars. The savings achieved are impressive: for instance 68% for air conditioners, 55% for refrigerators (between 1997 and 2003), and 26% for TV.

Generally speaking, manufacturers are opposed to anything that can disrupt market operation, which means efficiency standards in particular, but also labelling systems in certain contexts. Among the arguments frequently advanced by manufacturers is the risk of higher production costs in a context where the possibilities of increasing prices are limited by fierce competition, innovation focused on areas of little importance to consumers, and a less diverse range of products.

Experience has shown that such fears are largely unfounded: the turnover and profit levels of manufacturers are not adversely affected by the introduction of standards, nor do the standards compel them to eliminate certain functions to reduce energy consumption. The process of negotiating the introduction of new standards or reinforcing existing ones remains nevertheless conflicting and uncertain.

3.3.3 Other regulations

Other regulations implemented in some countries are mandatory energy consumption reporting, mandatory energy managers, mandatory energy saving plans, mandatory maintenance and obligation of energy savings imposed on utilities. Mandatory audits in industry, as well as energy savings obligations are analysed in detail in another section of the report. Other regulations, not directly linked to energy efficiency, but having significant impact on the energy use (e.g. speed limit), are not included in this review.

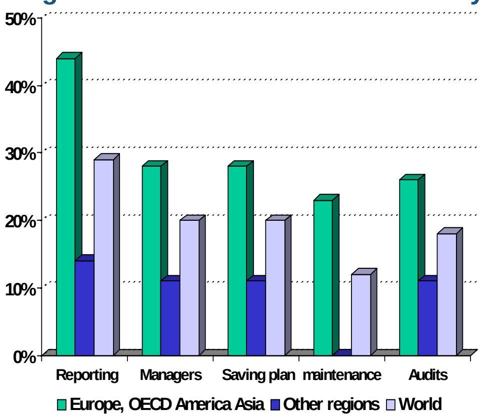
Energy consumption reporting

Some countries have set up regulations requiring designated or large consumers to report their energy consumption, either directly to the government or in their annual report. This measure is seen as an incentive to companies to monitor closely their energy performance.

Such measures exist in about 30% of the surveyed countries and are more frequent in OECD countries than in the other regions (**Figure 3.7**).

More recently, these measures have also been extended to CO_2 emissions68.

Figure 3.7 Countries with various types of regulations



Source: WEC/ADEME Survey

[68] In the EU, this measure is part of the Emission Trading Directive that sets a quota of emissions to large consumers and impose to participants to report their emissions to the European Commission,

In India, for example, companies in selected energy intensive sectors in their annual reports to company shareholders provide data on their overall consumption and on the specific energy consumption of manufactured products (e.g. cement, pulp, sugar). They also have to provide information on energy saving actions undertaken over the previous year. In some countries, this measure also applies to the building of large public enterprises (e.g. Switzerland).

Mandatory energy managers

In some countries, there is a regulation requiring the nomination of an energy manager in companies above a certain size. This concerns about 20% of the countries covered by the survey (**Figure 3.7**). This measure usually applies to large consumers in industry (13 countries) and in the service sector (8 countries) (e.g. in Denmark for the public sector). In some countries, transport companies are also included (e.g. Italy, Portugal, Romania).

Mandatory energy saving or DSM plans

Around 20% of the surveyed countries have set up regulations on the preparation of energy savings plans for consumers, generally in industry (30% in OECD and 10% for non-OECD countries). This measure exists for several sectors, including municipalities in some countries (e.g. Portugal, Italy, Poland, Romania, Russia, Japan, Korea, Thailand, Turkey, Algeria, Tunisia, and Iran69).

Maintenance

Maintenance of energy-consuming equipment is another important field of regulation. The major concern is that without proper maintenance of energy consuming equipment (e.g. boilers, vehicles), efficiency will decrease over time: the objective of any regulation is to maintain the initial efficiency of the equipment for as long as possible.

This measure on appliances is mainly in Europe. With the new Directive on buildings, the maintenance of heating boilers will become now mandatory in all EU countries. This measure already existed in Denmark, Italy and Germany. In a few countries (Italy, Romania), regulations on maintenance exist for the transport sector.

The mandatory MOT for cars that exist in many countries may to some extent contribute to saving energy, depending on the aspects to be controlled.

3.4 Financial Incentives

Financial instruments include economic incentives to promote energy efficiency (e.g. subsidies for energy audits or investment, soft loans), as well as fiscal measures. Financial incentives aimed at encouraging investment in energy efficient equipment and processes by reducing the investment cost, either directly (economic incentives) or indirectly (fiscal incentives).

3.4.1 Economic Incentives

Economic incentives fall into two broad categories: investment subsidies and soft loans. In about one fourth of the surveyed countries, the economic incentives are related to energy or environment funds with financing mechanisms that tend to depend increasingly upon the banking system rather than coming from the public budget.

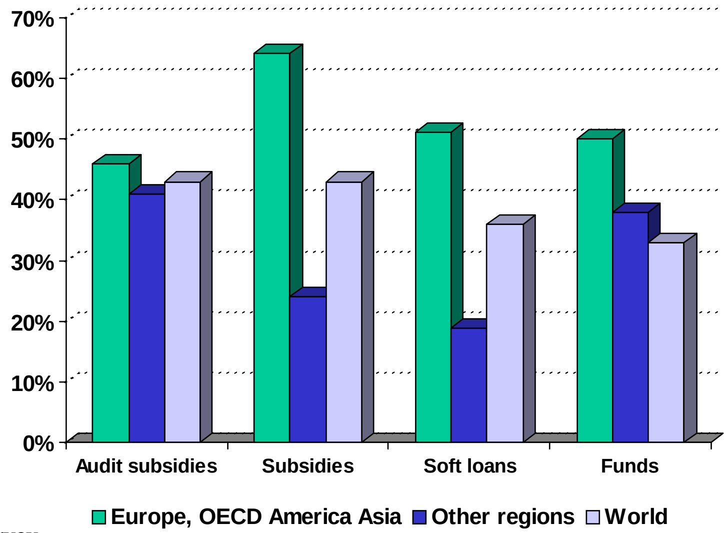
Investment subsidies

Investment subsidies to consumers were among the first measures to be implemented in the 1970s and early 1980s. Most countries developed various ambitious schemes, mainly to retrofit existing buildings or dwellings, as well as industrial equipment. The objective was to reduce the investment cost for consumers. In principle, these incentives apply to actions that are cost effective from the collective point of view, but which would not otherwise be undertaken by consumers. Subsidies can be defined as a fixed amount, as a percentage of the investment (up to a limit), or as a sum proportional to the amount of energy saved. Subsidies may also be given to equipment producers to encourage the development and marketing of energy efficient equipment.

In the surveyed countries, investment subsidies were mostly used in OECD countries: two third of surveyed countries have subsidy schemes, against one fourth of the countries for the other regions.

[69] See Annex 2

Figure 3.8: Countries with economic incentives



Source: WEC/ADEME Survey

Industry is the main sector receiving subsidies (about 30% of all countries, 50% European), closely followed by households (about 25% of all countries, 50% in Europe) (**Figure 3.8**).

Ex-post evaluation of grant schemes showed several drawbacks:

- Subsidies schemes often attracted consumers who would have carried out the investments even without the incentive, the so-called "free riders" (e.g. high income households or energy intensive industries).
- Consumers who could use the subsidies and were targets of the scheme (small to medium industries and low-income households) did not take advantage of them because they were unaware of their existence. This demonstrates the challenges of informing a multitude of consumers adequately about the existence of the incentives.
- Procedures for grants applications were often found to be too bureaucratic (complex forms to be completed and long delays in obtaining the agreement) and costly (high transaction costs), especially in comparison to fiscal incentives (staff to process the forms).
- Finally, subsidy schemes may have a negative impact on the market by leading to an increase in the cost of equipment and to the deployment of equipment with a poor quality[70].

These drawbacks did not prevent the use of subsidies, but led to their more careful use, taking into account their real effectiveness. Grants are now better targeted to limit the number of beneficiaries (e.g. low income households[71], tenants). They are also restricted to certain types of investments (from a selected list of equipment), with a long payback time but high efficiency gains (e.g. renewables, co-generation), or to innovative technologies (demonstration or further investment). The approach used in Thailand is innovative, as the selection is not based on a list of equipment but on a criterion of cost-effectiveness (grants apply to investments that have an internal rate of return above 9%). Subsidies are increasingly viewed as a temporary measure to mobilise consumers, to prepare for new regulations, or to promote energy efficient technologies by creating a larger market than would otherwise exist, with the objective of a cost reduction for the subsidised energy efficient technologies.

Subsidies are generally given to consumers to lower the purchase cost of energy efficient

[70] This is illustrated below in the case study on solar water heaters.
[71] UK has had for several years a very strong programme targeted towards low-income households.

equipment. Subsidies can also be given to producers to improve the quality and the cost of production. In some cases, the producer approach can lead to better results.

Soft loans

Soft loans are loans offered at subsidised interest rates (i.e. lower than the market rate) to consumers who invest in energy efficient technologies and equipment. Soft loans have the advantage of being easily implemented by banking institutions. Nevertheless, due to the current low level of interest rates, such measures are often not attractive to industrial companies.

Soft loans are less popular than subsidies as shown by the survey (**Figure 3.8**). Slightly less than 40% of all surveyed countries had such schemes (about 60% of them in Europe and 75% in OECD), where soft loans are almost equally used in industry, services and for households, whereas in non-OECD, industry is the main sector targeted.

Soft loan schemes are usually targeted at consumers. In some cased they are given directly to installers, which seem to be a promising approach in others, if well managed. This removes one important barrier, which is the access of consumers to information as the installers may have a commercial approach to promote energy efficiency.

3.4.2 Fiscal Incentives

Fiscal incentives include measures to reduce the tax paid by consumers who invest in energy efficiency. They comprise accelerated depreciation (industry, commercial sector), tax credits and tax deductions (households).

More recently, tax reductions on energy efficient equipment (on VAT or on import duties) or on energy efficiency investments (reduction in VAT rate) have been introduced in many countries.

Tax credits and accelerated depreciation are considered better than subsidies, as they are less costly. They can work well if the tax collection rate is sufficiently high. They usually have a poor performance in an economy in recession or in transition. They are more adapted to developed countries: tax credits exist in almost 40% of OECD countries (30% in Europe and 70% in OECD countries in America and Asia) (**Figure 3.9**).

Reductions on import tax or VAT on efficient equipment have been introduced in many countries and almost equally in all regions: they exist in about 30% of the surveyed countries[72]. The compact fluorescent lamp is the most common equipment to which this measure applies outside the OECD (e.g. Ghana, Morocco, Israel), followed by electric motors.

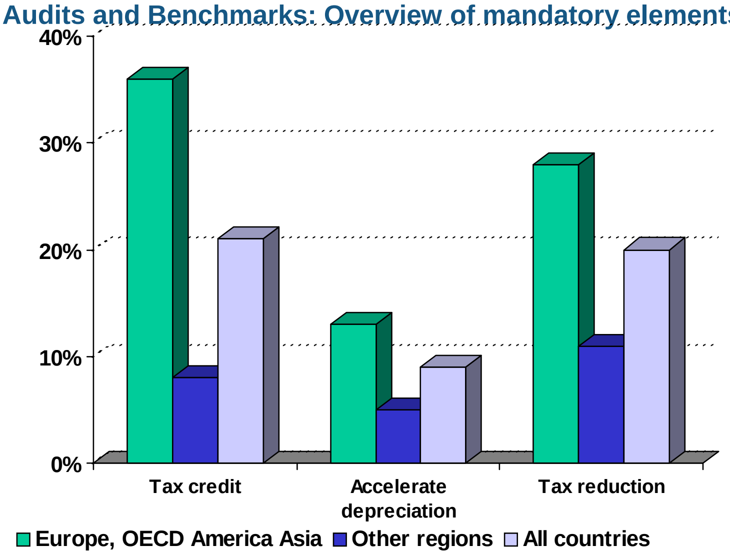
In European countries, tax reduction also exits for clean and efficient cars. VAT concessions also exist on labour costs to reduce the investment cost in building renovation (e.g. France, Sweden, Switzerland).

Tax concessions for companies that make concrete commitments to energy efficiency gains/ CO_2 reduction and meet their target are also another innovative way to promote investment in energy efficiency and CO_2 reduction (e.g. Denmark or UK).

[72] Further detail can be found in Annex 2

Figure 3.9: Countries with fiscal incentives

Table 3.1: Audits and Benchmarks: Overview of mandatory elements by sector



Source: WEC Survey

3.5 Mandatory energy audits[73]

Energy audits, either walk-through[74] or detailed energy audits, are essential for all sectors of the economy (including residential/tertiary sector buildings as well as industrial sector and transport companies) to promote a better understanding of the current status of end-use energy efficiency. The audits, which are usually coordinated by engineering or facility departments, will not only create awareness among those who are functionally involved in the management of energy but also justify the necessity for the implementation of energy efficiency activities. Detailed audits are required to verify the identified opportunities.

Energy audits exist in a mandatory form in all sectors, although much less frequently than audits on a voluntary basis (except in the building sector where mandatory audits are more often used). Although this chapter includes mandatory audits for the building sector, the main focus will be on the industrial sector and to a smaller degree on the transport sector because in these sectors mandatory audits are less common.

The evaluation of mandatory energy audits covers the following issues and questions:

- Are all sectors (industrial consumers, tertiary sector, transport sector, residential energy consumers) equally concerned by mandatory instruments and what are typical mandatory elements?
- Why is there a mandatory instrument chosen rather than a voluntary one? What the specific advantages of this approach may be?
- How is the instrument implemented in the different countries and what is the result from ex-post or ex-ante evaluations?
- What supporting measures are taken for mandatory energy audits and what is the interaction with other policy instruments of the sector (package of measures)?

3.5.1 Sector coverage and mandatory elements

Mandatory requirements for energy audits range from an obligation to carry out audits if a threshold of energy consumption is passed, to mandatory reporting, mandatory implementation of certain types of measures, to mandatory standards, including these industrial processes which need to be reached (**Table 3.1**). All of these elements have been implemented fairly often. Mandatory standards for industrial processes are, however, not implemented frequently and relatively new (except for industrial cross-cutting technologies such as industrial steam boilers or electric motors).

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[73] The following section is adapted from a general review of mandatory audits prepared by Wolfgang Eichhammer from Fraunhofer-ISI; it includes in Annex 1 five country studies (Algeria, Australia, Bulgaria, India and Taiwan). The full case study, with all the literature references used, is available at http://www.worldenergy.org/

[74] A walk-through audit is a basic and cost-effective exercise to identify opportunities for energy cost saving.

Sector	Possible mandatory elements
Residential/ Tertiary Sector	Obligation to carry out audits at regular intervals (generally buildings above a certain living space/working area) or when sold or rented out Obligation to carry out audits to obtain a building certificate (e.g. Green Buildings-Label of the EU) Obligation to inform about the outcome of audits (e.g. building certificates)
Industry	Obligation to carry out audits at regular intervals (generally companies above certain threshold of energy consumption) Reporting obligations to governmental organisations and communication of audit results to the public (energy consumption reporting, reporting on saving measures, reporting on implemented measures) Obligation to propose action plans to implement the energy savings measures identified in audits Obligation to carry out certain types of measures Obligation to appoint an energy manager Mandatory certification of auditors Mandatory comparison to reference values (benchmarking)
Transport	Mandatory obligation to audit vehicle fleets

The mandatory elements mentioned in this section will be reviewed further when describing the audits in the different countries[75].

3.5.2 Advantage/disadvantage of mandatory audits/benchmarks

One important question to be raised about mandatory audits why is a mandatory instrument preferable to a voluntary one? What are the specific advantages of the mandatory approach?

Advantages of mandatory energy audits are numerous. It is possible to reach right from the beginning a substantial number of consumers, thereby achieving a major reduction in energy consumption in a relatively short period of time. In addition, such an instrument can be used to react rapidly in a case of urgency such as shortfall in energy supply (e.g. case in India), negative impacts of high energy prices on the economy etc.

Disadvantages of mandatory audits include consumers' perceptions of the mandatory nature of instruments as an administrative burden rather than a process helping them to reduce their costs or to become more competitive. They will intend not to comply with the regulation, or worse, they will comply formally but will not integrate the basic idea of energy audits in the company culture. Finally, in case the audits are coupled with mandatory benchmarks, compliance becomes difficult to prove, given the complexity of industrial processes.

Given these different aspects, it is difficult to judge on theoretical grounds whether the regulatory nature of the instrument improves or hampers efficiency. Much depends, the same as for voluntary audits, on the implementation, and in particular also on accompanying measures such as the qualification of the auditors. Naturally, this is also an issue for voluntary energy audits but the requirements are more important, when suddenly a larger number of companies have to be audited.

3.5.3 Impact evaluations available for selected cases

Mandatory audits in nine countries are characterised according to the following elements (**Table 3.2**):

[75] There may often be specific mandatory features linked to a given technology. For example in Taiwan, an energy user with central air-conditioning system should have an independent electric meter and circuit for this system, provided the capacity of the refrigerating unit exceeds the level set up by the central authority.

- Implementation date
- Sectors concerned by the legislation
- Main mandatory features
- Threshold for mandatory participation
- Period for a renewal of the audits
- Sanctions for non-compliance
- Availability of subsidies for saving measures
- Establishment of a central database
- Quality control of reports
- Information about the impacts of the audits

Most countries have implemented audits only recently, which confirms that a number of countries consider this instrument as new. A strong increase in energy prices over the last years has possibly triggered this but there are others reasons. The economic boom in large developing countries such as India or China is hampered by the shortfall of energy supply.

Frequently, legislation for mandatory audits covers all sectors, including transport, although there are also examples where only commercial entities from industry and the tertiary sector are subject to audits.

There is a wide variety of mandatory features reaching from the soft approach in Australia, which aims at business culture changes, to strong regulatory approaches in Taiwan, India or Bulgaria, which include mandatory standards for industrial processes. Energy-use benchmarking – comparing the specific energy consumption (SEC) of a particular sector or sub sector with its rivals in the country or at international level – is also used quite frequently.

The threshold for participation covers ranges from 260toe (3,000MWh) in Bulgaria to 30,000toe in India which reflects to a certain extent the size of the companies in a country. The thresholds also differentiate frequently between sectors or energy carriers. In the case of the Czech Republic, there is a much lower threshold for government facilities, for example.

The typical period for renewal of the audits is 3-5 years, but there are also cases of shorter periods (1-2 years in Romania) or the Czech Republic, where the audit requirement is a one-time obligation.

Sanctions for non-compliance, often fines, are foreseen in most cases. In Taiwan on the other hand, a restriction or suspension of energy supply can be among the sanctions. However, there is no evidence so far that such sanctions are applied. In general, a consensus-oriented approach is preferred.

Despite the mandatory character of the instrument, quite frequently, the measures found in the audits, or even the mandatory audits themselves are financially supported in order to enhance compliance. Often, a central body such as an energy agency collects the information on the audits in databases. The intention is to use this information for evaluation purposes to generate benchmarks and feedback to the participating companies

In most cases, there is quality control of the reports, or even of the audits themselves through control by a central body in charge of managing the audits.

In many countries, investigated mandatory audits are fairly new, the knowledge about their impacts is still fairly limited. From the information obtained so far it can be concluded that energy audits and the implementation of subsequent measures lead to savings of 5-10% for the participating companies. Equally important is the cultural change that mandatory audits can also initiate in companies by making energy efficiency a regular goal at all levels of the company. Experiences in Australia show that an "external view", implemented by an energy auditor on energy use in a company, often also brings additional value.

Although the country case studies have also been chosen to ensure a certain geographical coverage, the spread of this instrument is rather heterogeneous. While it receives strong interest in Asian and Eastern European countries, as well as in Northern Africa, it is absent from OECD countries, with the notable exception of Australia and OECD countries in Latin America and Sub-Saharan Africa. However, countries that have no mandatory requirements for audits place stronger emphasis on voluntary or negotiated agreements76. This is mainly valid for the industrial sector. Larger residential or tertiary sector buildings are in these countries also subject to mandatory audits, for example in the frame of building certification in Europe (EPBD, 2002). The larger spread of mandatory approaches in Asian and Eastern European countries may be explained by a more hierarchical society where regulation is accepted easier, or by the fact that command and control instruments were more familiar to the former planned economies. However, these cultural factors are not enough to explain all of the renewed interest in this instrument. The pressure from the energy sources or stronger concerns about climate change also justify the introduction of mandatory instruments. Germany, for example, in its recent climate change plan envisages to couple, starting from 2013, energy audits for industrial companies with reductions in energy and electricity taxes (BMU, 2007). The audits have in this case not a mandatory character but there is a strong incentive to introduce them.

3.5.4 Supporting measures and interaction with other policy instruments

Energy audits in general are crosscutting measures which in itself do not lead to energy savings. They need to be followed by actions. Mandatory audits are no exception in this. For this reason, the introduction of mandatory audits is generally accompanied by a variety of measures.

The most important accompanying conditions are subsidies for energy efficiency measures recommended by the audits, or the audits themselves (e.g. in Thailand), even if they are mandatory. This is to improve the compliance. One way of providing subsidies for energy efficiency measures are revolving energy efficiency funds[77].

In developing countries, the mobilization of domestic and foreign funds is needed. Some of these international funds can be obtained through the Clean Development Mechanism (CDM), the Global Environment Facility (GEF) and other sources. However, their support for energy efficiency investments in developing countries is still limited. For example CDM projects have mainly been taken up in other fields such as the reduction of methane from waste or the reduction of fluorinated non-CO_2 gases from industrial processes.

Other supporting measures may include fiscal policies to provide incentives: import or sales tax exemptions for energy-efficient equipment and energy efficiency services, accelerated depreciation and the establishment of investment banks lending criteria for promoting energy efficiency. Such policies are effective at removing barriers to energy efficiency by reducing the investment payback periods and minimizing the perceived performance risks. Popular incentives are subsidies for the engagement of energy managers, tax bonuses, soft-loans, grants and credits for energy efficiency investments.

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[76] See case studies on voluntary agreements in 2004 WEC report on Energy Efficiency.

[77] This was introduced for example in Ivory Coast in the World Bank project to realise measures from audits, even if the energy audits are not mandatory in this country (IEFP, 2000). Another example is the ENCON Fund in Thailand (Sources of fund: Initial from Oil Fund ~ 40 million US Dollars); tax from the use of transport fuels is 0.1 cents per litre; Interests. Applications: Grants for R&D, Pilot projects, Training, Higher Education, Soft Loan for Investment/Revolving Fund)

Table 3.2: Main features of mandatory audits in selected countries [78]

	Algeria	Tunisia	Bulgaria	Romania	Czech Republic
Implementation date	2005/6	2004	2004	2000	2004/2005 (large industries)
Sectors concerned	Industry, Tertiary, Transport Companies	Industry, Tertiary, Residential, Transport Companies	Industry, Tertiary, Residential	Industry, Tertiary (public buildings)	Industry, Tertiary
Main mandatory features					
mandatory audit	X	X	X	X	X
mandatory reporting	X	X	X	X	X
mandatory action plan	X	X	X		X
mandatory comparison with other companies (benchmarking)		X	X		
mandatory standards			X		(X) (energy supply)
mandatory implementation of certain type of measures		X (evaluation of previous actions)		X (target control+ sanctions)	(X) (public sector)
mandatory energy manager	X			X	X
mandatory certification of auditors	X	X	X		X
Threshold for mandatory participation	Industry: 2000 toe Tertiary: 500 toe Transport: 1000 toe	Industry: 1000 toe Tertiary/Residential/Transport: 500 toe	Industry: 3000 MWh Tertiary/residential: 1000 m^2	1000 toe	Government. facilities: 1.5 TJ Private companies: 35 TJ
Audit schedules	Industry/Transport.: 3y Tertiary: 5y	5y	Industry: 3y Tertiary/Residential: 5y/10y	Industry: 1y (>1000 toe); 2y (> 200 toe) Tertiary 5y (> 1500 m^2)	One time
Sanctions for non-compliance	X		X	X	X
Subsidies for saving measures	X	X	X		X
Central database	X (Energy Agency APRUE)	X	X (energy agency AEE)	X	
Quality control of reports	X (APRUE)	X	X (control audits)		X (State En. Inspect. SEI)
Impacts	unknown	unknown	30% of company EC (based on 7 companies); expected savings: 50 ktoe in 2010; 134 ktoe in 2016:	unknown	unknown

[78] Annex 1 gives more detailed information for Algeria, Australia, Bulgaria, India and Taiwan.

Table 3.2: Main features of mandatory audits in selected countries (cont'd)

	Australia	India	Taiwan	Thailand
Implementation date	2005/6 (NSW)	2001/2007	2001	1997
Sectors concerned	Industry, Tertiary, Transport Companies	Industry, Tertiary, Transport Companies	Industry	Industry, Tertiary Sector
Main mandatory features				
mandatory audit	X	X	X	X
mandatory reporting	X	X	X	X
mandatory action plan		X	X	X
mandatory comparison with other companies (benchmarking				
Mandatory standards		X	X	
mandatory realisation of certain type of measures	X (NSW: progress report)	X		
mandatory energy manager		X	X	X
mandatory certification of auditors		X	X	X
Threshold for mandatory participation	0.5 PJ	30,000 toe 5 MW electricity connected load	Coal 6000t/y Fuel oil 6000kl/y Gas 10 mill. m^3 Elec. 1000kW Steam 100t/h	Industry: 20 MJ, 1,000 kW
Period for audit	5y	3y	1y	3y
Sanctions for non-compliance	X (NSW)	X	X (financial + suspend supply 7-30 days)	X
Subsidies for saving measures				X
Central database	X	X (Bureau of En. eff. BEE)	X	X
Quality control of reports	X		X	X
Impacts (EC = energy consumption)	Case studies: typically 5% of company EC Extrapolated from 250 obligated companies: 0.7 Mtoe "Culture change"	2001-2004: EC 3% (1-9%); Electricity 2% (0.2-11%) 2001-2004: 2TWh, 750,960t coal, 6.5 bill. Indian Rupees oil/gas	2001-2005: 0.5% annually of company EC 2001-2005: Top 100 + other companies audited about 286 ktoe savings (60% of saving potential, identified in the energy audits)	Electricity (ex-ante): Achievable savings: 5-14% Economic potential 42%

Subsidies that depress the price of energy can provide a significant disincentive for energy efficiency investments. Unfortunately, government controls on fixing energy tariffs and pricing often act as such disincentives, particularly in developing countries. If these government controls were more market-responsive, then a favourable investment climate could be created to the benefit of energy efficiency.

This approach would also strengthen the role of energy services companies (ESCOs) in the realisation of the measures recommended by audits. Taxation of energy may further contribute to internalizing the externalities (such as social cost, opportunity cost and scarcity cost) in the energy price, thus supporting the measures proposed in mandatory audits.

Information benchmarking tools on energy performance indicate the level of efficiency at which the various industrial sectors operate, at which tertiary sector or residential buildings are run, or transport fleets used. Other informational tools include award schemes that accompany the audits.

3.5.5 Observations and conclusions on mandatory audits

Mandatory audits – like voluntary audits - suppose a certain quality of the auditors as well as of the staff responsible for energy management in the companies (energy managers). This can be assured by the certification of the auditors and by the training of energy managers. In reality, however, especially in the early phases, too few qualified staff is available to handle the large number of units to be audited rapidly when the instrument is mandatory.

One possible solution is to include issues around audits in the curricula of the higher education levels to demonstrate that the planned rapid impact of mandatory audits may take time unless the qualification process is run at the same time. If the participation is voluntary the number of auditors will grow more slowly leaving more time for the establishment of qualified auditors.

In addition to the qualification problem, the financial means foreseen may frequently be sufficient for detailed audits, which is an obstacle in industrial companies where the processes are heterogeneous and complex. Careful consideration is essential; the quantity of information from the audits is necessary and relevant79.

Frequently, government agencies are involved in the administration of the process via a central database of the audits (such as the Bureau of Energy Efficiency BEE in India). The main obstacle is the insufficient response of administration to the information collected (feedback on the quality of the reports and on the results to the consumers) due to an understaffing of the involved government bodies or agencies.

In the introduction of mandatory audits, there is a very important "learning by doing" aspect, which deserves a lot of attention. As a consequence, capacity-building process of all participating organisations is a prerequisite for successful mandatory audits.

The main argument for mandatory instruments is that they allow to reach right from the beginning a substantial fraction of consumers (e.g. case of India). However, the mandatory nature of the instruments implies inherently that a variety of consumers are not yet convinced by the benefits and consider the procedure an administrative burden rather than a process that helps them to save costs or to make their company more competitive. This poses particular requirements on the quality of the process to convince the more reluctant participants.

[79] Denmark for example has removed detailed energy audits after some time – considering them too administrative and costly – and replaced by the establishment of simple energy flows. This was done after some time, when energy flows were better known from the detailed audits.

Mandatory energy audits for the building sector, especially in the residential sector, are most widely spread and exist in many countries and regions. Mandatory energy audits in the industrial sector appear to be quite frequently used in Asian countries[80], in Australia, in North African countries (Algeria, Tunisia) and East European countries (Bulgaria, Romania, Czech Republic). Mandatory energy audits in the transport sector are less common and aim at fleet owners (e.g. Tunisia and Algeria). However, even in those countries mandatory audits in the transport sector are at a very early stage.

Non-compliance with the regulation may be sanctioned, although there was no evidence that sanctions were really applied. In general, a co-operative approach was preferred. The implementation of the measures recommended in the audits is most commonly not mandatory; however often they entitle to subsidies.

The implementation of the measures proposed during the audits is another critical point, unless there is a legal requirement to carry out such measures or unless they were convincing enough for the energy users.

Quite frequently, the mandatory audits are therefore accompanied by supporting measures such as subsidies for the audits or for all or certain types of investments[81]; training measures and seminars for the auditors and the staff of companies (both management and technical staff).

Measures to accompany the audits with the development of a market for energy service companies was also considered (e.g. in Taiwan) but not systematically undertaken. In the Ivory Coast, an Energy Efficiency Fund was set up with the aim to support the implementation of the measure proposed by audits (which were however, not mandatory).

[80] India, Taiwan, Thailand with, however notable exceptions such as China or Japan
[81] For instance, measures that are not economic under current conditions but appear as reasonably close.

Energy audits and the realisation of subsequent measures led to savings of 5-10% for the participating companies. Equally important is the cultural change that mandatory audits also try to initiate in companies by making energy efficiency a regular target at all levels of the company. Experiences in Australia show that an "external view" on energy use in a company from an energy auditor often also brings additional value[82].

In summary, there are various approaches also within the instrument of mandatory audits, reaching from the softer, process-based Australian approach to more regulative approaches with stronger requirements also on the results to be achieved such as in India, Taiwan or Bulgaria. Both approaches have attractive features which are not necessarily mutually excluding.

The comprehensive approach of "cultural change" in the attitude of companies towards energy efficiency and energy audits is fully compatible (and necessary) for a more regulatory approach. It may however, depend on the culture of a country the numbers of mandatory elements on audits. In any case, the qualification of auditors, company and government staff as well as a suitable mix of accompanying measures including the development of a market for energy services appears as an important aspect in the realisation of the measures found in the audits.

[82] Australia considers in its Energy Efficiency Opportunities programme the introduction of mandatory audit as a "cultural process" with six key elements for a comprehensive assessment of energy efficiency: leadership; management; quality of data and analysis; skills of a wide range of people; decision making; communicating outcomes.

3.6 ESCOs[83]

3.6.1 The concept of ESCOs

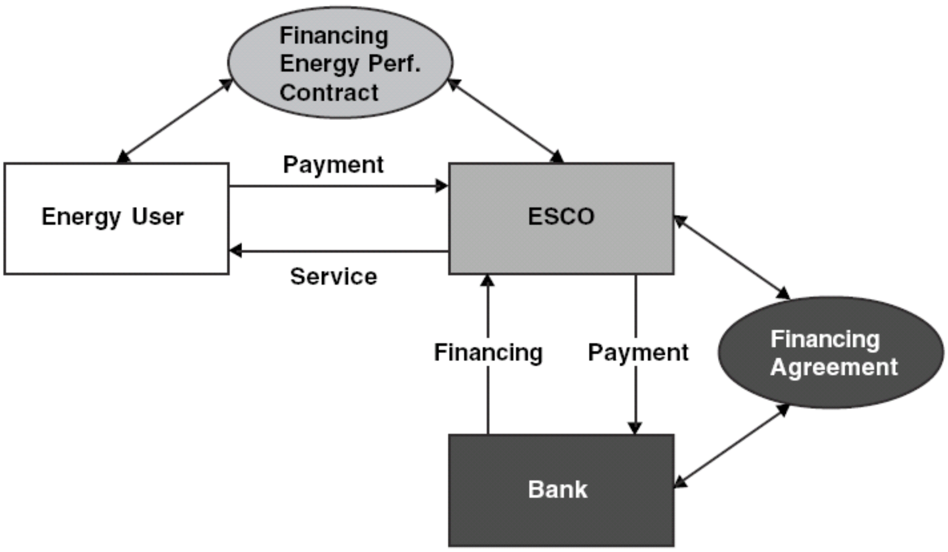
Definition of ESCOs and Energy Performance Contracting

ESCOs, Energy Services Companies offer energy efficiency improvement services including a guarantee of the savings. The remuneration of ESCO is linked to the projects' performance (concept of performance- based contracting)84, which means that the ESCO's payment is directly linked to the amount of energy saved.

While ESCOs are not a policy instrument per se, they are often discussed among policy instruments because they are, similarly to policy tools, important vehicles to capture energy-efficiency potentials and the business model they use, energy performance contracting, helps overcome a number of market barriers.

ESCO's usually offer the following services: development and design of energy efficiency projects; installation and maintenance of energy efficient equipment involved; finally, measurement, monitoring and verification of the project's energy savings. Financing for the investment can either be provided by the ESCO from its internal funds or by the customer, or by a third party funding (TPF), in which a financial institution allows a credit either to the ESCO or directly to its client; the loan is then backed by a guarantee for the projected energy or cost savings given by the ESCO **(Figure 3.10**).

Figure 3.10: Mode of Operation of ESCOs



Source: ECS Third party financing Achieving its Potential (2003)

There are two main models for energy performance contracting: the shared savings model and the guaranteed savings model. Under the first model, the cost savings are shared by the ESCO and the client at a pre-determined percentage for a fixed number of years (**Figure 3.11**). In the guaranteed savings model, the ESCO guarantees a certain level of energy savings to the customer: this model has the advantage that interest rates are usually

[83] The following section is adapted from a general review of ESCOs prepared by the Central European University under the coordination of Diana Ürge-Vorsatz; it includes in Annex 1 six country studies (Germany, Hungary, the United States, India, China and Brazil). The full case study, with all the literature references used, is available at http://www.worldenergy.org/

[84] Referred to as EPC, Energy Performance Contracting

much lower. In contrast, in the shared savings model, the ESCO assumes both the performance and the credit risk.

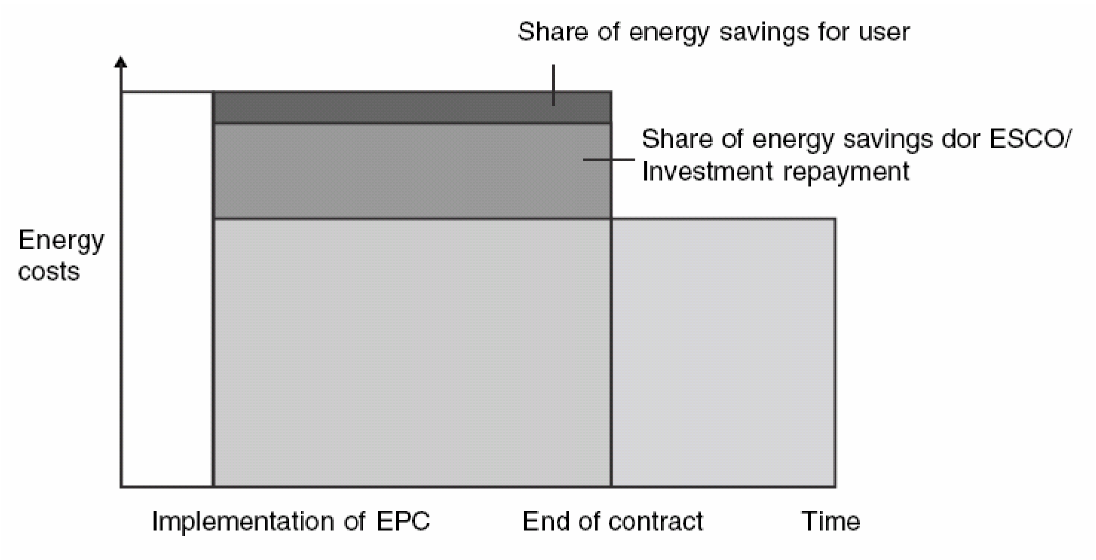
Development and current situation of ESCOs worldwide

ESCOs emerged in the United States in the 1970s, after the first oil crisis. Then, the concept spread to Europe where the ESCO industry has successfully developed in some countries, such as Germany, but not in others. In the 90s, the first ESCOS were created in developing countries. Today, the ESCO concept has spread with varying success to most industrialized countries, to several economies in transition and to the biggest developing countries.

The USA has always been the leading ESCO-country with a total number of about 500-1000 ESCOs today achieving an annual turnover estimated at about 5 billion US$. In the rest of the world, the success of the ESCO-industry varies widely, even within the European Union: Germany, Austria and the United Kingdom are often considered as ESCOs champions, while the Netherlands and Denmark have seen little commercial EPC, due to mandatory DSM programs and strong public involvement in project implementation. By contrast, Hungary is proud to have more ESCOs than some of the old EU-member states. According to an international ESCO-survey in 2001[85], the total value of ESCO-projects outside the United States was highest in Germany with US$150 million, followed by Brazil US$100 million, Japan US$62 million, Canada, China, Poland, Sweden, Australia, Korea and others. ESCO success is not only concentrated in developed countries, but also in some developing countries. In relative terms, the USA has the highest value of ESCO projects per capita (6US$/capita), followed by Sweden (3.3US$), Germany and Switzerland (1,8 US$) and Canada.

ESCOs are active in different sectors depending on the country. In industrialized countries such as the United States and Germany, the public sector is one of the most important ESCO clients and has even often triggered the development of the national ESCO-industry through projects in public buildings as well as through favourable legislation

Figure 3.11: Contracting arrangement for shared savings



Source: ECS 2003

[85] These numbers date back several years and might therefore be outdated in some cases; however, this survey represents the only publicly available international comparative ESCO study. Source: Vine E., 2005.

and financial support. The commercial sector is an emerging ESCO-client, especially in developing countries such as Brazil or India. ESCO-activity in the industrial sector often seems to be higher in developing or transition countries86. The residential sector is the least important for ESCOs in most countries87. This is due to the expected low profits, to legal complications between owner and tenant as well as to other factors such as difficult decision-making due to the often high number of stakeholders.

3.6.2 Barriers to the ESCO development

Some barriers are country-specific, whereas others are common for several or even all countries. Since they differ somewhat in the various sectors, sector-specific barriers will be presented first followed by general barriers.

Barriers to EPC in the public sector

Although the public sector was a trigger for the ESCO market development in many countries and remains one of the most important sectors in the ESCO activities, numerous barriers prevent the implementation of more projects.

In some countries, public authorities are cautious about outsourcing through EPC, because job losses and a loss of control over outsourced systems. Administrative procedures are often burdensome allowing for only large projects. If the energy costs are reduced through EPC the budget will also decrease, so incentives for the public authorities to use less energy are missing[88]. In addition, if the public authority provides the financing for EPC, long-term EPC contracts are considered as a credit, which is a constraint if there are credit limits. In most countries, many municipalities have to pay energy efficiency investments from their investment budget whereas the resulting savings are credited to the operational budget (see Annex 1). This separation of budgets does not allow cost savings to be invested into new energy efficiency improvements.

Energy performance contracting in the public sector almost always requires public procurement and therefore needs to follow public procurement rules, such as a tendering obligation. Unfortunately, public procurement decisions are often focussed on assets rather than energy services and based only on the best price without taking into account the lifecycle costs of new equipment. It is therefore very difficult to consider EPC in public procurement.

An important barrier for EPC, mainly in developing countries, is the inadequate energy service level. If satisfactory comfort standards are not met prior to the intervention (e.g. under-heated or low lighting), this complicates the development of baselines and inevitably results in some savings absorbed to reach acceptable comfort levels.

Barriers to EPC in the industrial sector

In the industrial sector, EPC is much less spread than in the public sector since numerous problems hinder ESCO activities. In many countries, including China and India, big companies that would be the most profitable clients for ESCOs consider that they can implement and finance energy efficiency improvements themselves since they have sufficient funds and technical in-house expertise.

Therefore, they might only need an energy audit. In the United States, numerous companies do not allow ESCOs to check the core industrial processes because of fears about trade secrets and because specialized expertise and interruptions of the production would be necessary to implement changes there. For these reasons, ESCOs concentrate on standard applications such as boilers, pumps etc, in the industrial sector rather than on processes.

One of the major problems for EPC in the industrial sector is that the time spans considered in many companies are shorter than the payback-periods

[86] According to Vine (2005), Bulgaria, Egypt, Kenya, the Philippines, Thailand, and Ukraine targeted at least 70% of their activity in this sector (Vine 2005)

[87] Only ESCOs in 7 countries targeted at least 10% of their activity in this sector, including Nepal (30%) and South Africa (15%

[88] Hungary is an exception as local authorities can keep their operational costs constant if they have a signed contract with an ESCO.

for many ESCO-projects: managers accept payback-periods longer than 3 years only when investments in the production area are concerned, but not for “inputs” such as energy.

In developing countries, many companies prefer to modernize their outdated manufacturing processes rather than invest their small revenues in energy efficiency.

Finally, ESCOs often consider it more risky to invest in the private than in the public sector because industrial sites might be moved to another country or location or the company can go bankrupt before the end of the EPC contract, or change production processes or lines. In addition, in developing countries where the credit system is not well developed, the private sector often involves higher credit risk, which also makes ESCOs more willing to cooperate with the public sector.

Barriers for EPC in the residential sector

The residential sector is the most problematic and the smallest part of ESCO activities. In this sector, the major barriers are the high relative transaction costs, the low level of information and lack of interest for this mechanism among building owners as well as the complexity of the decision process.

First, energy and cost saving possibilities of a single project/site are usually small compared to the transaction costs, especially in cases when ownership of buildings is shared by many private owners. Secondly, transaction costs and the complexity of projects implementation are usually high.

Many building owners also mistrust the projected saving potentials, mainly because the EPC mechanism is not understood. In Brazil, a survey was conducted among consumers, ESCOs and utilities to identify barriers for EPC in the residential sector89. Building owners with higher incomes showed interest in energy savings, but not in ESCOs since they can implement energy efficiency improvements on their own as measures are simple and the amount to be invested insignificant to their budgets.

In the UK where the Energy Efficiency Commitment obliges energy suppliers to achieve energy savings with their customers, several programs were aimed at increasing the interest of consumers in EPC, but with limited success: consumers could not believe that energy suppliers were interested in reducing energy use and feared that the energy audit would be used to sell other products.

Furthermore, they judged EPC to be too complicated and not even free since they are paying a premium. Since the price for cavity insulation is very low in the UK, energy performance contracting is not considered necessary and effective. Other barriers to EPC in this sector include initial capital constraints and fiscal/VAT barriers. In Hungary, for example, EPC projects only enjoy reduced VAT rates if the ESCO operates the equipment and the project is therefore classified as an energy service project[90].

Barriers to EPC in the commercial sector

Barriers to EPC in the commercial sector resemble those in the residential sector. Building owners often lack awareness about the possibility of EPC or knowledge on how to implement it, but they cannot or do not want to hire an expensive adviser. Some building owners are bound to running service contacts, others are reluctant to engage in multi-year contracts and large companies owning many buildings often have sufficient funds to implement energy efficiency upgrades themselves.

Barriers related to financing of EPC projects

Lack of financing is probably the major barrier to EPC in developing countries. Whereas ESCOs in developed countries concentrate on the technical and energy-saving efforts since a mature financing sector usually takes care of the investment, ESCOs in developing countries have to exert significant efforts to secure funding for the ESCO projects. Sometimes this means that they co-finance energy efficiency improvements as the ESCO industry is

[89] See Brazil case study Annex 1.

[90] See Hungary case study Annex 1.

still young and unknown and the banking sector is too conservative.

Since numerous banks and financial institutions lack information about energy efficiency potential and especially experience in lending to ESCOs, they often consider EPC as a risky business, or do not fully understand the financial model involved in EPC. This is further complicated by the fact that the banks need to evaluate their clients' credit-worthiness - either the ESCO's or the client's. For this reason, they often either do not want to lend any money to ESCOs or demand high interest rates[91].

However, in principle sufficient money is available in the international markets: a plethora of financial support mechanisms (e.g. grants, loans, credit facilities) are offered to countries in transition and developing countries by multilateral organisations or banks (e.g. the European Bank for Reconstruction and Development (EBRD), the World Bank, the Global Environmental Facility (GEF), IFC)92. However, in many other countries, the main problem seems to be the missing link between these possible sources of funding and ESCOs.

Finally, funding for EPC competes with explicit or implicit energy price subsidies, which still exist in many developing and transition countries, and other energy efficiency support mechanisms such as subsidies and soft loans provided by the governments.

To summarise the barriers; ESCOs as well as their partners (banks, clients etc.) face numerous risks when engaging in EPC (technical, financial, operational, credit risks etc.).

[91] Interest rates for many ESCOs in developing countries can reach up to 50-70%, which severely compromises the profitability of energy efficiency improvements.

[92] Such a fund, the UNDP/GEF Hungary Public Sector Energy Efficiency Project, has considerably supported the development of the ESCO-industry in Hungary by providing partial guarantees to EE projects

3.6.3 Enabling factors for a successful ESCO industry

General context

A wide variety of factors has enabled the development of a successful ESCO industry in various countries. Some of these factors, such as favourable legislation are generally important93; however, other factors are more specific to certain countries or groups of countries than others.

High energy intensities, as in Central and Eastern Europe (CEE) or in developing countries such as India, usually imply high potentials for energy savings and thereby for EPC.

General programmes and policy tools for energy efficiency even if not targeted specifically at ESCOs can still help them, including building codes, energy efficiency obligations or energy audits, since their implementation usually increases the demand for energy service providers such as ESCOs.

As the example of the US shows, a requirement or at least incentive to improve the energy efficiency in public buildings can be an important ingredient of success for the ESCO industry94.

Demonstration projects by the public sector may be essential to increase awareness about EPC as well as trust in ESCOs among other potential clients95.

Since high transaction costs are a major barrier for EPC projects, bundling projects in a pool, e.g. several buildings into one project, can be a solution

[93] The recent EU Directive on energy end-use efficiency and energy services May 2006, aims to develop the market for energy services in EU Member states and should be very beneficial to the ESCO's development in the future.

[94] In the USA, federal administrations were obliged to improve their energy efficiency by certain deadlines. Laws enabled public institutions to enter into multi-year financial commitments and to favour ''best value'' proposals rather than lowest-cost bids in procurement decisions

[95] In Germany, for instance, the ESCO industry was greatly stimulated through EPC projects commissioned by the government of the city of Berlin in the 1990s

in the municipal and commercial sector for lowering transaction costs96. Bundling of buildings is especially important since many ESCOs and banks do not accept projects below a certain value.

Providing information and raising awareness about the importance of energy efficiency and measures to improve it is vital. Communicating the role and potential of ESCOs in public campaigns as soon as the first EPC projects have taken off, helps to sustain the nascent ESCO industry. Public communications about ESCOs can be done for instance by energy agencies.

Developing countries and economies in transition: special need for financial instruments

Access to financing of energy efficiency is a major barrier in many developing countries and specific support mechanisms have to be developed.

Co-financing is especially important at the beginning of ESCOs' activities in a country, since at that stage the ESCO industry is largely unknown, but subjected to similar, or even stricter treatment when seeking financing than other customer. Since ESCOs in developing countries often are not set up by utilities or other large companies, but independently, they need guarantees enabling them to receive credits from banks as well as financial support.

The Brazilian government for example has created a guarantee facility for energy efficiency projects, called PROESCO, where the Brazilian National Development Bank (BNDES) shares up to 80% of the credit risk and the remaining 20% is assumed by the intermediary bank (see Annex 1). The Hungary Energy Efficiency Co-Financing Program (HEECP2) aims at enhancing the energy efficiency financing capacity of domestic Hungarian financial intermediaries and thereby at facilitating the development of energy efficiency projects97. A similar guarantee fund initiated by the World Bank and Global Environmental Facility also exists in China. Other financial support mechanisms may include partial risk guarantees, loan loss reserve funds, special purpose funds or interest credits.

Because of limited budgets, many developing countries may not be able on their own to create guarantee funds and other support mechanisms for ESCOs. Financial support from multi-lateral banks and other agencies such as EBRD, the World Bank, the GEF and UNDP has therefore been very important. Grants are widely used as a mechanism for supporting ESCOs as well as, more rarely, loans e.g. in China and in the UK (Carbon Trust). They may be issued as unsecured interest-free loans for SMEs98.

Since international or national funds are usually not granted for a long term, it is of crucial importance to create a local banking system open for EPC financing. A mature financial industry that understands and supports EPC, or perhaps even considers it a good business opportunity (e.g. Hungary), can enable a sustainable ESCO industry.

As presented above, the major problems for banks in developing countries are lack of knowledge about EPC, high initial costs and uncertainty about the credit-worthiness of ESCOs and their clients, limited understanding of the logic of ESCO projects. Therefore, information and capacity building are important for bankers to help them understand EPC. ESCOs need also to understand how to deal with banks or financial institutions. Energy agencies or other entities can organise training workshops and provide manuals for stakeholders (e.g. India).

The transition from public funding through subsidies or loans to commercial financing is

[96] In the Berlin Energy Saving Partnership, about 100 buildings were bundled together in pools so that the necessary tender as well as negotiation process could be combined. This has significantly contributed to the success of the Energy Saving Partnership (see case study on Germany in Annex 1)

[97] See case study on Hungary in Annex 1.

[98] The World Bank has for example given loans for EPC in Croatia and Poland. In Bulgaria and Romania, an energy efficiency fund has been created. In China, ESCOS supported by a World Bank/GEF Project had made an investment of 117 million Euros by the end of 2005, thereby reducing carbon emissions by 7 Mt CO_2 per year.

however not easy since the former can usually give better conditions than the latter, and they might even compete with each other. For this reason, withdrawing public loans or funds as soon as the commercial banks are able and willing to engage in EPC is very important otherwise, the support programmes will only finance less profitable projects, which banks do not want to take on. One option is not to give loans or grants not ESCOs, but to set up guarantee facilities for (local or national) banks and financial institutions[99].

Standardisation of contract procedures and measurement and verification

End-users' and the financial community's concerns about the reliability of ESCOs can also be addressed by standardisation of contracts or key contractual provisions. Standardisation also improves time and cost effectiveness, and promotes competition and transparency (such as in Germany for instance100). Standard contracts can increase the trust of customers, especially in the public sector, and thereby their willingness to engage in EPC.

They can also simplify and accelerate the negotiation process. However, ESCOs often prefer not to be bound to fixed standard contracts but develop their own unique contract approaches instead (e.g. Germany). For this reason, standardisation of key contractual provisions is often more helpful than complete standardized contracts)101.

Development of Accreditation systems

Since mistrust is often a major barrier, information about ESCOs needs to be complemented by measures confirming their reliability for the potential clients. This is especially important in countries with a large number of ESCOs (e.g. accreditation system by the US ESCO association, NAESCO or the Chinese ESCO association). Similarly, the European Standardisation Organisation CEN is currently developing criteria and mechanisms for an EU-wide certification system.

Special measures to promote EPC in the residential sector

In the residential sector, new efforts such as special incentive programs are currently supporting ESCO activities and helping to achieve a breakthrough as for instance in the UK. Improving the information about energy use of buildings and introducing smart metering and billing in more buildings could also raise the consumer awareness about energy use and therefore their interest in EPC102.

Other supportive policy measures include demand-side management or energy efficiency obligations (e.g. UK with the Energy Efficiency Commitment103). Furthermore, the EBRD has created a credit line for EPC in the residential sector in certain countries.

Special measures to promote EPC in the commercial sector

Since large building owner companies frequently outsource the building management and operation to facility managers, combining EPC and building management by the ESCOs or the facility managers is a new and promising model. Similarly,

[99] For instance the IFC CEEF programme (International Financial Corporation – Commercializing Energy Efficiency Finance) or the Hungary Commercialising Energy Efficiency Co-Financing Programme (HEECP

[100] Such a step taken by the Berlin energy agency and the state of Hessen was very important for the success of the German ESCO industry during the 90s, especially in the public sector.

[101] For instance, NAESCO, the US ESCO association, is now drafting standard elements of each EPC contract (e.g. insurance, equipment ownership and purchase options), instead of drafting an entire model contract. CEN and CENELEC (European Standardization Bodies) are jointly developing common standards, defining requirements for certified ESCOs and energy experts. Furthermore, standardization of measurement and verification, for instance through the International Measurement and Verification Protocol (IMVP), can be helpful in increasing the trust of customers and banks in ESCOs' activities.

[102] See for instance Bertoldi, P. and Rezessy, S. Energy Service Companies in Europe Status Report 2005. Ispra, Italy: European Commission DG Joint Research Centre.

[103] See below the section on energy efficiency obligations

EPC is increasingly combined with leasing, which companies prefer due to its balance-sheet benefits.

Necessity of country-specific approaches

Although experience can be shared and lessons learned from others, measures rarely fit all countries, especially since barriers are often country-specific. International donors and governments have to adopt a country-specific approach in each case. When choosing the ESCO business model, for example, some countries or sectors might favour the shared savings, others the guaranteed savings model. Building owners with little experience in energy efficiency often prefer the guarantee of savings, whereas industrial facilities are more interested in the shared savings model. The choice should finally be made by the local market.

3.7 Policy Instruments for Cars Energy Efficiency [104]

The policy instruments for cars include measures to improve the energy efficiency of vehicles and also measures that influence the use of cars. The measures considered here are; road pricing, CO_2-labeling of cars, incentives for car scrapping, subsidies for the use of bio-fuels and fiscal measures (taxes or subsidies) on car purchases, car ownership and motor fuels.

3.7.1 Road pricing

Road space is often a scarce commodity. For the vast majority of roads there are no road user charges and so there is no pricing system to balance supply and demand. The results are traffic jam, congestion, time loss and pollution. One way to share this scarce commodity is to charge the users for road use.

According to the spatial extension and complexity of road charges there is a categorisation of three stages of road-user pricing: corridor scheme, area scheme and national scheme:

- The corridor approach involves a toll for the use of a stretch of road, tunnel or bridge where access can easily be controlled. The main objective is to generate revenue that will recover the costs of constructing and maintaining the road. Electronic tolling is now well spread around the world, and in some countries about half of all charges are now collected in this way.
- The area scheme implies pricing for an integrated local road network. The reasons for implementing such a scheme are not only the financing of road infrastructure and the improvement of traffic conditions, but also the reduction of the costs of congestion, pollution and noise. Singapore is the pioneer of the area scheme since 1975. The area scheme has also been implemented with good results in Norwegian cities (e.g. Oslo, Trondheim and Bergen) and got a new boost with the successful implementation in London in 2003 (Box 3.1). Stockholm had a successful trial in 2006105.
- National schemes extend the charged area to a wider road network, rather than an individual area. Therefore, the emphasis is on charging for the distance travelled rather than for targeted bottlenecks. In some countries like Austria, Switzerland and Hungary the highway users have to buy a vignette, which allows them to use the highway-network for a certain period. In other countries, e.g. France or Italy, the driver pays according to the driven kilometres. In many countries, such schemes have been implemented using different types of technology for example onboard units combined with GSM or infrared devices. In many European countries the discussion is focussed on expanding these technologies to private car-traffic.

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[104] The following section is adapted from a report prepared for the project and coordinated by Romain Molitor from Trafico, with the assistance of Liette Clees, Peter Czermak and Helmut Koch. It includes in Annex 1 six country studies: UK (case of London road pricing), Austria (CO2 labelling), Denmark (car scrapping) and Brazil (biofuels). The full report, with all the literature references used, is available at http://www.worldenergy.org "Policy Instruments on Cars Energy Efficiency, ADEME/Trafico, April 2007"

[105] Stockholm set up a half-year congestion charging trial in 2006 in an area of 34 km^2 using the transponder system, which allows different charges according to traffic density. Although, the majority of the city residents agreed to this charge in a referendum, the Government is now considering a final decision because of the opposition of municipalities outside of the city.

Box 3.1: Toll area schemes: examples of Singapore and London

In 1975, Singapore introduced a scheme that levied a charge for the right to enter a 6km[2] zone covering the central area during morning peak hours, unless the vehicle had four or more passengers (1€/day or 20€/month). In 1998, this was replaced by an electronic system with smart cards in the vehicles. The pricing is based on a per-trip-system with highest tolls in the peak hours. With the introduction of this scheme in 1975 there was a reduction of car peak traffic by 45% - and in the last 30 years it stayed on this low level without any major increases. The use of public transport by commuters rose from 46% to 65%.

The London scheme, one of the largest of its kind in the world, charges vehicles driving into central London a flat fee of €12 a day between 7:00 am and 6:00 pm[106]. The results are very successful: car traffic in the zone was reduced by 15% and congestion by 30%. Traffic speed increased by 37%. This led to reduced fuel consumption of 10% and reduced CO_2 -emissions of 19%. It is planned to double the size of the zone by end 2007.

Road user pricing will become an important issue in the future, with the rapid development and massive cost reduction of road pricing technologies, with the increasing car traffic that cannot be satisfied with additional road infrastructure, and the environmental needs to slow down the car-traffic.

3.7.2 Car labels for fuel consumption and CO2 emission

Introducing labels for new cars, which display information on fuel consumption and/or CO_2 emissions, is a relatively simple measure, provided that most car manufacturers on the global market have such information already available and standard test cycles (like those established in the European Union) are being applied. It is advisable to promote such labelling schemes with adequate information campaigns and eventually promote low-energy cars through fiscal or financial incentives. Fuel efficiency and CO_2 labelling schemes are currently implemented in EU member countries following a European Directive. They are also in operation in Australia.

The EU Directive (1999/94/EC) obliges car manufacturers and distributors to display information on fuel consumption and CO_2 emissions of new passenger cars in showrooms and within any marketing activity (CO_2 label). It also makes it mandatory to publish annual guides on fuel economy and CO_2 emissions, with data for all new passenger car models available on the national markets107.

Some EU member states have started additional promotional campaigns around the labelling schemes and have monitored the impacts of their national activities on consumer behaviour. The use of labels could lead to a reduction in fuel consumption of 4-5% due to consumer awareness.

The labels include mandatory data on CO_2 emissions (g/km), fuel consumption (l/100km and/ or km/l). In some countries an efficiency rating system and additional data like noise, emissions standards, tax and other technical data are included.

The EU directive allows the member states plenty of room for national implementation; as a result, the labelling systems differ within Europe. Two types of comparison methods are used, which hamper harmonisation (see **Figure 3.12**):

- The **absolute comparison method**, in which the energy efficiency/CO_2 classes (6 or 7) are

[106] The charged area is 21 km2 in size and involves daily monitoring and charging of around 200.000 vehicles. The enforcement of the charge is based on automatic number recognition (ANPR) technology using cameras situated on the boundary and throughout the charging zone.

[107] In practice, templates for the label are normally available on internet for download by retailers. Also the guides are widely available on internet besides printed versions which are distributed by retailers or can be ordered from manufacturer's associations or other institutions.

defined by fixed values[108] (e.g. Denmark, Belgium, France, Germany, Austria, UK, Portugal).

- The **relative comparison method**, in which the energy efficiency classes are related to the stock average[109] (e.g. The Netherlands, Spain or Switzerland).

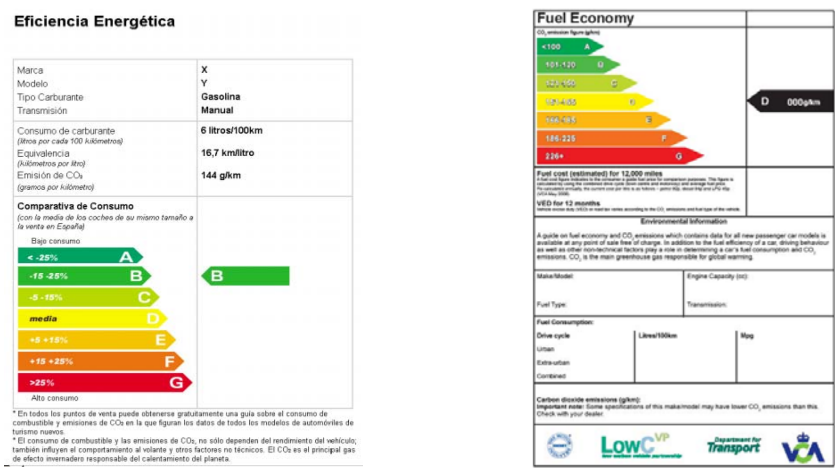
In the EU directive the labels are not required to show any comparative information that could allow consumers to draw conclusions about the fuel efficiency of a certain model in relation to the overall market. With the relative comparison method, consumers mostly select a new car within a certain range that is primarily determined by size, price and needs. So they are interested in the fuel economy of a certain car with respect to other cars, which are the same in their eyes. It proved difficult to develop a consistent and fair method for a relative comparison, which would be accepted by all involved parties, especially the car manufacturing industry.

The advantage of the absolute system is that it is the most simple comparison method to handle and the easiest to understand for consumers. It avoids the arbitrary and contentious issues of defining the categories of classes.

CO_2 labelling is a practical method to inform consumers about the fuel economy and environmental standards of the new cars. But as the buying decisions are strongly influenced by costs, size, power, manufacturer and safety of the car, the impact on the consumer decision is quite low. For this reason, relative comparison methods on the labels are preferable. CO_2 labelling may lead to a growing awareness about environmental impacts of car use. And in combination with tax incentives (e.g. the "Green motor tax" in Denmark), it may already help shifting consumer decisions to more environmental friendly cars.

CO_2 labelling for used cars imported by developing countries could inform consumers about the fuel economy and environmental standards of the used cars and thus influence their decisions. Nevertheless, the fuel price in relation to the

Figure 3.12: CO2 label: Spain / UK (relative/absolute comparison)



personal income in the countries importing used cars, plays an important, even a crucial role, which might have a strange impact on the decision of buying a car.

[108] Each class covers is based on a fixed range of CO_2 emissions: in France, for instance, Class A covers cars with CO_2 emissions below 100g CO_2/km.
[109] Each class car is labelled in relation to the market average: in Spain, for example, Class A corresponds to cars with emissions 25 % below the market average.

3.7.3 Car scrapping

Several countries within and outside Europe have implemented car scrapping schemes during the 1990s to increase the rate of renewal of the car fleet and to improve environmental conditions[110]. Scrapping old cars is a possible instrument for reducing transport-generated air pollution, because they disproportionately contribute to pollution, but it has proved difficult to design a scrapping policy without side effects.

The direct impact of scrapping schemes is to reduce emissions caused by cars, since they substitute older, more polluting vehicles with newer, cleaner ones. However, they may have a negative effect as they shorten the average car's life and, therefore, if the schemes are permanent or repeated over time, they increase the amount of energy and materials used and emissions produced during manufacturing. As the actual difference in environmental performance between some older and newer vehicles is substantial, and the energy input and environmental damages are much higher in car use than in car production and car recycling, the positive environmental effect is likely to prevail for most of the schemes implemented.

Two main types of scrapping schemes are used:

- **Cash-for-scrapping** gives a certain reward for any scrapped car, whatever the subsequent replacement decision taken by the consumer. The bonus is awarded even if a replacement vehicle is older than the scrapped one, or if no car is bought to replace the scrapped one.

- **Cash-for-replacement** gives a bonus conditional upon a specific kind of replacement – typically, but not necessarily, a new model car.

The major findings of evaluations of cars scrapping schemes are the following:

- There is not much empirical evidence about the cost-effectiveness of scrapping programmes;

- When the selection of vehicles to be retired is made carefully, cash-for-scrapping schemes may achieve emissions reductions at a reasonable cost.

- Small scale programmes are more efficient than large-scale ones. The number of vehicles retired by either type of scheme should not go beyond a certain number of vehicles selected among the 'gross emitters' in the fleet. Otherwise, the cost per tonne of emissions avoided increases considerably.

- By bringing forward a large number of scrapping and replacement decisions, the schemes may cause considerable distortions on the car market. For example; older vehicles may migrate to other parts of the region as a result of the market response.

- The cash-for-replacement schemes implemented up to the present time appear to have been much less cost-effective, as they constrained the consumers to purchasing a new car. In doing so, they have excluded lower-income groups who cannot afford to purchase new cars even with an incentive bonus. This makes the schemes somewhat inequitable, but more importantly, prevents them from attracting many of the oldest cars in the fleet, used typically by lower-income families intensively, as their principal means of transport. These schemes, therefore, have not properly selected the vehicles to be retired, leaving in use a large proportion of the 'gross emitters'. Moreover, higher payments are necessary to influence the decision to purchase a new car, rather than simply scrapping a car (which might be replaced with a used car or not replaced at all). As a

[110] Incentives for scrapping old cars were given by Greece (1991-1993), Hungary (1993 up to now), Denmark (1994-1995), Spain (1994 up to now), France (1994-1996), Ireland (1995-1997), Norway (1996) and Italy (1997-1998). Various local governments in the United States and the Canadian Province of British Columbia have also implemented such schemes (see the full report for a detailed presentation of the scrapping schemes).

consequence, these schemes have a high average cost per tonne of pollution avoided and they do not compare favourably with other alternative policy tools on purely environmental grounds.

- The scrapping programmes in the EU have produced the highest emissions reductions when implemented along with the introduction of new technologies with significantly lower emissions, e.g. the three way catalytic converter and particle filters.
- Inspection and maintenance is a much more generally applicable instrument to reduce the emissions from the existing car fleet.
- In developing countries, where cars older than 10 or 20 years and more are in use, a car scrapping program may have more positive environmental effects than in the industrialised countries. It is evident that not only cars and their emissions and energy efficiency standards but also the fuel quality is a precondition for positive environmental effects.

3.7.4 Biofuels

Biofuels are considered as a corner stone for reduction of greenhouse gases in transport, to limit the impact of rising oil prices and to improve the security of supply[111]. The recent years showed a boom in biofuels production and new political strategies all over the world to promote a future market. With increasing oil prices, new strategies to promote biofuels have been developed and investment in new biofuels facilities have boomed in Brazil, Europe, the United States, and elsewhere[112]. In Europe, the European Commission launched the Biofuels Directive (2003/20) that requires all member states to ensure a minimum proportion of 5.75% of biofuels in total road fuels by 2010. Another directive gives the member states the possibility to grant tax reductions or exemptions in favour of biofuels. Most member states have started implementing a biofuels policy, through tax reductions; new large-scale investments are being planned to increase the production capacity.

The two most prevalent biofuels are ethanol, currently produced from sugar or starch crops, and biodiesel, produced from vegetable oils or animal fats. World production of ethanol more than doubled between 2000 and 2006, while production of biodiesel quadrupled. In total, biofuels now provide around 1% of the world's liquid transport fuels. Another biofuel is biogas from organic waste fermentation with the potential to reduce (or to be mixed with) the natural gas.

Although very attractive, a large scale development of biofuels raises certain issues.

- Apart from a few cases, they are still more costly than diesel or gasoline and need subsidies; however, with increasing oil prices some biofuels are becoming competitive even without tax reductions. Ethanol from Brazilian sugarcane is the cheapest fuel.
- The energy output from biofuels is lower than from fossil fuels: for 1 litre biodiesel the equivalent is 0.92 litre diesel and for 1 litre ethanol it is 0.7 litre gasoline.
- Biofuels require large land areas, which may compete with other land uses (e.g. food production).
- Large scale biofuels production may lead to an increase the price of food.
- Intensive production of biofuels may have many environmental impacts; erosion, pesticides, water etc.

The greatest potential for biofuels lies in the development of new technologies that will significantly expand the range of biomass

[111] The benefits of biofuels are discussed in detail in the full case study.
[112] Among the countries that have made major commitments to biofuels in recent years are China, Colombia, India, the Philippines and Thailand.

feedstock, increase conversion efficiencies, and lower production costs113.

International trade in biofuels is currently limited by the fact that many countries maintain high tariffs for these fuels. This is likely to change in the years ahead. Many of the rich countries that consume large quantities of transportation fuels (e.g. Europe and Japan) have limited land available for growing biomass feedstock, which leaves them unable to generate more than a fraction of their transportation fuels from domestically produced biofuels.

For biofuels to make a large and sustainable contribution to the world energy economy, governments will need to enact consistent, long-term, and well coordinated policies. These policy priorities include:

- Biofuel policies should focus on market development, creating an enabling environment based on sound fiscal policy and support for private investment, infrastructure development and building of transportation fleets that are able to use the new fuels.
- Policies are needed to expedite the transition to the next generation of feedstock and technologies that will ensure dramatically increased production at lower cost, while reducing negative environmental impacts.
- Maintaining soil productivity, water quality, and other ecosystems is essential. National and international environmental sustainability principles and certification systems are important for protecting resources as well as maintaining public trust in the merits of biofuels.
- Government fiscal and land use policies will help determine how broadly the economic revenues from biofuels are spread and how they will shape rural economies.
- Continued rapid growth of biofuels will require the development of a true international market unconstrained by the trade restrictions in place today. Freer movement of biofuels around the world should be coupled with social and environmental standards and a credible system to certify compliance.
- Biofuels should be developed within the context of a broad transformation of the transport sector aimed at dramatically improving transport efficiency.

Fiscal Measures on Cars

The share of car-related expenditure in household budgets (around 15%) suggests that fiscal measures should have an influence on the key drivers which affect energy use and CO_2 emissions of cars: ownership levels, annual mileage, and specific consumption/emissions. Fiscal policies include taxes or subsidies on car purchases, on car ownership and on motor fuels.

Car Purchase Tax

The first level of taxation is on car purchases **(Figure 3.13**). Some countries rely only on the value added tax (VAT) system, with cars taxed at the normal rate, and low registration fees. This is generally the case in car producing countries (e.g. France, Germany, the UK, Italy, and Sweden since 1997). The VAT on cars may have a large range from 5% (Singapore, Japan) to 25% (Denmark, Sweden).

[113] One of the innovations is to generate the fuels from cellulosic materials such as plant stalks, leaves, and wood. The technologies are still relatively expensive, but are close to being introduced commercially.

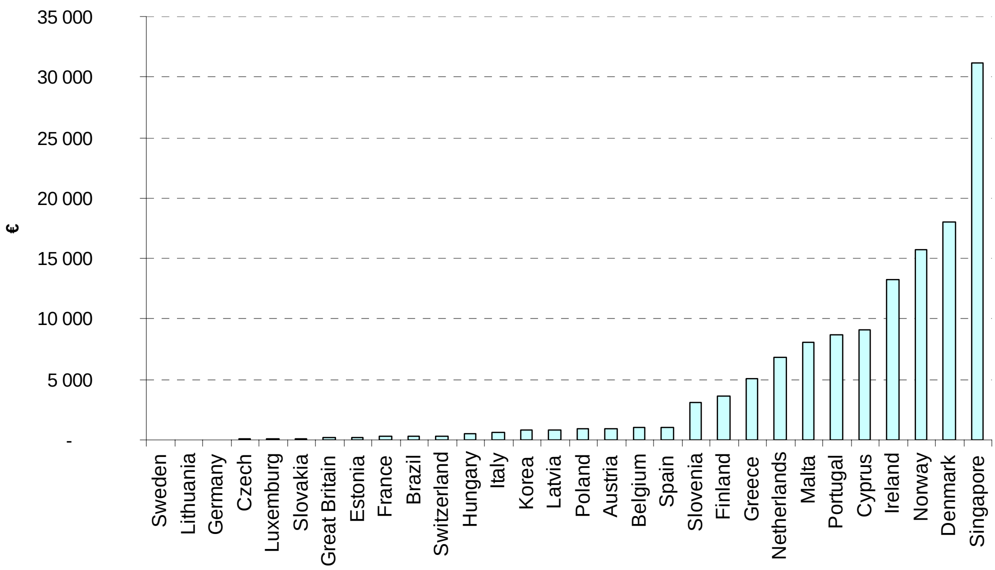
In other countries, there may be a specific tax on car purchases, which give incentives to the consumers to buy less energy consuming cars or cars with a lower specific CO_2 emissions or, more recently, efficiency/CO_2 emissions. This is presently the case in several European countries: Austria (since 1992), Denmark (since 2000), Norway (since 1996), the UK for company cars (since 2002), France for "powerful" cars (since 2006) and the Netherlands (since 2006). Some countries are planning the introduction of similar green taxes (e.g. Portugal, Spain). Incentives are given in some countries for low-polluting cars, such as diesel cars equipped with a particle filter (e.g. Austria) or for clean cars (e.g. Germany for cars meeting the Euro IV emissions standard), either through a bonus, which is deducted from the purchase tax or from the circulation tax.

High taxes result from long-term policies designed to deter people from buying a car – this is the case in Singapore, Denmark, Norway and Finland, and also in some developing countries where cars are an important component of imports. Even though these taxes may be based on technical characteristics, their level is mainly dependent on the vehicle's price. The pre-tax price of the car reflects indirectly the level of consumption, since consumption is related to weight and power.

There is some concern about unintended effects from such taxes. First, high taxes can deter consumers from changing cars, and thus the penetration of new technologies is slower. Second, a high level of tax on car purchases concentrates the new car market on the most affluent part of the population, whose tastes may be more oriented towards energy intensive cars. Finally, with the introduction of new technologies, new cars may be more expensive because they are more efficient; a US$600 additional cost at market price for improved fuel economy may translate into US$1,500 when taxes are included in the Danish system, for example.

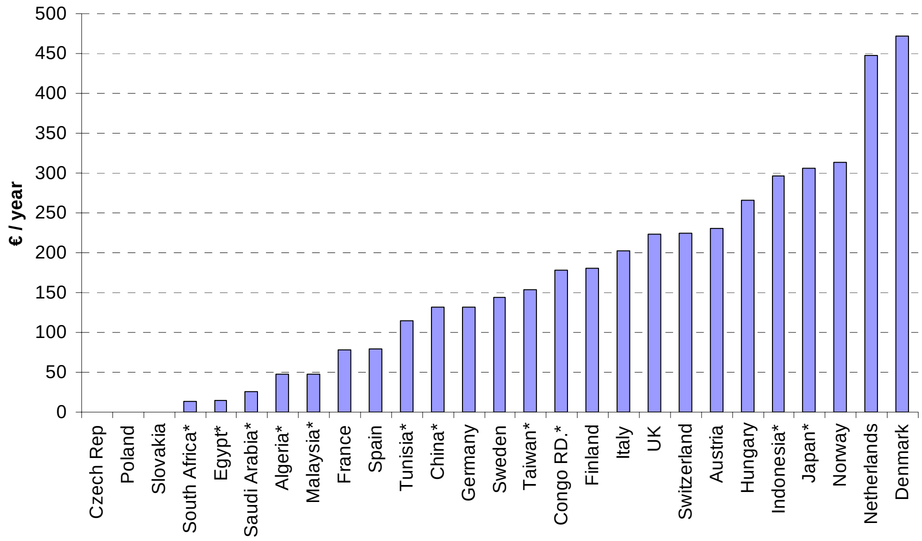
High car purchase tax has an impact on the motorisation rate. Countries with high car purchase tax have a motorisation rate significantly lower than countries with similar level of development (e.g. Denmark with a motorisation rate 25% below the EU average or Singapore with a very low motorisation rate).

Figure 3.13 : Average car purchase tax and fee, excluding VAT (Euro per vehicle) [114]



[114] Source: DIW, Trafico : estimation based on a average car (Golf 1.4/TDI 2.0 resp. similar car).

Figure 3.14: Annual taxes on cars[115]



Nevertheless, a high motorisation rate does not only depend on a low taxation of the car purchase but also on the transport scheme (public transport offers; land-use and urbanisation) and on the cultural and economical differences. Thus a low motorisation rate in Singapore or in many large cities (e.g. Paris, Tokyo, New York) is also influenced by the high quality of public transport and the scarcity of land.

Car registration tax

The second level of taxation is the annual registration tax (or tax on car ownership) (**Figure 3.14**). Consumers will take into account such a tax in their car-buying decisions (whether a new or a used car). In most countries, this tax varies depending on the power of the car, which is linked to the fuel consumption116. In an increasing number of countries this annual car tax also includes environmental or energy efficiency aspects. In several EU countries, the tax varies according to the fuel consumption and/or CO_2-emissions: Denmark since 1999, Germany since 1997, the UK since 2001, France since 2006 (for company cars), and Sweden (since 2006 for new cars)117.

Taxation of Motor Fuels

The third level of taxation is related to motor fuels. There are large differences between countries in the taxation of motor fuels, both gasoline and diesel. It ranges from subsidies for motor fuels to high taxation.

In Europe, such taxes are much higher than in the rest of the world, for three reasons:

- Most European countries are oil importers.
- Revenue from motor fuel tax is an important source of income for the government budgets (infrastructure).
- There is a strong commitment to meet Kyoto targets, and one way of doing this is to regularly increase the tax on motor fuels. In some countries, this is being achieved by adding CO_2/environmental taxes (e.g. Norway, Sweden, Finland and Germany). Such, green taxes are more acceptable to the population, especially if part of the revenue is recycled to support energy /CO_2 efficiency measures.

[115] Source: DIW, Metschies, Trafico, Estimation based on an a standard car (Golf 1.4 or similar), March 2005.
[116] On the other hand, this link is not absolute and in few cases a more powerful engine may be more efficient.
[117] If car pollution is also included 11 countries have such green taxes in the EU.

Figure 3.16 Gasoline tax index[119] in relation to income (2005)

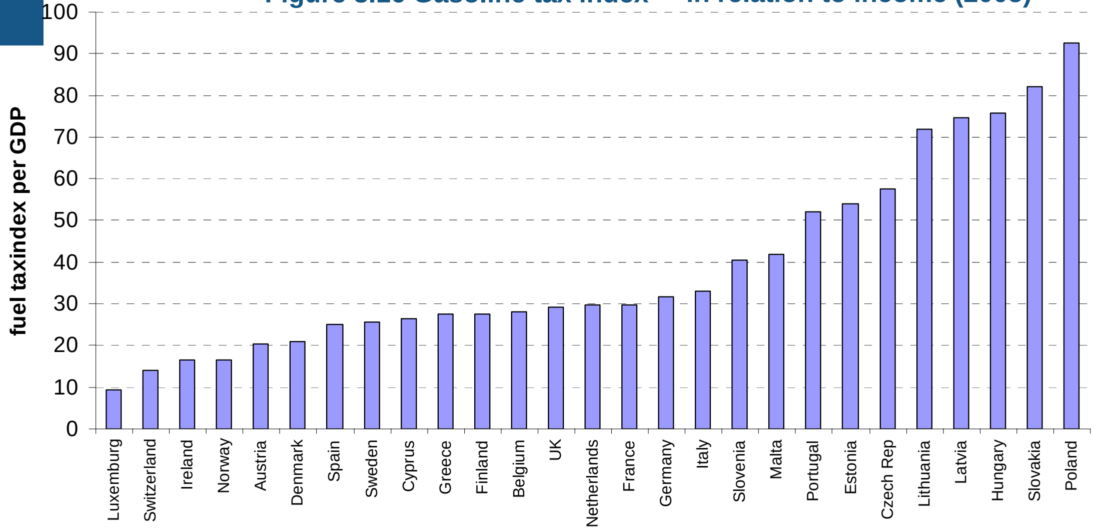
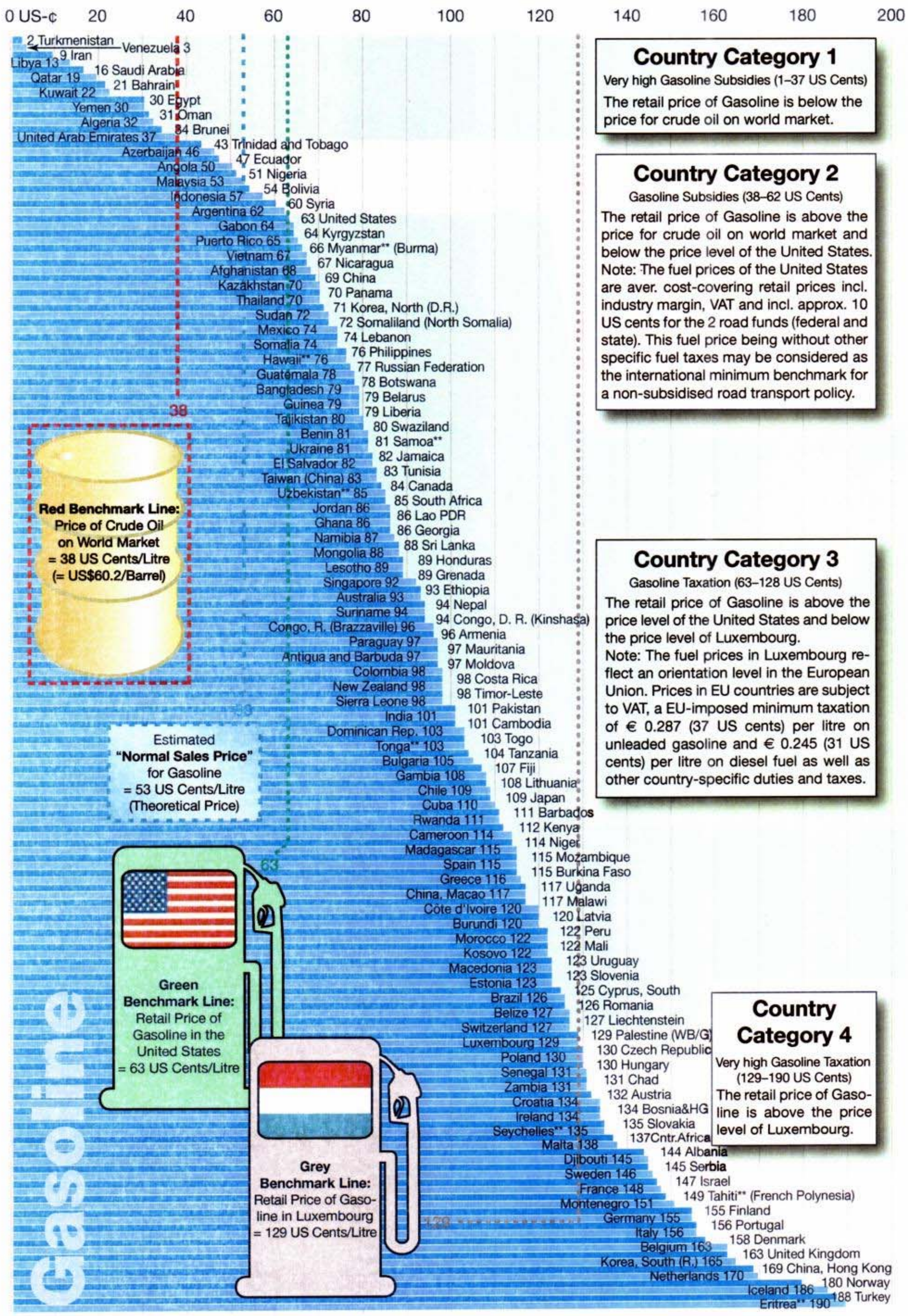


Figure 3.15: Retail prices of gasoline: role of subsidies or taxation (US Cents per litre)[118]



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118 Source: GTZ, Internati Prices 2007, available at: www.gtz.de/fuelprices ; data as of November 20(

119 Ratio of the tax for GDP per head); source Trafico

The level of fuel taxes can be compared to the per capita GDP, considered an indication of national wealth. For Europe this indicator shows a clear hierarchy: it is lowest in Luxembourg and Switzerland and then come most of the older EU countries on a quite similar level. The new EU member states from Central and Eastern Europe have a ratio twice or three times as high, which explains the lower levels of car ownership and use (**Figure 3.16**).

Fuel taxes can have a high impact on national revenues. For example Venezuela spends 17 % of its total state revenues on subsidising fuel. On the other extreme South Korea receives 33 % of its total state revenues from fuel taxation and EU countries between 10 and 15%.

There are two aspects to motor fuel taxes: the average level of taxes, and the difference between fuels (gasoline and diesel). The second aspect of the tax differentiation between gasoline and diesel may be of no importance, for example in the USA, where there are very few diesel cars. In Europe, this was of little importance until the end of the 1970s, because diesel use was limited to large cars with specific uses (taxis). However, this aspect gained in importance in the 1980s and 1990s, because consumers were offered diesel versions of cars, both at the top and the lower end of ranges.

On the one hand, the specific consumption and emissions of diesel cars, compared to equivalent gasoline cars, are slightly lower (despite the carbon content of diesel being higher than gasoline). Diesel cars are usually driven over much larger distances annually. In France, where the tax differentiation is high, the annual mileage of a diesel car is around 20,000 km, compared to around 11,000 km for gasoline cars. As a result, the annual emissions of a diesel car are higher than a gasoline car.

Is this difference directly linked to the price? There is a debate between experts on this point. Some experts consider that travel needs are constant, and for those with high needs, diesel is more cost effective because the lower fuel cost more than balances the higher price of the car. Other experts consider that the difference in the energy price per kilometre explains at least part of the difference in the distance travelled120.

With regard to the average price level, many studies have demonstrated a link between the fuel consumption of cars and the price. Their results are consistent, and converge towards a long-run elasticity of fuel consumption to fuel price of -0.64121. In the long run, a 10% increase in the price of motor fuel leads to a total reduction in consumption of 6% (**Table 3.3**) (of which 2.5% reduction in the car stock, 3% reduction in the mileage per car, and 11% increase in fuel efficiency)[122].

The intervals of variation around the mean value of these estimates are relatively large, which means that other policy demands (other types of fiscal and non-fiscal measures) and the change over time in personal incomes are of importance as well.

The elasticities in **Table 3.3** show a clear reduction of car mileage in relation to the fuel price. The empirical data in Germany, when the fuel taxation was significantly raised from 1999 to 2002, show a reduction in the total mileage per year. Looking at the energy consumption (based on fuel sold at the petrol fuel stations), the data show a higher reduction, due to border sales.123

Conclusions and policy recommendations

[120] See further development on this issue in the full report.

[121] On the short-term, the elasticity is lower (between -0.2 to -0.3) as the consumers have less possibilities to adjust to higher prices.

[122] Source: Goodwin et al., 2004 (see full bibliography in the complete case study in Annex 1).

[123] The consumers living near the border tend to fill up their cars in the neighbouring country, if the price difference is high enough. Thus, a significant part of the fuel is bought abroad, e.g. in Austria, the Czech Republic, Poland or Luxembourg, where a price difference up to 20 €c/litre can be registered (see full report).

Table 3.3. Elasticity of car fuel consumption and fuel price per litre

Effect of fuel price on:	Short term elasticity (mean elasticity)	Long term elasticity (mean elasticity)
Fuel consumption (total)	-0.25	-0.64
Fuel consumption per vehicle	-0.08	-1.1
Vehicle km (total)	-0.10	-0.29
Vehicle km per vehicle	-0.10	-0.30
Vehicle stock	-0.08	-0.25

Source: Goodwin et al (2004)[124]

As regards car purchase taxes, countries with high taxes (Denmark, Finland, Norway, the Netherlands, Ireland and Portugal) have lower rates of car ownership (per inhabitant or per unit of GDP) than the European average. Countries with no significant registration fees have higher car ownership rates. However, high levels of taxes on car purchases do not influence the consumer drive towards more efficient cars.

Fuel taxation has different effects, both in short and in the long-term:

In a short term, a comparatively low elasticity shows that a dominating share of the trips made are trips with a low elasticity: The daily trip to work or to school, the trips for shopping, for personal services and for leisure are "ritual" trips, often optimised in a daily time budget. Only, if the opportunity is given to shift to public transport or to use other, nearby shops, personal services etc., vehicle mileage can be reduced easily by the consumers. Thus the accessibility of different activities is important; and vice versa, the influence of the transport system (i.e. accessibility) and the urban structure are significant factors in assessing the effects of pricing in the transport system.

In a long-term, the accessibility through a reorganisation of the spatial structures and through the introduction of new services in public transport might have a secondary effect on pricing of the transport system (road pricing, fuel taxation, and car taxation). The long term elasticity in fuel pricing and vehicle mileage is higher. It seems evident that pricing policies need to be linked to a public transport policy as well as spatial planning.

The total taxation of car use (purchase, ownership and fuel) is another important indicator. Countries with high purchase or ownership taxes as the Netherlands, Norway or Denmark also have high taxes on fuel, whereas UK has high fuel taxes but a low purchase tax and comparatively low ownership taxes. It is evident that the total costs of car use per yearly mileage, including all taxes, might be the only figures used for comparison.125

The taxation of fuel should follow an escalator approach with periodical growth rates. Thus the behaviour of car use could be influenced in the longer term. This approach has been applied in Germany and UK. Otherwise, consumers tend to get used to the higher prices in the longer term and the short term effects of a rise in taxes are counterbalanced.

3.8 Energy Efficiency Obligations in Europe[126]

Energy efficiency obligations is a recent and innovative measure whereby energy companies (supplier/retailer or distributor) have a legal obligation to promote and stimulate investment,

[124] Altogether, 69 empirical studies have been analysed covering different periods spread over 62 years from 1929 to 1991 and which has been carried out in the UK or other countries comparable with the UK.

[125] s. DIW (2005)

[126] This section is based on a report prepared for the project by Eoin Lees. The report, with all references, is available on the WEC web site: "European Experience of White Certificates ", ADEME, May 2007. The study includes 4 country case studies (Belgium, France, Italy and UK), which can be found in Annex 1.

Table 3.4: EU Countries with currently active energy efficiency obligations

Country	Obligated Company	Eligible Customers	Target set by	Administrator
Belgium-Flanders	Electricity distributors	Residential and non energy intensive industry and service	Flemish Government	Flemish Government
France	All suppliers of energy	All except EU ETS	Government	Government
Italy	Electricity & gas distributors	All including transport	Government	Regulator (AEEG)
UK	Electricity & gas suppliers	Residential only	Government	Regulator (Ofgem)
Ireland	Electricity (ESB)	All except transport	Regulator	Regulator (CER)
Denmark[127]	Electricity, gas & heat distributors	All except transport	Government	Danish Energy Authority

Table 3.5: More details on the EU Energy Efficiency Obligations currently in place

Country	Nature of saving target	Current size of target	Discount rate	Cost[128] (€M/yr)	Penalty [129]	Trading
Belgium-Flanders	Annual primary energy	0.58 TWh annual	n/a	25.8	10€/MWh missed + fine not eligible for tariff	No
France	Lifetime delivered[130] energy	54 TWh over 3 years	4%	*200*	20€/MWh missed	Yes
Italy	Cumulative primary energy	33.7 TWh in 5th year	0%	*90*	Related to non-compliance	Yes
UK	Lifetime delivered energy	Carbon weighted	3.5%	570	Related to size of miss	Only between suppliers
Ireland	Lifetime delivered energy	0.24 TWh annual	0%	3	Potential reduction in subsequent regulated allowance	n/a
Denmark	Lifetime delivered energy	0.12 TWh annual	6%	20	n/a	n/a

[127] Denmark has just embarked upon a much expanded programme which is expected to produce energy savings equivalent to 1.2% of present Danish consumption. The nature of the energy saving target will change from lifetime (the original Danish Electricity Saving Trust methodology) to annual energy saving targets. There will also be many more obliged players (over 100) than the smaller numbers in UK, Italy and France

[128] Estimate in italics

[129] Penalty if target missed

[130] Delivered or final energy

which will save energy in customers' premises or households. When this obligation can be met by

buying or selling the energy saving credits, it is usually called White Certificates.

Energy efficiency obligations are in some aspects similar to the older Demand side management (DSM) activities since there is an obligation on energy companies to undertake energy efficiency activities with their customers. However compared to many of the 1990s DSM programmes, the obligations approach focuses on outcomes (i.e. energy saving targets) rather than money spent and has developed much cheaper monitoring and verification systems.

3.8.1 Existing Energy Efficiency Obligations in Europe

Six countries currently have energy efficiency obligations on energy companies in Europe: Belgium (Flanders Region), France, Italy, UK, Ireland and Denmark. Energy efficiency obligations are placed on energy suppliers in the Netherlands in the second half of 2007 and similar activities are under development in Poland and Portugal.

The approach to energy efficiency obligations on energy companies has developed differently with different mandatory parts of the energy industry and a wide variation in the end use sectors to which the obligations are applied (**Table 3.4**). Nevertheless such obligations have been shown to be extremely flexible and have proved capable to work either with a traditional monopoly energy utility or in a fully liberalised market.

Table 3.5 provides details of the targets, their size and other key parameters of the energy efficiency obligations in four countries.

This review of energy efficiency obligations in Europe concentrates on the four major experiences which have been accumulative for some time and which are of a significant scale: Belgium, France, Italy and UK131.

3.8.2 Experience from the Four Countries

Although there are many differences between the way the targets are set, the size of the targets, the concerned parties and the energy using sectors covered, there are in fact many similarities. The common experience to date in the four European countries is analysed below using a common format132. However, the programmes do vary considerably in their nature, in the length of time that they have been running and the extent to which they have had independent evaluation, which is publicly available. Therefore, it is not possible to cover all aspects to the same extent.

The size of the target, the end using sectors to which it applies, etc vary from country to country (**Tables 3.4 and 3.5**). However, the key principles are an obligation placed on an energy company by Government (or a Regulator) and a formal monitoring and verification process is enacted to ensure the targets are met by eligible energy saving measures. Most countries have penalties for those companies which do not fulfil their energy efficiency obligations (**Table 3.5**). In practice, no penalties have been issued as virtually all the energy companies have met their targets.

Target Sector & Size

Usually the size of the target and the sectors to be covered are decided by government rather than the regulator for that particular energy industry, although in some cases the Regulator is the appointed body to oversee and verify the energy efficiency obligations. Having national governments decide on the size of the obligation seems appropriate as energy efficiency obligations are linked to environmental concerns and have an important social dimension. It is not easy for an unelected regulator to make judgements which are not solely based on economic grounds and can have a significant impact on energy bills in the

[131] As the Irish Energy Efficiency Obligations are very similar to that of the UK, and are of a very small magnitude, they have not been included.
[132] Country case studies in Annex 1 give more details of the individual experience.

short term. The targets are set in relation to the volume of electricity or gas supplied or distributed. In the residential sector, the simple proxy of customer numbers is often used rather than volumes of electricity.

The cost or implied cost varies considerably but even in the UK it is currently only ~1.5% of household fuel bills (**Table 3.5**,).

Most of the energy efficiency obligations allow "banking", e.g. carrying forward of excess savings from one target period to the next. This has important benefits, not just for the energy company but also for the energy efficiency industries133.

In Flanders and the UK, the energy companies are required to ensure that there are also savings in low income households. This is achieved by ring fencing a fraction of the energy saving target that has to be met by savings in such households. In fully liberalised markets where the supply price controls to residential customers have been dropped, it is up to energy suppliers to decide how to cover the costs of the energy efficiency obligations. Where prices are still controlled the Government could influence the way the tariffs recovered the costs and social tariffs could be exempted to address equity issues.

Interaction with Other Policy Mechanisms

Inevitably national governments have a variety of policies designed to improve energy efficiency in all end use sectors. There can be complications from interactions between such policies, which either are required by legislation or are subsidised by central Government and the obligations on the energy companies.

In other words, is there either genuine collateral (in the case of existing legislation requiring Minimum Performance Standards of energy efficiency) or double subsidies of the measure by Government and the energy company?

A pragmatic approach has been taken to dealing with these issues in all countries. For example, in the UK only energy efficiency measures, which produce a performance above, that required by legislation (e.g. in new build or major refurbishment or EU Minimum Performance Standards for Appliances) are approved as eligible energy savings and only for that part which is in excess of the regulatory requirement. Indeed, the UK has gone further in the appliance field by only allowing an energy saving for an energy efficient appliance or heating boiler, which is above the market average for such products.

In a similar vein, the UK disallows the parts of the savings which are supported by any central government funding (e.g. programmes tackling low income households)134.

In Italy and France, certain energy efficiency measures can be offset against income tax, but this has been allowed only as central Government funding/subsidies are not considered additional.

Nature of Target

There is widespread variation in the nature of the target set (**Table 3.5**). There are local reasons for why this might be the case, and it is worth examining some of the key considerations.

The energy saving credits are based (or in a few cases measured) on the saving of delivered energy. For countries concerned with reducing their energy imports, the use of primary energy which is usually 2.5 times delivered or final energy for electricity with the other fossil fuels being taken as equivalent to their delivered energy, is common. For countries, which are concerned about reducing CO_2, it is quite common for the energy savings to be carbon weighted by the carbon content of the saved fuel.

[133] In the UK in 2000, when there was a transition and before the carrying forward of savings was permitted, the energy suppliers met their targets early and the insulation industry suffered nearly a 25% drop in activity until the new obligation started.

[134] Any measures, which are double, subsidised by that programme and the energy supplier result in the energy savings that can be claimed by the energy supplier being proportional to the share of their contribution towards their measure.

In terms of for how long the energy savings should be defined, the two extremes are simply an annual energy saving and lifetime energy savings[135].

Another issue for debate is whether the energy savings should be discounted over time to reflect the time value of money, as is common in normal financial appraisals. The discount rates have varied between 8% and currently 3.5- 4%. The key question is perhaps whether this is being done for economic or environmental reasons. If for economic reasons, then the use of discount rates merely conforms to standard energy appraisal options. However, if this is being done for climate change reasons, it may not be appropriate to discount the energy and consequently carbon dioxide savings, certainly not at a high discount rate136.

Definition of Eligible Measures

Again the eligible measures are usually defined in advance by the monitoring and verifying authority. This means that only measures that have been independently proven to save energy are utilised. In one sense this is clearly a good safeguard for consumers but it has also been said that it can work against development of innovative technologies. To counteract that, Italy, France and the UK have the option of allowing energy suppliers to deploy innovative technologies and to monitor the resulting energy savings which can subsequently be claimed. This option has been rarely used and the UK is currently looking at how innovation can be encouraged better by other means from 2008-2011. However, many studies have shown that at least 20% of energy consumption can be saved through the widespread application of existing, proven technologies, which is clearly the short term policy focus.

To date, most of the obligations have focussed on energy saving measures. This means that co-generation, solar water heating and other renewable forms of heating have generally been included but there has been less promotion of renewable energy generation technologies. This is not least because there are usually different policy mechanisms to support the development of renewable generation technologies. However, in the UK, with the move to CO_2 targets in 2008, supporting household and community scale renewable energy sources will be possible under the new obligation.

Although the countries have various end-use sectors to which the obligations apply, they all have included the residential sector. While lighting and heating measures feature strongly in all four countries, there are marked differences in the appliance and insulation areas (**Table 3.6**). Some of this can be explained by local conditions, e.g. the UK has low standards of insulation in its existing stock.

At present there are few, if any, energy saving credits for “behavioural” change measures such as smart meters with consumption feedback to households, energy efficiency advice, etc. However, this reflects more the difficulty in establishing firm energy saving values and the appropriate lifetime for such measures rather than any fundamental barriers. Indeed, work is currently underway in the UK to look at introducing energy savings for such measures from 2008.

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[135] In Italy, energy savings are counted for the period of the obligation, i.e. for five years, except for building fabric measures where the savings are counted for eight years. This is to address the criticism that by only counting annual energy saving, longer life measures are discriminated. For example, for two measures with the same cost and the same annual energy saving, lasting respectively 5 and 20 years, there would be no difference with an annual saving target, although the savings for the longer life measure would be 4 times as great.

[136] Climate change is driven by the concentration of CO2 in the upper atmosphere. Thus it is the total amount of carbon saved rather than the annual carbon savings which are more important

Monitoring and Verifying Energy Savings

The great majority of projects have been carried out by utilities utilising the estimates or extant energy savings, or in the case of industrial and commercial measures, by scaling engineering estimates of proven energy savings137. For example, in the residential sector although the energy savings will vary from household to household, for either insulation or new appliance. Measures are being adopted, as long as the average energy saving has been established. Then the use of an estimate or extant savings will represent the real situation because of the large numbers of households involved. This approach greatly simplifies the monitoring and verification process which in effect becomes the same as counting the number of energy efficiency measures implemented and can be verified using the standard "dip check" or random sampling audits. In addition, this method has low costs for implementing and verifying such energy efficiency measures.

In the UK, energy suppliers submit outlines in advance of what they intend to do and the energy savings they are likely to claim. This has benefits

both for the Regulator and the energy company in minimising later disputes in terms of energy savings achieved. The final approved energy savings are of course related to the actual outcome rather than the outline. In the fully traded White Certificate schemes, as in Italy, the energy company can either provide the approved savings from its own projects or purchase an appropriate number of White Certificates to meet their targets[139].

Table 3.6: Measures employed to save energy in the residential sector 138

Measure	Flanders	France	Italy	UK
Air conditioning units				
Appliances: Cold			OO	OO
Set top boxes				
Wet			O	OO
Cogeneration			OO	#
CFLs	OO	O	OO	OO
Condensing Boilers	OO	O	O	OO
Fuel switching			OO	O
Glazing	OO	O	O	O
Heating controls		O	O	OO
Heat pumps	O	O	O	O
Insulation: Attic	OO	O		OO
Draught proofing				O
Hot water tank				O
Wall		O		OO
Low flow showerheads	OO		OO	
Smart meters			n/a	
PV panels			O	O
Solar water heating	O	O	O	O

OO widely used ; O used

[137] Scaling of energy savings according to the size of the plant again provides a simple and robust method for determining energy savings.

[138] For France it is too soon to differentiate between used and highly used measures

[139] None of the existing White Certificates schemes trade certificates outside of the specific energy efficiency obligation although there is an expectation that in the future trading may take place in wider carbon markets

Obviously, to make the estimated energy saving or engineering estimate approach work successfully, transparent and clear information should be available from the body responsible for accrediting energy saving values or White Certificates to energy companies, which are published well in advance of the duration of the obligation[140.]

The Treatment of "Free Riders"/ Additionality

As with all public policies, there is a need to address dead-weight/free riders/additionality issues i.e. end users that would have utilised the energy saving measure anyway. The way this issue is handled is linked to the size of the target but this issue is topical for French, Italian and UK energy efficiency obligations.

For low targets, when the size of the activity being supported by energy companies is comparable with the historic activity in the energy saving measure, minimising the number of free riders on a project-by-project basis has been widely used141.

However, as the scale of the activity being supported by energy companies becomes greater than the earlier activity in the energy saving measure, a different approach is required particularly for measures using retailers to reach the energy companies' customers. This is currently the situation in the UK and the approach taken there has been to build the free riders into the target[142]. In other words, the Government decides on the energy savings over "business as usual" target it wants to achieve and then adds on the business as usual activity to determine the final target for the energy company[143].

Supplier or Distribution Obligation. Which is Optimum?

There are pros and cons of both approaches. In favour of suppliers is their strong links to the customers and, in a liberalised market, increasing marketing skills. In favour of a distribution levy is the fact that utilities are more stable organisations, being often regional monopolies, and they are already regulated. The main disadvantages are that distribution companies' contacts with customers, particularly in the residential sector, are usually only when there is a failure in the wires or pipes business and that depending on the Government's view, such distribution levies can be counted as part of public expenditure, a cost which Governments usually wish to minimise.

The key is that both systems can be made to work but certainly there is more of an incentive for energy suppliers to reduce the amount of energy supplied to their customers than for distribution companies.

Meeting the Target: Energy and CO2 savings

The experience to date in the UK, Italy and Flanders has shown that the companies have easily met their targets. In the UK, on average the energy suppliers have met their targets with an expenditure of 20% less than the Government expected, and since 2002 have carried forward energy savings from one phase of the obligation to the next. In Flanders, the energy distributors met their targets at 40% less cost than budgeted in 2004 and at 24% less cost than budgeted in 2005.

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[140] In France, standardized technical file have been prepared to specify the amount of savings linked to all eligible energy savings actions or equipment. They are available on the Ministry web site (in French) (http://www.industrie.gouv.fr/energie/sommaire.htm).

[141] For example in the UK in the early 1990s, there were around 10 million properties capable of having their cavity walls insulated and yet the annual installation rate was ~120,000 per year or 1.2% of the potential. By requiring the energy suppliers to arrange their insulation promotions on a localised basis, the probability of getting free riders was greatly diminished.

[142] For the first phase (2002-5), the Government expected a deadweight contribution to the target of 28% and the evaluated deadweight figure was ~21%. Since then the targets have increased by roughly a factor of 2 in 2005 and will do so again in 2008; consequently, the free rider issue will become less of an issue.

[143] Clearly there is a need to know previous sales of energy saving measures and this is obtained from a variety of sources (e.g. commercially available market data on energy efficiency products sold through retailers, numbers of insulation/ heating products through the appropriate trade bodies).

In Italy, the first year's targets have been met and the corresponding price of White Certificates indicates that the distribution companies have met their targets well below the allowance in the distribution price.

In Flanders the energy and carbon savings are for electricity users only. By the end of 2005, the electricity distributors had reached 494GWh/year electricity savings with their larger customers (>1kV) and 520/yearGWh with low voltage customers (mainly residential); both figures are inclusive of "deadweight". In principle, this would correspond to over 6% of Flemish electricity consumption144. The reported CO_2 savings are 0.37Mt/year (end of 2004).

In the UK, the energy savings from the first period (2002-2005) have been estimated to be around 40TWh for electricity and 100TWh for fossil fuels with both figures being lifetime savings including deadweight[145]. The CO_2 savings have been estimated by Defra after correction for deadweight to be 0.5Mt/year (1.8MtCO_2/year) or 1.3% of household annual emissions.

In Italy the targets for 2005 were equivalent to 456GWh/year electricity saving and 675GWh/year gas savings (both figures in delivered units). The Italian regulator has reported that both figures were easily exceeded. The 2005 annual target corresponded to 0.15% and 0.13% of Italian electricity and gas consumption respectively. This is only the first year's savings and the targets will increase in subsequent years. In the first year, the CO_2 savings were 0.76 Mt/year. To date, the CO_2 savings are 2.3 Mt/year.

Targets were generally set at a low level to initiate the process, which explains why they were reached in all countries146. They consisted so far of simple measures and have not yet tapped the large energy efficiency potentials in the structure of the existing buildings[147].

Trading

To date, the experience of trading in White Certificates has been somewhat limited. This is perhaps to be expected because only in the more recent Energy Efficiency Obligations in Italy (since March 2006) and France there are opportunities for market players other than the energy companies to attain independently and trade White Certificates. Thus the market is in its early stages and will undoubtedly grow over time.

In the UK, trading is only permitted between energy suppliers and has rarely been used. The main example of trading was between some of the smaller companies which had their requirements fulfilled by one of the six major energy suppliers.

In Italy, because of the very limited trading nature (less than 20% of the White Certificates in 3 months were traded), it is not entirely clear what the prices of the White Certificates in the market place are signalling. Most of the White Certificates in Italy have been obtained directly by the energy distributors working either in bilateral or contractual arrangements with deliverers of energy efficiency measures148.

The current (May 2007) situation in Italy is that the average price of White Certificates is around €43/toe primary energy for electricity and around €85/toe for gas. Both are well below the €100/toe primary energy allowed in the distribution price control.

[144] Estimates subject to concern as some changes have been made to how the savings are calculated and there is also insufficient clarity on how additionality/deadweight has been handled.

[145] It is difficult to be precise about the impact of deadweight but a rough estimate is that the savings would reduce to 33TWh for electricity and 50TWh for fossil fuels with both figures being lifetime savings.

[146] In France, the target is estimated at 0.4% of the consumption; it is around 0.2% in Italy and 1% in UK

[147] The only exception is in the UK where part of the savings were obtained by insulating cavity walls, which is however a simple and not expensive action.

[148] The market structure for White Certificates is dominated by ENEL for electricity and Italgas for gas (ENEL had over 90% of the target for the 10 electricity distributors and Italgas 35% of the 20 gas distributors' target).

Although, trading is not widely permitted in the Flemish and UK, certain facets are similar. For example, energy companies may carry forward excess energy savings from one phase to the next.

Financial Costs and Benefits Arising from Energy Efficiency Obligations

Although all the costs are ultimately borne by energy users, it is perhaps helpful to get a range of the transaction costs involved and who initially pays them. Currently, only the UK has the full data publicly available (**Table 3.7**).

The great majority of the total cost is associated with promoting and installing the energy saving measures. Although energy suppliers are the single biggest contributors to these costs, money is also coming from those customers that can afford to pay as well as landlords, charities, manufacturers etc. The energy companies need to spend significant sums to ensure that these energy saving measures reach their customers: such energy supplier indirect costs were evaluated in 2002 to be around 20% of total costs[149].

Table 3.7. Breakdown of the costs associated with UK energy efficiency obligations[152]

Cost Area	Cost Borne by	Share (%)
Direct costs associated with energy saving measures	Energy suppliers, customers, landlords, charities, manufacturers etc.	80%
Energy company indirect costs (e.g. marketing & sales, project management & facilitation, planning, reporting etc.)	Energy suppliers	20%
Monitoring and Verification of the energy saving projects	Obligations administrator – UK energy regulator	<1%
Target setting	UK Government	<<1%

Then there is the cost of monitoring, verification and general administration of the energy saving projects by the energy suppliers. In the UK, the energy regulator Ofgem carries out this task and estimates that this cost is less than 1% of energy supplier expenditure. Finally, there is a cost of setting the target and the associated legislation[150].

Data on costs and benefits are available for Flanders, Italy and the UK. They are evaluated from an energy company's perspective and also from a national perspective. The former only considers expenditure by the energy supplier; the latter includes the costs to all participants, i.e. energy companies, customers, third parties (e.g. local authorities, landlords, manufacturers, charities etc.).

The energy company perspective

Comparison of cost effectiveness from an energy company perspective is complicated by the difference between the targets (annual or lifetime), the use of a discount rate (6%) for lifetime savings and the different measure mix and hence average duration (**Table 3.8**). The Flemish value is the average of residential and non-residential customers. Separating the two classes, the values are for non- residential 2.7c€/kWh and for residential 7.6c€/kWh (with both figures being annual savings compared to a 0.027€/kWh "one-off" cost of the measures).

Table 3.8: Comparisons of cost effectiveness from an energy company's perspective[151]

Country	c€/kWh annual	c€/kWh lifetime
Flanders (2005)	4.8	
Italy (2006)	3.8	
UK (2004)		0.8

To enable a rough comparison of all three countries, we have used an average life of 12

[149] It is likely that as the scale of the obligation has increased significantly since then, this percentage has reduced

[150] In the UK, this is undertaken by one of the UK Government Departments (Defra). As this is only undertaken periodically, the costs are less than those of Ofgem.

[151] Broad estimates using published data

[152] Indicative breakdown of cost

years and undiscounted savings. The annual cost per unit of electricity in the UK is estimated at around 6.8 c€/kWh. As the UK obligation is only targeted at households (more expensive than saving energy in commercial and industrial sectors) then the results are broadly comparable.

The estimate for Italy is derived using a market price for White Certificates for electricity of €70/toe primary energy saving; this is likely to be an overestimate as the cost of a White Certificate is currently below €50. In France, the expectation is that the cost to the energy suppliers of saving a unit of delivered energy will be less than 1c€/kWh lifetime.

The national perspective

Insufficient data have been published for Flanders to make any estimate possible; likewise for Italy. The only readily available data are from the UK: results from the evaluation of the energy efficiency obligations are drawn upon here153.

The traditional way is to look at the lifetime net present value (NPV) of the obligations, which ran for 3 years from 2002-2005. The responsible UK Government Department, Defra, has evaluated that for a total investment (i.e. all costs of the energy suppliers, customers and third parties) of €0.9billion, the NPV (using a 3.5% discount rate) is €4.5billion. In terms of resource cost to save a tonne of CO_2, Defra evaluated this at - €450/tC, i.e. a net benefit rather than a cost.

An alternative way of looking at this in more familiar units is to look at the cost to the nation of electricity or gas saving: 2c€/kWh for electricity and 0.7 c€/kWh for natural gas; both figures are considerably less than the average consumer prices during that period of 10c€/kWh and 2.6c€/kWh respectively.

[153] See UK case study in Annex 1. The evaluation covers the period 2002-2005.

3.9 Packages of Complementary Measures: Case of Solar Water heaters[154]

This section describes the different instruments used to promote the diffusion of solar water heaters, with a specific focus on the way complementary measures have been implemented to create synergy between instruments ("package of measures)". The measures will be divided into three groups:

- economic incentives to lower the investment barrier and improve cost effectiveness (direct subsidies, low-interest loans, tax exemptions, third-party financing, etc);
- regulations requiring new or renovated apartment buildings to be equipped with solar energy systems;
- strategies to improve the quality of equipment and installations through the use of technical standards and quality labels.

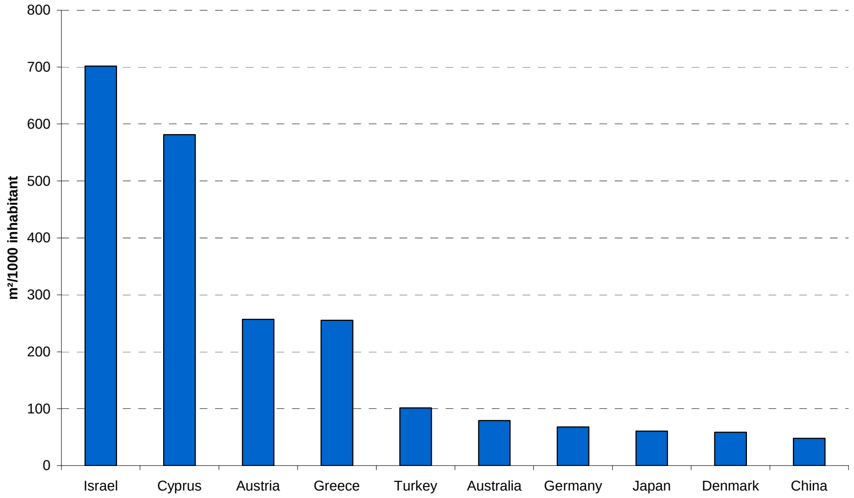
The most important packages of measures considered are:[155]

- direct subsidies and access to loans to improve cost-effectiveness while limiting investment constraints
- economic incentives contingent upon the use of products with quality labels to encourage the diffusion of high-performance installations
- special financing schemes or labels to complement regulations to limit impacts on the

[154] This section is based on a report prepared for the project by Philippe Menanteau from LEPII/CNRS-University of Grenoble. The report, with all references, is available on the WEC web site: "Policy measures to support solar water heating: information, incentives and regulations ", ADEME and LEPII, May 2007. The study includes 6 country studies (Austria, Spain, India, China, Mexico and Tunisia), which can be found in Annex 1.

[155] Public procurement have not yet be used at a significant scale to promote solar water heaters; this is why they are not considered here.

Figure 3.17 : Cumulated installed capacity of solar water heaters per capita



price of housing and prevent cost constraints from leading to a drop in housing quality.

State of the market and barriers to diffusion

China: the market leader

The market for solar collectors is dominated by China, which accounted for close to 80% of world annual sales of collectors for solar water heating or for heating buildings, ahead of Turkey and Germany. Sales in China are increasing by approximately 20% per annum, representing an additional collector area of 1.5 to 2.0 million m² every year[156].

A few countries such as Brazil, India, South Africa and Mexico already have significant cumulative collector area. Elsewhere, installed capacity is much lower but numerous markets seem to be emerging in the developing world in response to he growing demand for solar water heating.

Apart from a few exceptions, the per capita installed area of collectors is still very low in developing world. In the leading countries (Israel, Cyprus, Greece and Austria), per capita installed area varies between 250 and 700 m²/1000 inhabitant[157] but the market is gaining very slowly (**Figure 3.17**).

In Germany and Turkey, the installed area of solar collectors is well below these levels but the market is rapidly expanding with per capita installed areas increasing from 44 and 70 m² respectively in 2001 to 68 and 101 m² in 2004.

China, is still only in tenth position with a per capita equipment rate of 48m² but this figure is increasing rapidly (the equipment rate was expected to reach 80m²/inhabitant in 2006, i.e. a 4-fold increase between 2000 and 2006).

Principal barriers to diffusion and cost considerations

The cost of a solar water heating system varies considerably. It can be as low as 300 – 400€ in China and India and as high as 5,000 – 7,000 € in the countries of Northern Europe. The differences in cost can be explained by the differences in installed surface area (from 2 m² to 6 m² per installation), which will depend on hot water needs and hours of sunshine. But there are also significant differences in the cost per unit of area (**Figure 3.18**).

In Europe, a solar water heating system costs on average between 600 and 900 €/m², compared

[156] Data for 2004. A more complete analysis of the market development can be found in the full report.

[157] All data on per capita m2 are in m²/1000 inhabitant.

with 200 – 300 €/m² in India, China, Greece Turkey and Israel. There are several explanations for the large difference in systems costs: the level of sunshine (lower cost in countries with more sunshine as simpler technologies can be used), the size of the market (economies of series, such as in Turkey or in China)158, quality and standards of the systems and, finally, labour costs. The two last factors explain a lower cost in developing countries

In Europe, solar water heating systems are not, at present-day prices, generally competitive with conventional water heating technologies (gas or electricity)[159]. The situation is better in Mediterranean countries, where the climate is more favourable and where less sophisticated technologies are used.

Individual thermosiphon systems can be a viable alternative to conventional water heaters in the developing world (e.g. unit payback of 2 years in Barbados or between 3.5 and 6 years in Mexico, a country with relatively low energy prices). In some countries however, the subsidised energy prices may create market distortions and prevent the dissemination of solar water heating systems (e.g. Algeria). When the payback period is acceptable, the initial investment, compared to standard water heater may nevertheless be a big constraint for consumers160.

[158] The right scale of the Figure indicates for each country the size of the market (installed capacity per year).
[159] In countries in the central and northern areas of Europe, average payback periods can exceed 10 years, even when available subsidies are taken into account.
[160] In Mexico for instance, the cost of a solar installation is 3 times that of a standard water heater.

3.9.2 Measures and packages of measures

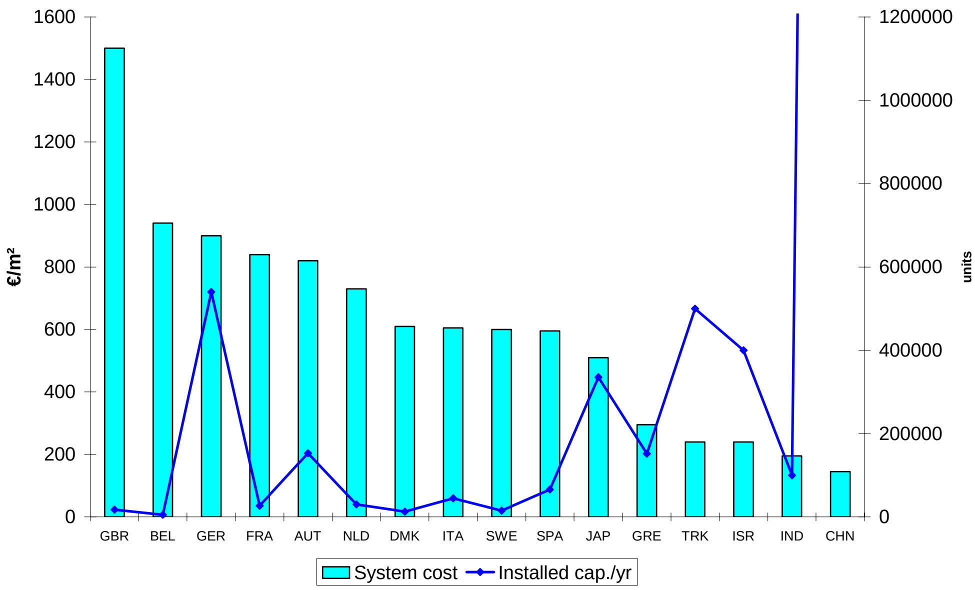
In most countries, solar water heating is a mature technology but its diffusion is still severely limited by economic constraints. The main economic barriers are the excessively high initial outlay and long payback periods for investors (residential or tertiary) who expect a return on their investment after no more than a few years (typically 2 to 3 years). For this reason, measures to support the development of solar water heating technologies are based principally on economic instruments (subsidies, low interest loans, tax relief). Regulatory approaches have also started to appear in recent years. Regulations make the use of solar energy compulsory in situations where economic incentives have not been sufficient to overcome existing barriers. In addition, other measures to provide information and enhance awareness, and to improve quality in general, are used to help overcome the non-economic barriers and identify other factors that influence consumer motivation.

Subsidies

Subsidies are intended to reduce the capital cost at the time of purchase and shorten the payback time. They can also be used to promote quality if they are granted on condition that the equipment or the contractors comply with certain quality criteria. Finally, subsidies provide the public authorities with the opportunity to show their interest in solar technologies. Combined with a clear and policy to develop solar technologies, this can help mobilise professionals in the sector and build consumer confidence in the reliability of solar water heating equipment

Numerous examples of policies to support the development of solar collectors show that subsidies are an effective way of boosting sales. In Europe, financial incentives are seen as a key factor for developing the market for solar water heating systems and almost all member states provide financial incentives for their installation.

Figure 3.18 : Total cost of solar water heating per m²



Source : from ESTIF, 2003

The experience of Tunisia and Taiwan among other countries shows that if subsidies are discontinued prematurely, it is quite possible for sales to plummet161. However, once the critical mass has been reached economic incentives can be reduced and even stopped without slowing down the diffusion dynamics (e.g. Greece)[162].

But direct subsidies are not without a certain number of drawbacks, the main one being the cost for public budget if the financial incentives concern a large volume of equipment over a long period of time. Furthermore, direct subsidies can involve very high transaction costs, in particular when they are granted for individual systems. Finally, as discussed above, subsidies may also have negative impacts on markets for a number of reasons:

- negative impact on demand, on networks of contractors and on manufacturers and importers if subsidies are withdrawn too rapidly in markets that are not sufficiently prepared (cf supra);
- effects of the market anticipating the withdrawal or introduction of subsidies, leading respectively to a rush to buy or to a waiting game;
- the cost of equipment might increase if manufacturers or contractors raise their prices in anticipation of the rebates that purchasers will be granted.

To limit these drawbacks, it is first of all necessary to avoid changing the subsidy schemes too often and in an inconsistent way. Subsidies could also be reduced progressively as the market develops and actors can anticipate their phase out.

Tax credits / tax incentives

There are various types of tax incentive: tax reductions (lower VAT for example) applicable to equipment or installation costs, reduced tax rates on imported equipment where applicable, tax credits, accelerated depreciation, etc.

Several European countries have lowered their VAT rates on solar equipment (e.g. Spain and Austria with full exemption from VAT). Tunisia has also introduced a reduced VAT rate in its incentive programme financed by the GEF (1997-2004). Several countries have implemented tax credit schemes, where households can deduct part of the purchase cost of the solar water heating equipment from their income tax[163].

The aim of tax incentives is much the same as that of direct subsidies: they reduce the investment cost and therefore improve the return on this investment. For public authorities, they represent a loss in tax revenue rather than an additional expenditure. However, unlike subsidies, tax credits do not lower the barrier of the initial upfront payment, and therefore do not help low-income households.

Low-interest loans / third-party financing

Providing access to credit is another way of lowering the initial cost barrier as long as the interest rates are lower than those generally applicable to consumer loans. Loan facilities are often set up as a complement to direct subsidies to help cover the remaining cost that has to be paid by the investor.

In Spain, the possibility of obtaining low interest loans has greatly facilitated implementation of legislation on solar installations[164]. India has also adopted a strategy based on low-interest loans to help consumers to invest in solar water heating systems.

[161] See the full report and the case study on Tunisia.
[162] Greece, Israel, Japan and China have succeeded in making solar water heating a standard technology that now competes with conventional water heating systems sufficiently well for such incentives to be no longer needed (see the case studies on Greece and China).

[163] In France, since the start of 2006, consumers installing solar water heaters have benefited from a tax rebate of 50%.
[164] See case study for Spain in Annex 1.

It is possible to go even further by adjusting loan repayments according to the energy savings produced by the solar water heating system. This is the principle of third party financing where the party paying for the equipment, usually an ESCO (energy services company), is reimbursed from the savings made[165]. This type of arrangement has been used to finance solar installations in the hotel sector in Spain. However, this method of financing is still not very widespread.

Regulations

Even in fairly mature markets, solar water heating systems are not used in all situations where they would be justifiable from a financial point of view.

The reasons are numerous and include: lack of trust in new technologies, long payback times and preference for immediate savings, insufficient visibility and information, lack of motivation and awareness on the part of decision-makers, high transaction costs, problems with owners / tenants, and so on. In such circumstances, regulations making the use of renewable energy sources mandatory provide a way of expanding deployment and benefiting from increasing returns to adoption.

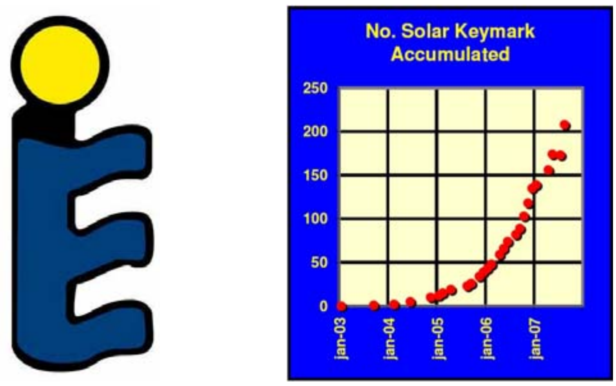
Israel was the first country to make the use of solar water heaters mandatory in 1980, followed recently by Spain (first in 1999 in Barcelona City and in March 2006 in the rest of the country with a new Building Code).

In Spain, the purpose of the new Building Code is to promote the use of solar water heating systems in all new or renovated buildings. It stipulates that in these buildings 60% of hot water demand must be met by solar. The results achieved by Barcelona demonstrate the effectiveness of this approach, since the average surface area of collectors installed each year increased by 1.1 m²/1000 inhabitants before the Ordinance to 13 m² in 2004.

The additional investment cost was finally kept within 0.5 and 1% of total construction costs and was covered by no-interest loans offered by the Instituto de Crédito Official.

Regulatory measures result in a much larger market for the technology and can thereby help improve performance (reliability/cost) and enhance the visibility of the technology, as well as set in motion a virtuous spiral that will lead to greater diffusion. Nevertheless, minimum quality levels must be imposed to prevent the solar energy obligation from encouraging the use of inexpensive but inefficient equipment. Standards and quality labels can ensure that such minimum requirements are met.

Figure 3.19 : Keymark label for solar water heaters



Source: ESTIF

[165] See section on ESCOs.

Improving quality: standards and labels

The real or perceived quality of systems is an important driver or obstacle to further dissemination of solar water heating. In several countries, the low quality of equipment and installation, and the lack of adequate maintenance is a clear barrier to the development of solar water heating. At the opposite, the high perceived quality of solar products and installations can be a key element for consumer confidence and an important driver for the dissemination of solar water heating (e.g. in Austria). The quality issue does not concern the manufacturer alone but also the installer and often first the after sales and maintenance network.

The aim of standards is to guarantee or improve quality. Technical standards are drawn up with reference to a given set of specifications and guarantee a specific level of quality. In addition to product standards, there are standards relating to the installation of equipment. In Europe, the Keymark certification scheme developed by European manufacturers with ESTIF is now recognised and facilitates the movement of products between countries by making it easier to get financial incentives (**Figure 3.19**)[166]. China intends to develop its own national technical standards on the basis of this label. While the technical standards are restrictive, labels designed to achieve the same ends are, in theory, less restrictive. In practice, labels may become restrictive if consumer access to subsidies or loans is conditional on certification of the product or contractor.

In addition to standards, special contractual approaches have also been developed aimed at guaranteeing or improving the quality of solar water heating systems. For example, the Guarantee of Solar Results project has been implemented on an experimental basis in certain countries such as France and Spain. Applicable to large installations, its aim is to check that the real performance of a system corresponds to the advertised performance, and to compensate users if this is not the case. The risk related to poor performance is no longer borne by the user but by manufacturers and installation contractors, who are thus strongly encouraged to supply high quality equipment.

Anyway, setting standards is not enough. It is also necessary to make sure that these standards are effectively enforced. Without certification facilities, it may be difficult or impossible for most countries to check the compliance of imported products with national standards; it may also be impossible to adapt or strengthen the national standards to follow the technical change in state of the art technology. A national or regional testing and certification centre that can verify the compliance of marketed products with the national law (technical standards) is a key element for the implementation of policies intended to promote de diffusion of solar water heating.

Complement of instruments

In reality the policy instruments presented above are seldom implemented alone and often used in combination to complement each other. Therefore, the support to solar is often based on a package of complementary measures.

Subsidies at time of purchase / access to credit

Direct subsidies help address the problem of capital outlay but are not sufficient in themselves to help the lowest income families to purchase solar water heating equipment. Similarly, tax credits and tax rebates help improve the return on investment in solar water heating but do not help families with very limited financial means to purchase solar water heating systems. In this case, it is essential to provide complementary measures to facilitate access to credit, such as low-interest loans or schemes involving third party financing[167].

Energy and environmental taxes are other factors that determine the economic competitiveness of solar water heating systems. A number of European countries have introduced environmental taxes or adopted energy taxation systems that make fossil energy sources more expensive and

[166] www.keymark.org

[167] See case study for Tunisia, where loan repayments are made through the electricity bills and are calculated in such a way that they remain lower than the savings on electricity made by using solar water heating.

improve the return on investment for solar installations. However, existing energy taxation is not always compatible with the objective of promoting renewable energy sources. In many developing countries, fossil fuel subsidies that are intended to facilitate access to energy for the poorest families have an adverse effect on sectoral policies aimed at promoting solar water heating.

Most of the time, direct subsidies must be combined with systems providing access to credit (in particular low-interest loans), especially in developing countries where the cost barrier is felt most strongly.

Economic incentives and quality labels

Economic incentives are almost always conditional upon certification as a way of promoting the use of high quality equipment. In practical terms, this means that economic incentives are granted only for equipment that has an approved quality label, in other words that meets stringent quality requirements[168]. Economic incentives thus enhance the effectiveness of labels which themselves are designed to promote better quality equipment.

Subsidies can be granted to encourage the use not only of high quality products but also of qualified installation contractors and high-performance installations if they are awarded on the basis of minimum performance levels. For instance, in the Netherlands, the amount of the subsidy is determined by the performance of the installation. On the other hand, experience in Tunisia has shown that it is not enough to set up schemes to finance investment in solar water heating; they must be accompanied by measures to improve quality. In fact the market collapsed when subsidies were withdrawn because of insufficient quality control and a negative perception of the quality of solar equipment among consumers.

[168] In France for instance, the tax credits are applicable to solar water heating equipment that have been awarded CSTBat or Solar Keymark certification. Similarly, in India, only solar collectors certified by the Bureau of Indian Standards are eligible for low-interest loans.

More generally, financial incentives and public information and awareness campaigns are complementary. Information campaigns are intended to stimulate public interest in solar water heating; to be effective, consumers need incentives to be able to purchase solar water heaters. In the same way, any economic incentive schemes must be promoted through public awareness campaigns if they are to be truly effective. Public information and awareness campaigns are thus a vital complement to economic incentive programmes.

Regulations / financial aid / quality labels

Where regulations have been introduced, additional economic incentives may be necessary to ensure that the initial extra costs involved (at least during the early stages) do not give rise to increased construction costs and make home ownership more difficult for lower-income families. At the same time, regulatory measures must be accompanied by equipment certification schemes to ensure that pressure on building costs does not lead to poorer quality installations and ultimately a decline in consumer confidence.

A regulatory approach, more than any other type of instrument, must be part of an overall strategy based on a wide variety of incentives. For reasons discussed above, financial incentives must be made available (subsidies and/or low-interest loans), and quality improvement measures should be introduced, such as product labels and special certification for installation contractors. Generally, when regulations are introduced making solar systems mandatory, additional support measures are necessary: information and awareness programmes, schemes to maintain or improve quality (standards / labels), training and certification schemes for installation contractors, special support measures on the supply side (R&D programmes, opportunities to achieve economies of scale), urban planning regulations that take into account solar water heating, and so on. More generally still, the motivation and involvement of all the players in the sector is needed to find the best solution for promoting the integration of solar water heating in buildings.

The development of an energy efficient economy is a crucial, difficult and motivating challenge for all countries. The high oil prices and the limited public resources for investment in energy supply and, in the long-term, the prospective depletion of fossil energy resources and the risk of climate change provide strong incentives for the exchange of experience on energy efficiency policies: it is a win-win strategy as it addresses at the same time many strategic issues. The World Energy Council is a unique forum, which can assist countries in overcoming these challenges.

4. Conclusions and Recommendations

Various reasons justify the introduction of energy efficiency policies. On the short term, macro-economic constraints brought about by the high oil prices are often the main drivers with their impacts on the deficit of the balance of trade, on consumers welfare (reduction of purchasing power) and on the competitiveness of industrial companies, and, when prices are subsidised, on the public budget and profitability of energy utilities; in developing countries, shortage of capital for public investments is an additional incentive. Long-term issues such as global warming, but also the looming depletion of oil and gas resources and the consequences for the energy security are also important drivers.

The WEC's Energy Efficiency project aims to facilitate the exchange of information and share experiences on energy efficiency measures among countries around the world. This can help government decision makers, industry leaders and analysts select appropriate and cost effective sets of measures for each sector, taking into account their national circumstances. Decisions tools such as energy efficiency/CO_2 indicators are useful to monitor trends in energy use and CO_2 emissions and to contribute to evaluate and understand the impact of the measures implemented in each sector.

4.1 Energy Efficiency and CO2 Trends

Energy productivity improvement of 1.6% p.a. between 1990 and 2006 at world level; poor performance of China since 2000 after a very rapid progress before

Energy consumption is growing less rapidly than the economic activity in all world regions, except the Middle East: this corresponds to an improvement in the energy productivity.

At world level, the energy consumption per unit of GDP i.e. the energy intensity has decreased by 1.6% p.a. on average between 1990 and 2006. Almost two thirds of the countries in the world have decreased their energy intensity, of which 40% by more than 1% p.a. (70 countries) and 25% above 2% p.a. (40 countries).

On average at world level, the reduction was much faster before 2000 (1.8% p.a.) than after (1.4% p.a.), mainly because of the changes taking place in China. Indeed, China experienced a very rapid improvement in its energy productivity between 1990 and 2000, at around 7.5% p.a., as a result of various factors: more efficient use of coal, switch from coal to oil, industry restructuring and higher energy prices. After 2000 this trend has however slowed down significantly, to slightly less than 1% p.a.

If we exclude China, there is an acceleration of the energy productivity improvement at world level since 2000 because of the higher oil price in 2005 and 2006 (1.5% p.a. compared to an average trend of 1.3% before).

Large differences exist between world regions in their energy intensity level: the energy intensity of the CIS is three times higher than in Europe, the region with the lowest value; it is respectively 40% and 30% higher in China and in North America compared to Europe. Similar differences across regions can be seen in their energy intensity trends (very rapid reduction in China, increase in the Middle East and in the most developed regions of Asia).

Energy intensities are generally decreasing with economic development and are converging

Energy intensities are in general decreasing in energy importing countries, due to the pressure of high energy prices, as well as in most OECD countries. Even those with significant energy resources (e.g. USA, Canada, Australia), because of saturation in some end-uses and in some countries as a result of energy efficiency and climate change policies. Energy intensities are however increasing in non-OECD oil producing countries and, to a lesser extent, in some countries with significant energy resources.

As a very long-term trend, energy intensities follow a "bell curve", generally with developing countries to the left, with increasing intensities, and developed countries on the right side, with decreasing and converging values.

Energy productivity improvements in most world regions since 1990 resulted in 4.4 Gtoe energy savings in 2006 and avoided 10 Gt of CO_2

The reduction in the energy intensity between 1990 and 2006 in most world regions resulted in large energy and CO_2 savings, estimated at 4.4 Gtoe in 2006 (50% in China, 20% in North America and 10% in Europe) and 10 Gt of CO2. In other words, had technologies and economic structures of the main world regions remained at their 1990 level (i.e. at 1990 intensities), the world would have consumed 4.4 Gtoe more in 2006.

Energy productivity gains were generally greater at the level of final consumers, by 20% at world level

Energy productivity gains are greater at the level of final consumers (industry, transport, households and services) than at the overall level (i.e. including the energy transformation sector): increasing losses in energy conversion have offset about 20% of the gains achieved by final consumers. The increasing use of electricity by final consumers has resulted in greater losses in power generation, as most of the electricity is produced from thermal or nuclear power plants[169].

Energy efficiency of thermal power generation is still low in most emerging and developing countries, resulting in a significant source of energy savings

Energy efficiency of thermal power generation only improved moderately, by 2 points since 1990 at world level, the average efficiency at world level is presently 34%, which is far from the EU average (40%) or the EU best practice (Spain with 46% 170). If all world regions had the same performance as the EU average, 420 Mtoe of fuel would have been saved in 2006, avoiding 1.3 Gt of CO_2 emissions. The amount of savings would even reach 770 Mtoe or 2.4 Gt CO_2 if all thermal power plants followed the Spanish performance.

In industrialised countries, energy productivity improvements are mainly driven by industry, while in emerging countries and regions the household sector is the main driver

[169] Electricity is the most intensive energy source in terms of primary energy (unless it is produced from hydro or wind).
[170] Spain situation is mainly explained by the high penetration of the most efficient thermal power plants, gas combined cycles.

Industry is the main sector driving energy intensity reduction in industrialised countries. In emerging countries and regions, households is the main sector driving the reduction in energy intensity, because of the substitution by modern, more efficient fuels (e.g. LPG) by traditional fuels (i.e. fuel wood and wastes). In China and the CIS, energy productivity progress was almost equally driven by industry, transformation and domestically.

A convergence of performance in industry due to the globalisation

In OECD countries, China and India, the general trend in industry is towards a decrease in the energy required per unit of value added. This reduction in industrial energy intensity slowed down since 2000 in Europe, North America and China, and had even reversed in OECD Asia & Pacific, because of the recession in Japan. The CIS and the Middle East experienced an increase in the energy intensity of their industry until 2000. In the other regions, the energy intensity remained almost stable, implying an energy consumption growth in industry in line with the level of activity. The energy efficiency of energy intensive industries (e.g. steel, cement, paper) is converging and improving rapidly because of the globalisation of these industries. The best world practices are no longer found only in the most developed countries.

In transport, part of the energy efficiency gains with vehicles have been offset by non technical factors

North America and CIS are among the few regions where the energy consumption of transport is growing much slower than the GDP. In North America, the dramatic improvement in the efficiency of cars in the 80's, following the implementation of the CAFE standards for the fuel economy of new cars, and the initial high-energy intensity of transport in these countries explain this situation.

In Europe, the energy consumption of transport is growing slightly slower than the economic activity since 1990. In OECD Asia & Pacific, there was hardly any reduction. This is not in line with the improvement of the energy efficiency of vehicles as non-technical factors (e.g. congestion, larger and more powerful cars) had contrasting influences. In recent years (since 2000), the energy consumption of transport has remained relatively stable, or its growth has significantly slowed down in several European countries and Japan, because of higher prices and, also, as a result of the policies implemented[171].

Electricity use of households is still growing rapidly despite the energy efficiency improvement of large appliances because of the spreading new appliances in industrialised and emerging countries and progress in equipment ownership in developing countries

In non-OECD Asian countries, the per capita electricity consumption of households is increasing rapidly (above 10% p.a. in China and around 4% p.a. in India and other Asia). In OECD countries, the progress is slower and, (between 1 and 2% p.a.) and has slowed down over the 90's as the result of a certain saturation in appliance ownership and the effect of the policies implemented to improve the energy efficiency performance of electrical appliances (labelling, efficiency standards). In Europe and North America however, the electricity consumption of households is increasing slightly faster since 2000. This situation is due to the rapid spread of new appliances (e.g. ICT appliances[172]) and new devices (e.g. stand by modes for an increasing number of applications), as well as a spread of new end-uses, such as air conditioning in Europe. In addition, the policy measures have been focusing only on part of the household electric appliances173. In emerging

[171] Taxation of motor fuels and agreement with car manufacturers in Europe; top-runner programme in Japan.

[172] ICT: Information and Communication Technologies: TV, PC's, modems, etc…

[173] Usually, the most electricity intensive appliances have been the target of policy measures, such as cold appliances or washing machines, the share of which in the household electricity consumption is decreasing, at least in OECD countries, whereas the share of the multitude of small appliances, including ICT's and stand-by, is growing rapidly, while these appliances are most often not covered by the measures.

regions, this slow down is probably partially explained by efficiency policies.

CO_2 emissions from energy use have increased in most regions since 1990 (+34% at world level); more rapid growth since 2000 mainly driven by China

CO_2 emissions from energy use have increased for all regions since 1990 (they were 34% higher in 2006 than in 1990 at world level), except in the CIS and in Europe. The progression has been more than twice faster since 2000 than between 1990 and 2000 (3% p.a. compared to 1.2 p.a.), with China accounting for about half of the increase. In Europe, climate change policies have helped to keep CO_2 emissions from energy use to only 2% above their 1990 level in 2006.

Because of the growing role of emerging countries with lower levels of CO_2 emissions per capita, world CO_2 emissions per capita are now only slightly higher: they stand at 4.2 t CO_2/capita in 2006 compared to 3.9 t in 1990 (+8%).

CO_2 emissions generally grew much less rapidly than the economic activity (except in the Middle East, OECD Asia and other Asia). At world level, CO_2 emissions per unit of GDP (the CO_2 intensity) decreased by 1.4% p.a. between 1990 and 2006, with all the reduction due to energy productivity improvements.

Main world regions grouped indicators presented in this study. These indicators are mainly aggregated, as the data available for world regions are limited. Some additional indicators have been produced at the level of selected countries and made available on the WEC web site (www.worldenergy.org). More detailed indicators exits for EU countries and Norway in the ODYSSEE database[174].

[174] For more information: www.odyssee-indicators.org. The ODYSSEE data base covers presently 29 European countries; indicators harmonised with those of ODYSSEE have also been developed for 3 more countries: Tunisia, Turkey and Croatia.

4.2. Evaluation of Energy Efficiency Policies and Measures

These trends in energy and CO_2 indicators are the results of various factors, amongst which are changes in energy prices and the energy efficiency policy measures.

Appropriate pricing is a necessary condition for promoting energy efficiency. The first step of any energy efficiency policy should be to give correct price signals to consumers to give them incentives to change their behaviour or to acquire energy efficient equipment. Low price or inadequate tariffs may lead to very high pay back time and make energy efficiency equipment not cost effective at all.

Clear price signals alone are not enough to lead to a rationalisation of energy use: certain conditions are required to remove the usual barriers to energy efficiency and to develop and structure the market for efficient equipment and devices. Policy measures are therefore necessary to reinforce the role of energy prices.

The results of a comparison of the countries' experiences in the implementation of energy efficiency policies are presented in the report. This evaluation helps to draw conclusions and make recommendations as to the effectiveness of the policy measures implemented. It also shows the link between the various measures and their influence on the policy.

There are energy efficiency institutions everywhere

Almost all countries under review have set up specific institutions dealing with energy efficiency, such as energy efficiency agencies, either at the national level, or at regional levels or both, and more recently at local level. Although the legal status of these agencies is different from one country to another (e.g. public, public-private), their establishment almost everywhere, some quite recently, clearly indicates that all countries concerned with energy efficiency perceive such agencies as useful and that there is no contradiction between such agencies and the market.

The establishment of energy efficiency agencies is necessary, first of all, to design, coordinate/implement and evaluate programmes and measures since they have strong technical skills. These agencies can also be very useful to negotiate sectoral agreements with equipment producers (e.g. car manufacturers), national banks to implement financial packages for energy efficiency, or in developing countries with international banks or donors to act as the national counterpart with whom to negotiate loans for energy efficiency funds. A new trend is to enlarge the scope of such agencies and to transform them into environmental or sustainable energy agency.

Policies rely increasingly on quantitative targets for energy efficiency improvements

A proper regulatory framework, with an energy efficiency law and/or national programmes with official quantitative targets of energy efficiency improvement, can provide a long lasting context for energy efficiency policies and avoid the negative effect of “stop and go” actions. Almost half of the surveyed countries have set up quantitative targets[175], with generally annual monitoring requirement[176].

Regulations remain the favourite instrument for the household sector

Electrical appliances and buildings continue to be the main target of regulations, which are spreading to a larger number of emerging countries. In Europe, regulations represent about 40% of the measures implemented in the residential sector. Regulations are also being extended to new equipment and new areas. These include fuel efficiency of new cars, in China and very soon in the EU, mandatory use of solar water heaters, in Spain, mandatory certification (i.e. labelling) of existing buildings (e.g. EU countries), energy efficiency obligations for utilities, phase-out of use of incandescent lamps (e.g. Australia).

Building regulations are now set up for existing buildings

All European countries and most other OECD countries have energy efficiency standards for new dwellings and service sector buildings. Some non-OECD countries outside Europe have recently established standards for service buildings. Altogether, about 60% of the countries surveyed had mandatory or voluntary standards for new non-residential buildings.

Such a broad deployment indicates that policy-makers consider market signals alone are not enough to foster the right decisions by individuals, professionals or developers in regarding the thermal quality of buildings.

Thermal building codes have been changing over time from simple standards on building components to more complex standards, including for the most advanced countries, energy performance standards which cover the whole building system, including equipment (e.g. heating/cooling, hot water, lighting, motors/pumps, elevators).

Revisions in thermal building codes have become increasingly regular in EU countries: over the past 30 years, standards have been continuously tightened, independently of the oil price level (three to four times, including some very recent revisions). The new EU building directive has for the first time included provisions for a mandatory revision every five years to make such an updating more systematic.

The few evaluations studies of the savings achieved with building codes show that the actual

[175] The same also applies to programmes of CO_2 emission abatement with targets of CO_2 savings that exist in most Annex 1 countries (see Annex 2).

[176] In the EU for instance, exists since recently an official target of energy efficiency improvement of 1% p.a. between 2008 and 2016 (9% cumulated in 2016) and of 20% by 2020.

savings for new buildings are lower than the theoretical savings resulting from the standards: non-compliance of standards and behaviours[177] explain such a situation.

Few countries have estimated the additional costs resulting from new building codes: from the evaluations available, the additional costs linked to the building standards are usually limited to a few percentages.

Measures for buildings focused so far on new buildings. As new buildings represent a small share of the existing stock[178], buildings standards can only have a slow impact on the short term, which is however significant on the long-term. A more recent trend is to extend regulations to existing buildings and impose energy efficiency certificates for existing buildings, each time there is a change of tenant or a sale[179]. These certificates enable the buyer to obtain information about the energy consumption of the home that they are going to buy or rent. Furthermore these certificates could be an effective tool to implement incentives measures such as tax credit or low interest rate loans for owners who increase the performance of their building through refurbishment.

Standards for new buildings may also have an indirect impact on the technologies, material and practices used in retrofitting old buildings.

Labelling and standards for electrical appliances are spreading to a larger set of appliances

Labelling programmes and efficiency standards are an effective method of transforming the market and slowing the electricity demand growth. However, none of the programmes introduced has been able to reverse or stop the increase in electricity consumption in the domestic appliance sector. This is essentially because of increased ownership levels, especially in emerging countries, and the spread of new equipment (air conditioning, ICT's) and functions (e.g. standby), that often have not yet been targeted by the measures.

Energy labels and standards are complementary tools. Labelling acts as an incentive for manufacturers to differentiate themselves from their competitors and stimulates the introduction of new, more efficient models. Standards remove from the market the less efficient appliances.

To be effective, **labelling programmes and performance standards must be regularly updated.** Indeed, there is no incentive for manufacturers to go beyond what is required if no stricter standards have been planned for the future or when most of the models on the market are in the best efficiency classes. It is therefore essential to review and reinforce standards at regular intervals as a way to stimulate technical progress and to ensure a steady improvement in energy efficiency. In this respect, the "Top Runner" programme in Japan has the particular advantage of making easier the definition of new targets, as the most efficient appliances on the market at a given time are used to set the future standards.

In certain conditions[180], voluntary agreements can be an effective alternative to mandatory minimum energy efficiency standards, as they have the support of manufacturers and can be implemented more rapidly than regulations. Nevertheless, their effectiveness is still conditioned by the possibility of imposing performance requirements corresponding to genuine additional efforts from industry.

The diffusion of more efficient appliances did not result in a price increase for these appliances, as manufacturers were able to adapt and benefited of an increased market ("learning effect").

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[177] Because of the lower consumption in new dwellings, consumers can at the same cost increase their comfort (so called "rebound effect".

[178] Around 1% in industrialised countries, more in emerging countries.

[179] Such a measure has been introduced in Denmark some years ago (1999) and extended recently to all EU countries with the Directive on Buildings (generally in 2006 or 2007).

[180] This has been the case for washing machine and dishwashers in the EU.

Financial incentives rely more and more on tax incentives than on direct subsidies

Direct subsidies to energy efficiency investments remain popular. As they have often been considered as costly and questionable[181], they are now better targeted to limit the number of consumers that can benefit from them (e.g. low income households, tenants). In addition, they are also restricted to certain types of investment (from a selected list of equipment), with a long payback time but high efficiency gains (e.g. renewables, co-generation) or to innovative technologies (demonstration or pilot investments).

Subsidies are usually viewed as a temporary measure to mobilise consumers, to prepare for new regulations, or to promote energy efficient technologies by creating a larger market than would exist otherwise, with the objective of a cost reduction for the subsidised energy efficient technologies.

Subsidies can be used to promote quality of energy efficiency equipment and services: in that case, subsidies are only given to products and services that have been certified or accredited by a public authority, generally the energy efficiency agency.

Subsidies can also be given to producers to improve the quality and reduce the cost of production. In some cases the producer approach may lead to better results.

Very often, direct subsidy schemes are supported by energy efficiency funds. Because of the pressures on public finance, new innovative financial schemes have been recently designed to attract private funds into energy efficiency programmes. These innovative funds use tools traditionally used by the private sector (e.g. loans, equity participation, venture capital) and seek a partnership between public institutions and private investors, such as banks or private companies (ESCOs)[182]. These funds will attract private investors, only if there are opportunities of profit and will therefore be restricted to countries, with high-energy efficiency potential and incentive prices. They will also prioritise operations with high investment costs. These innovative funds should help developing a market for energy efficiency that would be "self-sustaining", without public intervention. Guarantee funds and revolving funds are examples of innovative approaches that have been developed in different parts of the world. New funds targeted at sustainable development can channel untaxed domestic savings.

Innovative ways of motivating the consumers to use such funds can be found in schemes where a loan is reimbursed through the electricity bill, as in the fund used to finance solar water heaters in Tunisia.

Fiscal incentives, such as tax credits, tax reductions and accelerated depreciation, are usually considered as less costly than direct subsidies for the public budget, especially for households, as they have lower transaction costs. They can work well if the tax collection rate is sufficiently high. Such measures usually have a poor performance in an economy in recession or in transition. They are more adapted to well-developed countries: in fact, mainly OECD countries have implemented such fiscal measures.

Tax reductions for energy efficient equipment or investments have been introduced in many countries and almost equally in all regions: they are in place in about 30% of the countries[183] surveyed. The compact fluorescent lamp is the most common equipment[184] to which this measure applies outside the OECD. In some European countries, lower VAT levels exist for labour costs to reduce the investment costs of building renovation (e.g. France, Sweden, and Switzerland). Another

[181] They did not always reach the targeted consumers and benefited those consumers who would have made the investment in any case, even without subsidies ("free riders" problem).

[182] See below the section on ESCO's.

[183] More detail about the countries affected by these measures can be found in Annex 2

[184] Among energy efficient equipment; such a measure is also widely used for renewables (solar water heaters, PV)

innovative way to promote investment in energy efficiency and CO_2 reduction is to offer tax concessions to companies that make concrete commitments for energy efficiency gains/CO2 reduction, and meet their target (e.g. Denmark or the UK).

Economic incentives, either subsidies or fiscal measures, are often part of packages of measures: they are for instance combined with audit schemes or voluntary/negotiated agreements with energy consumers.

Innovative measures are necessary to fully inform consumers about energy efficiency actions

One of the main barriers to energy efficiency is the lack of information supplied to consumers about what they can do. To address this issue, a large range of tools has been designed: e.g. general information campaigns, labelling of appliances and even dwellings rating their energy performance, audits, local information centres, comparative information.

One relatively new approach to reach more directly the multitude of consumers with well-targeted information, beyond the reach of traditional information campaigns in the media, is to set up **local energy information centres** to be always as close as possible to the consumer. These local centres are focal points that offer impartial and personalised information on energy conservation and, usually, renewable energy, to the general public and specific target groups, including advice on useful contacts.

Comparative information enables consumers to understand in bills or by means of special support, the consumption levels in comparison to similar consumers (domestic) or companies (industry and services). One of the most famous programmes of this kind is the best practice programme introduced long time ago in UK and still widely used worldwide. More recently, comparison has extended to the best practice in the world for industrial production, e.g. in The Netherlands with the “Benchmarking Covenant”. Energy performance certificates for buildings play the same role in many European Countries.

Audits are becoming increasingly mandatory

Audit schemes are useful ways to inform consumers about the possible actions to improve energy efficiency. They have been mainly developed in industry and in non-residential buildings and are increasingly made mandatory. Energy audits are usually partially funded by public agencies or by utilities in European countries and are more often free for consumers in the other regions to encourage participation. Evaluation of audit schemes shows that the degree of implementation of the suggested measures varies considerably, depending on the country[185].

Mandatory audits – like voluntary audits - need a certain quality of auditor as well as staff responsible for energy management in the companies (energy managers). This can be assured by the certification of auditors and by the training of energy managers. A capacity-building process of all participating organisations is a prerequisite for successful mandatory audits.

The main argument in favour of **mandatory audits** compared to voluntary schemes is that they allow to reach right from the beginning a substantial fraction of consumers. Equally important is the cultural change that mandatory audits also try to initiate in companies by making energy efficiency a regular target at all levels. Experiences in Australia show that an "external view" on energy use in a company from an energy auditor often also brings additional value.

Mandatory energy audits for buildings, especially in the residential sector, are wide spread and exist in many countries and regions. Mandatory energy audits in the industrial sector appear to be quite frequently used in Asian countries, in Australia, in North African and Eastern European countries.

[185] The degree of implementation of the recommended actions is usually around 60%: from around 50% in the US, to 60% in Taiwan, to around 75% in France and 80% in New Zealand. .

Mandatory energy audits in the transport sector are less common and aim at fleet owners.

In the case of mandatory audits, non-compliance with regulations may be sanctioned, although there was no evidence that sanctions were applied. In general, a co-operative approach was preferred.

The implementation of measures proposed during the audits is another critical point, unless there was a legal requirement to carry out the measures or unless they were convincing enough for energy users. Quite frequently, supporting measures such as subsidies for the audits or for all or certain types of investments therefore accompany the mandatory audits. Frequently the funds allocated may not be enough to carry out detailed audits, particularly in industrial companies where the processes are heterogeneous and complex. On average, energy audits and the introduction of recommended measures led to savings of 5-10% for participating companies.

ESCO's: an attractive mechanism to capture cost-effective energy-efficiency potentials with the involvement of the private sector

ESCOs (Energy Service Companies) and EPC (Energy Performance Contracting) are very attractive mechanisms to capture cost-effective energy-efficiency potential worldwide, mainly because they do not involve either public expenditure or market intervention. EPC can probably be considered among the most effective mechanisms for promoting energy efficiency in the public sector and, especially in developing countries, in the industrial sector. EPC has been demonstrated to lead to energy savings between 20 and 40% in individual projects.

Although the EPC concept is very attractive to tap the significant potential of cost-effective energy efficiency options in all countries, numerous barriers hinder the development of the ESCO industry. Lack of incentive due for example to low energy prices, inadequate energy service levels and lack of access to finance are major barriers in all areas. In the public sector, the lack of clarity in administrative and budgetary procedures concerning EPC, as well as unsupportive public procurement rules, are often additional barriers. In the residential sector, the lack of awareness and information, high transaction costs compared to the expected profits, and split incentives, limit the business opportunities for ESCOs.

Access to financing for ESCOs is often compromised by other problems including the lack of creditworthiness, and insufficient links between the lenders and ESCOs. The financial industry itself can act as a promoter of EPC, but banks and financial institutions usually first need to be educated and convinced about the advantages of EPC through positive experiences.

Policies and incentives can be introduced to kick-start and catalyse the ESCO industry. The examples of the most successful ESCO host countries e.g. China, the United States and Germany have shown that direct and indirect governmental support to EPC as well as the exemplary role of the public sector in initiating energy-efficiency change through ESCOs are crucial to kick-start a sustainable ESCO industry. Accommodating public procurement legislation, in addition to government initiatives, is also a must for the EPC concept to take a strong foothold. EPC in the public sector is especially important as it does not only help reduce energy costs in this sector, but also triggers the development of the ESCO-market and demonstrates the advantages of EPC to the economy in general.

ESCOs and EPC cannot be the panacea, even in the most fertile market and supportive policy environments, as they can only capture energy-efficiency potentials that are cost-effective under market conditions, and because ESCOs add their own costs through their operation and profits.

The introduction of market based instruments, such as CO2 or energy efficiency certificates, create good opportunities for the development of ESCOs activities worldwide.

Towards a greening of measures to improve energy efficiency of passenger transport and cars

Policy instruments for cars include measures to improve the energy efficiency of vehicles as well as measures that influence the use of cars. These include fiscal measures (taxes or subsidies) on car purchases, car ownership and motor fuels, road pricing, CO2-labelling of cars, incentives for car scrapping and subsidies for the use of bio-fuels.

As regards **car purchase taxes**, countries with high taxes (Denmark, Finland, Norway, the Netherlands, Ireland and Portugal) have lower rates of car ownership than the European average. However, high levels of taxes are not enough to influence the consumer towards more efficient cars. Several countries are now introducing a green tax, in which the amount of tax is a function of the CO2 emission or energy efficiency of the cars.

The annual tax on car ownership may play an additional role. Provided it is significant, this may orientate demand towards less powerful cars. Here also, some countries relate the tax level to the CO_2 emission or energy efficiency of the cars[186].

Fuel taxation plays a key role to orientate demand towards more efficient vehicles, to behaviours (e.g. driving style, driving less), even if tax increases are not always only motivated by energy efficiency. In some countries, however, specific CO_2/environmental taxes have been set up for motor fuels (e.g. Norway, Sweden, Finland and Germany). Such, green taxes are better accepted by the population, especially if part of the revenue is recycled to support energy /CO_2 efficiency measures. The taxation of fuel should follow an escalator approach with periodical growth rates planned in advance to give strong signals to the consumer as to the future price trends (e.g. Germany and UK).

Road pricing in its different forms shows an efficient way – comparable in its effects to fuel taxation – to enhance the energy efficiency in transport. The congestion charge in Inner London shows a reduction in fuel consumption (and CO_2 emission) of about 10% and modal shifts towards more efficient transport modes (e.g. public transport or bicycle).

CO_2/energy efficiency labelling is a practical method to inform consumers about the fuel economy of new cars. But as the buying decisions are strongly influenced by other factors (e.g. costs, size, power, brand and safety), the impact on the consumer populace is quite low. For this reason relative comparison methods on the labels are more favourable. Combined with tax incentives, they may help shifting consumer decisions to more environmentally friendly and efficient cars.

Scrapping programs do not seem to be a suitable instrument for energy savings and reducing CO_2 emissions as there is a clear trend to heavier and more powerful new cars that are less energy efficient than the old cars scrapped. **Inspection and maintenance** is a much more generally applicable instrument to reduce the emissions from the existing car fleet. In developing countries, a scrapping scheme might show more positive effects as very old cars (20 years or more) still comprise a considerable share of the stock of vehicles in use.

Support policies **for biofuels**, such as lower taxation or support to production, will need to be co-ordinated and to address the various side effects (e.g. energy input in production, risk that large scale biofuels production might replace food production187 and environmental impacts linked to intensive production).

In a long-term period, the accessibility through a **reorganisation of spatial structures** and through the introduction of new services in public transport might be a secondary effect of **pricing the transport system** (road pricing, fuel taxation, car taxation). Pricing policies need to be linked to a public transport policy as well as towards spatial planning.

Supporting measures of higher taxation are a precondition to reach the goal of higher energy

[186] Denmark since 1999, Germany since 1997, the UK since 2001, France since 2006 (for company cars), and Sweden (since 2006 for new cars).

[187] This “side” effect might even be more crucial in developing countries.

efficiency. Efficient, high quality and reliable public transport is a condition to lead to significant modal shifts. If this is true for industrialised countries, where supporting measures have been undertaken parallel to the introduction of higher taxes, such as in London or Singapore, with high quality public transport, this is even at higher extent true for developing and emerging countries, where the motorization rate is substantially lower than in the industrialised countries.

Energy efficiency obligations for utilities: a new and promising market based instrument

Energy efficiency obligations have been a success in EU Member States and are expanding in those countries that have implemented them. They are also being adopted in new countries[188].

Energy efficiency obligations in Europe have been shown to work in both monopoly and fully liberalised environments and for supply and distribution companies. The "rules of the game" need to be clear and transparent to all stakeholders and should not be changed to ensure regulatory certainty for the energy companies. Until now, energy efficiency obligations have largely operated without significant trading of energy savings certificates ("White Certificates"); nevertheless most countries remain convinced that in the long term this is the way forward, even if it requires more practical experience.

Energy efficiency obligations are attractive to governments, as they do not have to support the cost of obligations and are typically at around 1-2% of energy bills. In addition, by using assumed or extant savings, the administration, monitoring and verification costs can be kept low (e.g. <1% of total energy supplier expenditure in the UK).

Energy efficiency obligations could be an important policy option for developing countries to save electricity, as they offer a way for governments to tackle energy efficiency at a fairly modest increase in electricity customers' bills. Two types of obligations could be explored: saving electricity if inefficient technology is already in use and encouraging energy efficient equipment (e.g. lighting, TV) for new electricity customers (e.g. for newly electrified households or in new buildings).

In most developing countries, electricity companies usually have the skilled personnel required to implement such energy saving initiatives. There may be a need of some assistance in establishing expected levels of savings although many electrical appliances are global (e.g. CFLs), and that the experience of the other countries can be used. Trading of white certificates may be more difficult to implement, as it requires financial infrastructure and skilled market players; however, as shown by the experience in Flanders and UK, trading is not necessary in a first deployment stage.

Energy efficiency obligations change the business model of utilities from energy sellers to sellers of energy services. The adoption of a new directive in the EU, the energy service directive, aims in particular at fostering such a change189.

Packages of complementary measures: an effective way to speed up the development of new technologies, such as solar water heaters

Direct subsidies and tax credits are an effective way of stimulating the growth of the solar water-heating sector. These subsidies may however have negative impacts on emerging markets if they are applied without continuity190 e.g. "stop and go" effects, depression of market if subsidies are withdrawn suddenly, impact on selling prices, etc.

[188] Six countries have currently got energy efficiency obligations on energy companies in Europe: Belgium, France, Italy, UK, Ireland and Denmark. Obligations will be placed on energy suppliers in the Netherlands in the latter half of 2007 and similar activities are under development in Poland and Portugal.

[189] Directive on energy end-use efficiency and energy services of May 2006 that sets a target of 1% energy efficiency improvement to EU Member states over the period 2008-2016 (9% cumulative savings).

[190] This was for instance the case in Tunisia as shown in the country case study in Annex 2, as well as in Taiwan..

In certain markets (e.g. Northern Europe), environmental considerations seem to be sufficiently motivating to minimise the need for subsidies for solar water heating. Conversely, subsidies may be required in countries with significant price distortions (low fossil energy prices) on the residential energy market.

Additional measures are still necessary to complement subsidies when solar water heating is approaching competitive levels. These include suitable financing mechanisms to help overcome the investment barriers, (e.g. low interest loans, especially for low-income households), training of installers, quality labels or technical standards to ensure high performance levels of installations, or even regulatory measures.

Improvement of perceived **quality** by customers is absolutely necessary for a large dissemination of solar water heating systems. Quality labels and technical standards are effective tools for maintaining or improving quality, provided they are successfully enforced. The existence of independent **certification** centres is a key element to ensure that imported products are in compliance with national standards. The performance of the system is not only related to the installation of collectors but also to the quality of installation and the proper maintenance of the system. In this respect, the existence of skilled installers and appropriate networks for after sales services is essential for stimulating further deployment of solar water heating.

Regulations imposing the use of solar energy in new buildings are interesting steps to speed up the introduction of solar, such as in Israel in the 80's and more recently in Spain with the Solar Ordinance. The regulatory approach is the perfect example where the balance of policy instruments is vital. For regulations to work, they need to involve all stakeholders in the sector and must be accompanied by other measures: information and awareness programmes, measures to maintain or improve quality (standards / labels), training and certification of installation contractors, supply-side measures (R&D programmes, opportunities to achieve economies of scale), urban planning regulations (that take into account solar energy) etc.

Packages of measures that combine several instruments are more effective e.g. direct subsidies plus financing methods; economic incentives plus quality labels; regulations plus subsidies or financing mechanisms and quality labels, and so on.

Some policy measures are working well and can be considered successful; market instruments are playing a greater role

Regulations for household appliances and buildings have proved to bring significant energy savings, even if their implementation can still be improved. Voluntary/negotiated agreements have also led to energy efficiency improvements, especially in energy intensive industrial branches, with cars and with some electrical appliances (e.g. washing machines in Europe), even if the results could have been more ambitious (e.g. cars in Europe). Tax credits have also shown good results to stimulate the market for renewables and efficient appliances that would not have been purchased by consumers without financial incentives.

Market instruments are gaining in importance with white and carbon certificates, innovative funds and private stakeholders, such as ESCOs playing an increasing role in the promotion of energy efficiency and in the implementation of energy efficiency projects.

4.3 General Conclusions and Recommendations: Energy Efficiency Policies: a win-win strategy

The introduction and/or strengthening of energy efficiency policies is becoming a top priority and a sustained effort for energy efficiency will be required over the long term, for several reasons.

- The **present high oil prices** and their impact on the balance of payments[191] and the prospect of even higher price levels in the future, should lead governments to design efficient policies in order to prepare economies for an increasing cost of energy;
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- The **huge need of investment** for expanding energy supply (in production, transport, distribution and storage of energy) in emerging countries by electrification of households currently without electricity and the spreading of electric appliances, could be reduced. If demand growth slowed down, reducing investment needs through energy efficiency policies will free capital for other purposes or avoid shortages of capital for the required investment in energy supply, which may constrain economic growth.
-
- Many households in Africa and South Asia still do not have access to modern fuels and have to rely on fuel wood and waste for cooking. This represents a heavy burden in terms of time and money spent to obtain these fuels. In addition, reliance on fuel wood contributes to deforestation. Policies aiming at the distribution of more efficient cooking stoves could alleviate some of these tensions.
-
- The growing consensus among the experts of the International Panel on Climate Change about human induced impacts on the temperature increase has led several governments and institutions to consider drastic reductions of GHG emissions192, which can mainly be achieved by vigorous energy efficiency improvements. Several promising studies point to the role of energy efficiency in reducing greenhouse gas emissions: by 2020, energy efficiency could make up half of the reduction needed in scenarios with strong CO_2 constraints[193].

Energy efficiency improvement is a priority that also brings multiple benefits (i.e. a "win-win" strategy):

- It limits the macro economic impact of oil price fluctuations for oil importing countries
- It can extend the availability of fossil resources
- It lowers tensions in domestic energy supply
- It reduces local pollution and CO_2 emissions
- It enhances economic development by reducing energy shortages
- It increases competitiveness by reducing the energy costs
- It contributes to poverty eradication
- Finally, it reduces deforestation

To be successful energy efficiency programmes and projects need appropriate strategies, including:

- Incentive prices that reflect the real costs;
- The establishment of appropriate institutional and regulatory frameworks;
- The use of complementary instruments ("package of measures");
- A collaboration between the public and private sector to develop complete energy efficiency services offer, including access to funding;
- Good planning, a regular strengthening and proper enforcement of regulations;
- An exemplary role of the public sector;
- A quality control of equipment, certification processes;
- The promotion of innovative measures;
- The need to address all end-uses with an energy efficiency potential;
- The adaptation of measures for each national circumstance;
- A co-ordination at international level;
- The integration of energy efficiency concerns in other policies;
- An ex-post evaluation of implemented measures and a monitoring of their impacts using indicators.

Incentive prices: a condition for successful energy efficiency policies

Fiscal and pricing policies are, of course, the strongest instrument to internalise long-term costs and benefits in energy markets**.** The general unpopularity of taxes should not prevent the careful design of new taxation schemes, taking into

[191] With a possible impact of the economic growth, in oil importing countries, especially in the less developed countries.
[192]Reduction by a factor of 3/ 4 by 2050 is even explicitly adopted as an objective by some governments (e.g. UK / France)
[193] See United Nations report (2007)

account international competition and the disruptive impact on low-income households. A progressive increase of energy prices even at a low rate, announced publicly, can have, in the long-term, a large impact on technological innovation.

Need of a favourable and stable institutional framework

The establishment of energy efficiency institutions such as agencies is necessary to design, coordinate/implement and evaluate programmes and measures, as well as to contract various types of stakeholders, such as companies or banks for instance. A proper regulatory framework with an energy efficiency law and official quantitative targets of energy efficiency improvement adopted by the Government can provide a long lasting context for energy efficiency policies and avoid the negative effect of "stop and go" actions.

Package of measures are preferable to single measures

- The greater impact will come from the implementation of several complementary measures (package of measures) that need to be tuned to national circumstances. Good information is a necessity, but should be complemented with financial incentives or with both regulations and financial incentives. These complementary measures should be implemented simultaneously and not one after the other.

Public-private partnerships reinforce the effect of public policies

Public-private partnerships between public institutions and private companies, such as banks or private ESCOs are becoming necessary elements of public policy to account for the scarcity of public funds and the competition between diverse public needs (e.g. employment, education, health, security). These partnerships often rely on new and innovative funds that use tools traditionally used by the private sector (e.g. loans, equity participation, and venture capital). Energy efficiency services could provide a new field of activity for companies (ESCO's). However governments need to introduce some incentives (soft interest rates, tax credits, etc.) or mandatory targets, (quotas or commitments). In addition, the involvement of private actors is only possible if there is a stable regulatory environment. Availability of funding from private sources or international donors and financial institutions is not an issue. What is more important is to convince organisations of the advantages of their involvement in energy efficiency investments and in a support to ESCO through a dissemination of positive experiences.

To be efficient regulations should be well planned, regularly strengthened and enforced

Policy makers should give advance signals of future regulations to both consumers and manufacturers/constructors so that they can adapt in advance of these, especially with respect to mandatory efficiency standards.

To be effective, standards must be regularly **updated**. Indeed, there is no incentive for manufacturers/constructors to go beyond what is required if no stricter standards have been planned for the future. It is therefore essential to review and reinforce standards at regular intervals as a way to stimulate technical progress and to ensure a steady improvement in energy efficiency.

The experience shows that technologies and buildings corresponding to future standards (i.e. that are more efficient than what is being sold or built with current standards) are in general a few percent more costly than the market average; however, this **extra cost** drops rapidly with the implementation of upgraded standards, due to learning effect. Therefore complementary policies aiming at an increase in the market share of the most efficient appliances and buildings are highly effective to reduce the cost and to make easier the implementation of the new regulations.

There is a strong need to develop **energy efficiency norms** for appliances and equipment consuming energy: norms allow a differentiation between low and high efficiency equipment and could be used as labels to inform consumer and to implement incentive policies (tax credit, eligibility to funding schemes etc.). Equipment complying with energy efficiency norms could benefit from public procurement, allowing new efficient technologies to penetrate the market. There is a developmental need for internationally recognised norms through ISO or regional bodies such as CEN in Europe but governments should be able to implement such norms alone, since it is not a protective measure against imported goods.

Regulations on buildings or equipment are effective as long as they are properly **enforced**. This is often an aspect that is insufficiently addressed by policies, because of budget limitations. Enforcing existing regulations may be in some case as efficient as strengthening further these regulations.

The public sector should lead by example

The positive impacts of the public sector in the development of the ESCOs market as well as the role of public procurement of energy efficient equipment show that the public sector can contribute to promote and consolidate a market for energy efficient equipment and services.

The public sector should be involved at all levels of decisions: national, regional and local.

Quality of energy efficiency services and equipment should be strengthened through certification and testing

Policy measures should promote quality by supporting only equipment and services that have a recognised standard. For equipment, this can be obtained through norms, as indicated earlier, and certification of equipment. This implies the existence of **certification and testing facilities**, which may be a constraint in many developing countries (especially for small countries); regional centres could be a solution in that case. These testing and certification facilities are essential for the development of norms on equipment. Accreditation of consultants can guarantee the quality of the services offered.

Innovative measures should be promoted in emerging and developing countries through a transfer of experience

Innovative high impact measures should be promoted in emerging and developing countries based on the experience of the most advanced policies such as:

- Efficiency standards for buildings and buildings certificates
- Energy performance contracting and results guarantee
- Labelling and standards for cars
- Reduced or credit tax on energy efficient equipment
- Energy efficiency obligations

To be effective, co-operation/twining programmes should accompany such a transfer of experience between energy efficiency agencies, including technical assistance and know-how.

Energy efficiency policies should address all areas with energy savings potential

The analysis of energy efficiency indicators has shown that the best results in terms of energy efficiency progress were generally obtained in the industry sector. This sector is first of all the most sensitive to market forces. It has also been the target of multiple types of measures, ranging from financial and economic incentives, to various regulations (e.g. mandatory energy managers, mandatory energy consumption reporting, mandatory audits) and, more recently, to voluntary / negotiated agreements and mandatory targets for CO_2 reduction. On the other hand, passenger transport and households record lower achievements, as increased income and lifestyle changes have offset part of the technical energy efficiency gains. Transport of goods is also a sector with a rapid energy demand growth in which few real measures have been implemented so far. Finally, in many developing countries, the power generation sector has a large potential (electricity production and T&D) that cannot be left aside and represents often a very cost-effective strategy.

In the transport and household sector, improving the efficiency of new equipment, vehicles and building is important. But it is equally important to maintain the equipment and vehicles to avoid a progressive loss of efficiency. Policy measures also need to focus on maintenance.

In these two sectors, the impact of regulation is often partly offset by more energy intensive behaviour (e.g. higher heating temperature, longer utilisation of efficient lamps)("rebound effect"). To reduce the effect of behaviour, policies should promote technologies that limit these rebound effects (e.g. speed limiters, thermal regulation of room temperature, automatic switch off of lights in unoccupied rooms, light sensors etc.).

Each country needs to adapt the measures to its own circumstances

Although some convergence can be observed in the policy measures across countries, many differences still exist. They reveal that there is not a single model measure, or mix of measures, that can be considered as the most effective one in all circumstances: different sets of measures have to be adopted in different countries, and in a given country, new measures and new combinations of measures have to be designed to accompany market change.

The energy price and taxation context, the degree of market development for energy efficient devices and services and the level of integration between energy efficiency policy and other sectoral policies (transport, buildings etc.) are the primary factors behind such differences. Differences in countries' circumstances certainly play a role too, such as demography (age of population, size of households, growth rate of the dwelling stock), the climate, the level of economic development and the structure of economic activities, the degree of decentralisation of public administration, and, finally, the strategy of the energy producers and distributors

Co-ordination at international level should be reinforced

Although differences exist in the implementation of measures, a greater role is now given to the coordination of policies, especially in Europe with the various EU Directives that also affect non-EU countries. In general, co-ordination at international level could be reinforced to help overcome obstacles to the implementation of both standards and price signals.

Development of benchmark values could help each country set up its own target taking into account its national condition.

Other policies should integrate energy efficiency aspects

National governments, as well as regional and local administrations, should incorporate energy efficiency into all main sectoral public policies (environmental policies, land planning, transport infrastructure, housing policy, urban planning etc.). Infrastructure investment decisions should incorporate the expected growth in energy prices and constraints on CO_2 emissions. The mitigation of CO_2 emissions in the transport sector is particularly suited to this approach. A carbon value could be defined, which would be taken into account in public decisions to direct choices toward energy efficiency (with a low initial value which is expected to grow). An integration of energy efficiency and other public policies will make the mix of market instruments more efficient.

Ex-post evaluation of implemented measures and monitoring using indicators should be strengthened

Monitoring the impact of measures through ex-post evaluation, as well assessment of energy efficiency trends through indicators should continue and be strengthened so as to reveal possible shortfalls. Skillful evaluations could improve the impact of measures and guarantee reliable utilisation of public funds.

Energy efficiency/ CO_2 indicators are increasingly used to monitor targets of energy efficiency gains or CO_2 abatement. Indeed, most governments and the European Commission are setting quantitative targets and need to monitor the progress achieved on a yearly basis. This is also true at the sectoral level in the framework of voluntary/negotiated agreements or sectoral regulations. Indicators allow first to verify whether the objectives have been fulfilled and secondly to identify, through a set of more detailed indicators, why the objectives may not be reached. The European Commission is making use of ODYSSEE and Eurostat[194] indicators to monitor the impact of several Directives. IEA has also published several reports containing a variety of energy efficiency indicators[195]. All these experiences with indicators clearly show that energy efficiency indicators are useful tools to assess the countries' situations and developments with respect to energy efficiency.

The **benchmarking approach**, which is often used at the sectoral level, can also be useful at the country level to compare the relative performance of different countries, starting from indicators well adjusted for national circumstances196. In this respect physical indicators should be used whenever possible, as economic indicators, even corrected for differences in purchasing power parities, always have a bias.

Nevertheless, data collection still needs to be improved in many countries. As a matter of fact, energy and economic statistics remain limited in assessing energy demand trends. The experience of the EU and Norway with the ODYSSEE database should be extended to other regions. APERC's first experience for the member economies within the industrial sector needs to be updated and extended to other sectors. In Latin America, the comprehensive energy database of OLADE (SIEE) need to be completed with additional energy consumption by sub-sector and end-use and with data on the economic and technical determinants of energy use. Undoubtedly, poor data drastically limits the applicability of the indicators and therefore the scope and relevance of country energy efficiency assessments.

There is an urgent need to define, at the international level, the basic minimum data requirements that would allow relevant country evaluations and cross-country comparisons on energy efficiency, in particular in view of international discussions on CO_2/GHG effects. The recent efforts of EUROSTAT and IEA could help define such minimum requirements.

To be fully relevant, evaluation of policies should include effective criteria for the use of public funds in the economy and demonstrate how public expenditures on energy efficiency would benefit the economy? Such criteria are almost never available or public, which makes it difficult, for example, to judge if the taxpayer's money is better used when spent on energy efficiency measures than, for instance, on subsidies for public transport or agriculture or in energy supply infrastructure ("eviction effect").

Countries around the world can benefit from the exchange of information and experiences on the "best measures". Benchmarking of measures implementation should be promoted.

The World Energy Council provides a unique forum for the discussion and comparison of experiences on energy efficiency measures amongst different countries and economies.

[194] EUROSTAT has developed for EU member countries a set of so-called priority energy efficiency indicators (Eurostat, 2003).
[195] "Energy use in the Millennium: trends in IEA countries", IEA, 2007." Tracking Industrial Energy Efficiency and CO2 Emissions", IEA, 2007."30 years of energy use in IEA countries", IEA, 2004.
[196] See for instance the ODYSSEE indicators project.

Annex A : Energy Efficiency Workgroup

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Annex B : List of Figures, tables and Boxes

Annex C: List of Acronyms and Abbreviations

CDM	Clean Development Mechanism
CHP	Combined Heat and Power
CIS	Commonwealth of Independent States
CO_2	Carbon Dioxide
EBRD	European Bank for Reconstruction and Development
ESCO	Energy Services Company
EUROSTAT	European Union's Statistical Office
EU	European Union
GDP	Gross Domestic Product
GEIS	Global Energy Information System (www.worldenergy.org)
GHG	Greenhouse Gas
GJ	gigajoule
Gt	gigatonne
GW	gigawatt
IMF	International Monetary Fund
IEA	International Energy Agency
km	kilometre
kW	kilowatt
kWh	kilowatt hour
m	metre
m^2	square metre
MEPS	Minimum Energy Performance Standard
MW	Megawatt
MWh	Megawatt hours
SO_2	Sulphur Dioxide
toe	tonne of oil equivalent
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
US$95	United States Dollar (1995 value)
WEC	World Energy Council

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