

Energy Efficiency Policies around the World: Review and Evaluation

Executive Summary

World Energy Council 2008

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



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Energy efficiency has risen to the top of the policy agenda in many countries. However, assessments of its potential benefits vary widely. What do the trends show? What are the priorities? What energy efficiency measures produce the best results? Which measures are the most cost effective?

Introduction

Since 1992 the World Energy Council (WEC) and ADEME (Agency for Environment and Energy Efficiency, France) have been collaborating on a joint project “Energy Efficiency Policies and Indicators” with technical assistance by ENERDATA (France). The latest report presents and evaluates energy efficiency policies in nearly 70 countries around the world, with a specific focus on five policy measures: mandatory energy audits, ESCO’s, energy incentives for cars, energy efficiency obligations for utilities, and “packages of measures” for solar water heaters. The report describes the implemented measures and identifies those proven most effective.

The Kyoto Protocol objectives and, more recently, the constraints on energy supply have increased the attention given to energy efficiency policies. Almost all OECD countries are implementing new instruments adapted to their national circumstances. Given its broad geographical coverage, the report provides a comprehensive and valuable source of information. The correlation of indicators to policy measures represents an original approach to energy efficiency evaluation. Non-OECD countries are introducing regulations to slow down an increase in electricity demand. Beside market instruments: voluntary agreements, labels, information dissemination and others, regulatory measures are effective where the market fails to give the right signals (e.g. buildings or appliances).

This report will facilitate information exchange to help remove barriers to energy efficiency improvements and increase the transparency of policy and measures between countries.

Energy Efficiency Trends¹

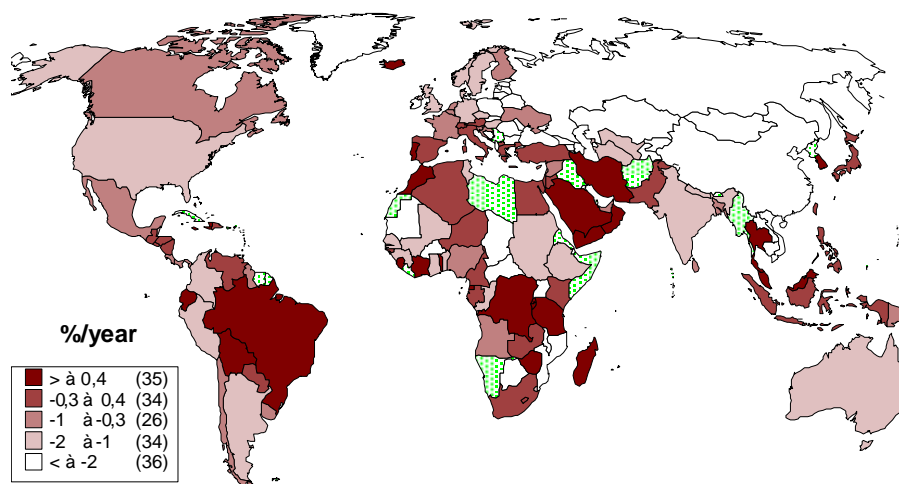
In most world regions the amount of energy used per unit GDP is decreasing steadily: 1.6% p.a. on average at the world level between 1990 and 2006. On a global level, the energy intensity has on average been decreasing by 1.6% p.a. between 1990 and 2006. Almost two thirds of the countries in the world have decreased their energy intensity over this period - 40% (70 countries) by more than 1% p.a. China experienced a significant 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. Excluding China, there is an acceleration of the energy productivity improvement at global level since 2000 due to the higher oil prices in 2005 and 2006 (1.5% p.a. compared to an average trend of 1.3% over 1990-2006).

Energy productivity improvements in most world region since 1990 resulted in 4.4 Gtoe energy savings in 2006 and avoided 10 Gt of CO₂.

¹ Energy efficiency trends are reviewed by world region using a set of homogeneous energy efficiency indicators from ENERDATA world energy database.

Figure 1 Primary energy intensity trends by country between 1990-2006 (%/year)

Source: ENERDATA



China accounted for about 50% of this improvement, North America for 20% and Europe for 10%. In other words, if technologies and economic structures in the main world regions had remained at their 1990 level, in 2006 the world would have consumed 4.4 Gtoe more energy.

Differences in the energy intensity among global regions are up to 300%.

Among the regions, Europe has the lowest energy intensity, 30% lower than in North America and Other Asia. China's energy intensity is 40% higher than in Europe, while the CIS requires three times more energy per unit of GDP than Europe. High energy intensities in countries, such as CIS and Middle East, can be explained by various factors: lower energy efficiency, dominant role of energy intensive industries and low energy prices.

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

Energy productivity gains are greater at the final consumer level - industry, transport, households and services than at the overall level which includes energy conversion. 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 plants².

Energy efficiency of thermal power generation is still low in most developing countries.

Energy efficiency of thermal power generation improved only moderately, by 2% since 1990 at global level. The average power plant efficiency is presently 34%, which is far from the EU average of 40% or the EU best practice (Spain at 46%). 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 CO₂ emissions. The savings would even reach 770 Mtoe or 2.4 Gt CO₂ if all thermal power plants matched the Spanish level of performance.

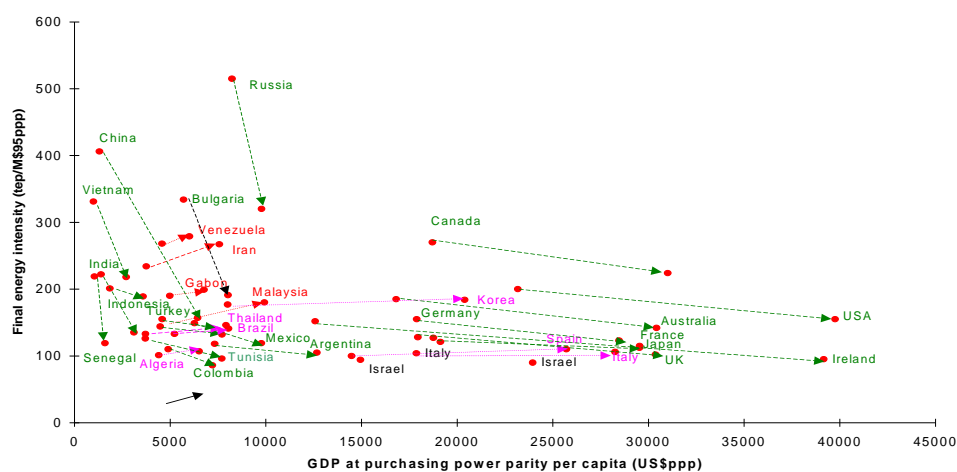
Final intensities are generally decreasing with economic development and convergence.

Final energy intensities are decreasing in energy importing countries with economic development, as well as in OECD countries with significant energy resources (e.g. USA, Canada and

² Electricity is the most intensive energy source in terms of primary energy (unless it is produced from hydro or wind).

Figure 2 Trends in final energy intensity and GDP per capita (1990-2006)

Source: ENERDATA



Australia). Several factors can explain this trend: higher prices, saturation in some end-uses in OECD countries and results of energy efficiency policies.

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).

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

Industry is the main sector driving energy intensity reduction in industrialised countries. In developing countries and regions, on the other hand, households are the main drivers. In China and the CIS, energy productivity improvements were almost equally driven by industry, energy conversion and households.

Convergence of industry performance due to globalisation.

The energy efficiency of energy intensive industries, e.g. steel, cement, pulp & paper is converging and improving rapidly as a result of ongoing globalisation. The best global practices are no longer found in the most developed countries only.

In transport, part of the energy efficiency gains has 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. Since 1990, transport energy consumption in Europe has been growing slower than the economic activity. In OECD Asia Pacific there was hardly any reduction at all. This trend does not reflect the improvement in energy efficiency of vehicles, e.g. 25-30% in Europe since 1973, and the policy measures, as non-technical factors, such as congestion, larger and more powerful cars had the opposite effect. Recently, transport energy consumption has remained relatively stable, but its growth has significantly slowed down in several European countries and Japan, because of higher prices and as a result of policies³.

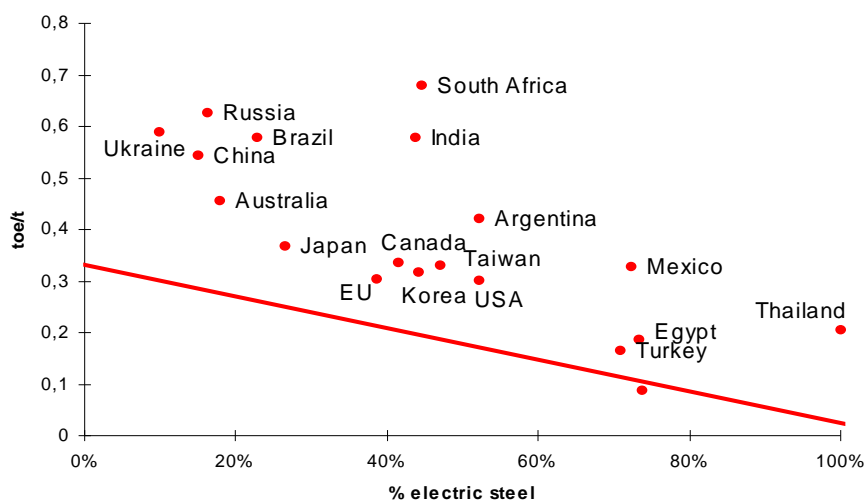
Electricity use in households is growing rapidly despite more efficient large appliances. This can be explained by the continuing introduction of new products and increased equipment ownership.

In non-OECD Asia countries, per capita electricity consumption of households is increasing rapidly: by more than 10% p.a. in

³ Taxation of motor fuels and agreement with car manufacturers in Europe; top-runner programme in Japan.

Figure 3 Energy consumption per tonne of steel as a function of process mix

Source: ENERDATA



China and around 4% p.a. in India and other Asia. In the OECD countries, the growth is slower - between 1 and 2% p.a. In Europe and North America, however, domestic electricity consumption has been increasing slightly faster since 2000, due to the ongoing introduction of new appliances, ICT appliances⁴ in particular, but also new end-uses, such as air conditioning in Europe

The electricity intensity of the service sector is increasing.

The amount of electricity required to generate one unit of value added (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 and Other Asia).

One fifth of the world's population accounts for about 60% of global CO₂ emissions.

Developed regions are the largest emitters of CO₂ from fuel combustion. North America, Europe, CIS, Asia Pacific OECD together account for 54% of the world total CO₂ emissions, whereas they represent only one fifth of the world population. China is the main

emitter in the developing regions with 18% of total global emissions.

CO₂ emissions from energy combustion doubled since 1990 in non-OECD Asia.

Trends in CO₂ emissions vary significantly between countries. Developing countries with high economic growth have doubled their CO₂ emissions, while Europe has nearly stabilised its emissions, partly because of climate change policies. North America and OECD Asia Pacific experienced a growth in their emissions by 36% and 17%, respectively, as their climate policies have been weaker. The decrease in emissions in the CIS is due to the sharp contraction of the economy in the 1990's. However, since 1998 their emissions have been increasing slightly, and as a result of these trends, global CO₂ emissions from energy use were 34% higher in 2006 than in 1990.

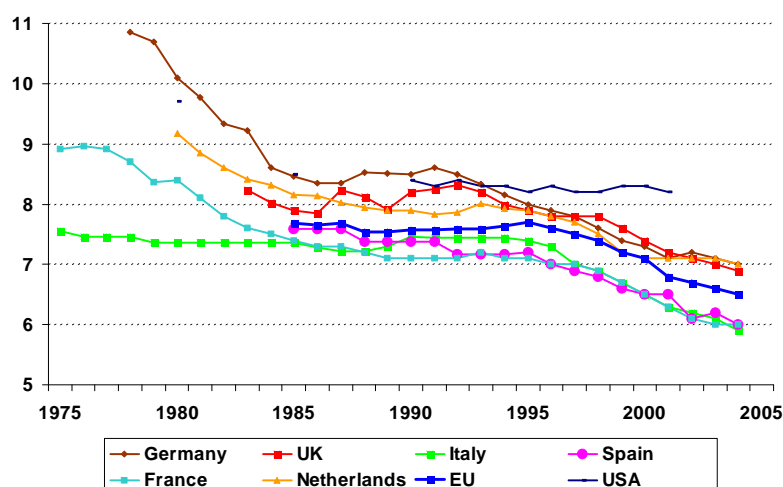
CO₂ emissions per capita are very diverse: around 1t CO₂/cap in less developed regions in Africa and India, 1.5t in Other Asia; slightly under 4t in China, around 7-8t for Europe, CIS, and the Middle East, close to 10t in Asia Pacific OECD and near 19t in North America.

Energy productivity improvements: main driver of reduction in CO₂ intensities.

⁴ ICT: Information and Communication Technologies: TV, PC's, modems, etc.

Figure 4 Specific fuel consumption of new cars (litres/100km)

Source: Odyssee



CO₂ emissions from energy use are increasing slower than economic activity in most global regions. In about half of the countries, both the CO₂ intensity and primary energy intensity are decreasing and most of the reduction in the CO₂ intensity is driven by energy productivity improvements, while fuel substitutions played a minor role.

Evaluation of Energy Efficiency Policies and Measures

What is the importance of energy efficiency measures? What are the priorities? What are the trends? What measures are being favoured? What are the innovative measures? What are the results? Which measures are cost effective?

Based on a comprehensive global survey covering a total of 76 countries, representative of all global regions⁵, the evaluation also draws on five in-depth case studies prepared by experts: 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.

⁵ The surveyed countries represent altogether 83% of the world energy consumption (32 countries from Europe, 9 from America, 17 from Asia and the Pacific, 12 from Africa and 6 from the Middle East).

There are energy efficiency institutions and agencies nearly everywhere in the world.

Almost all countries 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, their establishment almost everywhere clearly indicates that there is no contradiction between agencies and the market.

Policies rely increasingly on quantitative targets for energy efficiency improvements.

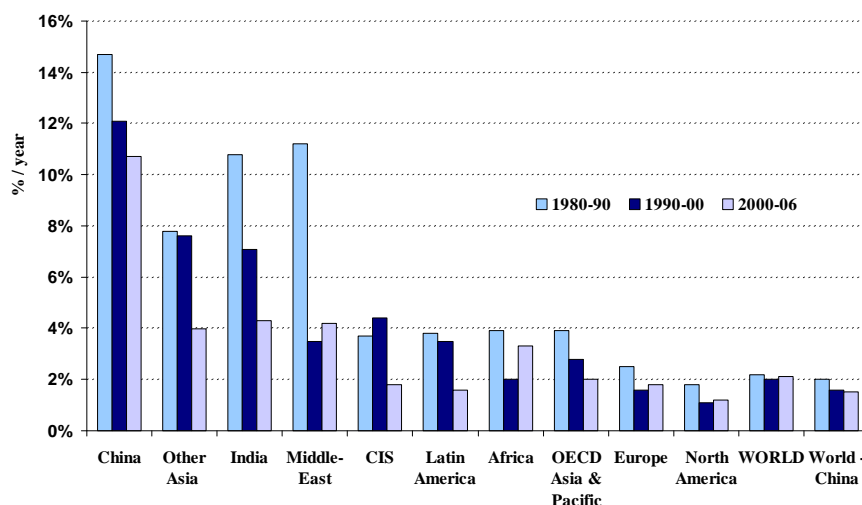
A proper regulatory framework, with an energy efficiency law and/or national programmes with official quantitative targets of energy efficiency improvements, can provide a long lasting context for energy efficiency policies and avoid the negative effect of "stop and start" actions: about half of the surveyed countries have set up quantitative targets, with annual monitoring requirement.

Regulations remain the favourite instrument for the domestic sector.

Electrical appliances and buildings continue to be the main target for regulations and are

Figure 5 Household electricity consumption per capita

Source: ENERDATA



spreading to a larger number of countries. In Europe, regulations represent about 40% of the measures implemented in the residential sector.

Regulations are now set up for existing buildings.

All European countries and most other OECD countries have energy efficiency standards for all new 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.

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 recent revisions). The new EU building directive for the first time includes provisions for a mandatory revision every five years.

The few evaluations studies of the savings achieved with building codes show that the actual savings for new buildings are lower than the potential theoretical savings. This can be attributed to non-compliance with standards and changes in behaviour.

A more recent trend is to extend regulations to existing buildings and introduce energy efficiency certification of existing buildings; each time there is a change of tenant or owner.

Labelling and standards apply to a growing number of electrical appliances.

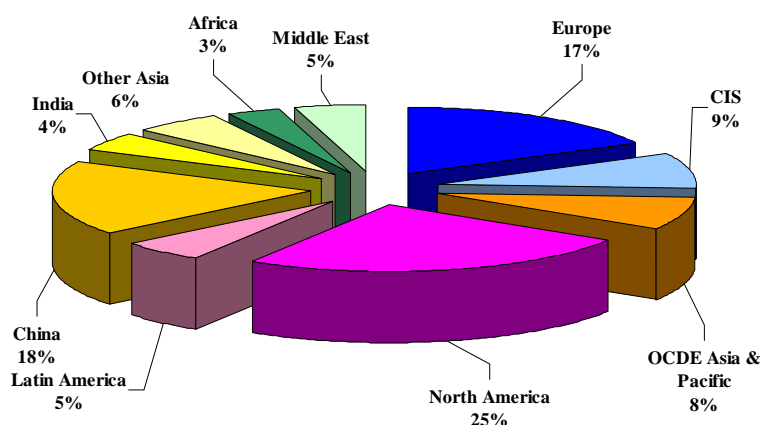
Labelling programmes and efficiency standards are an effective method of transforming the market and slowing the electricity demand growth. Labelling programmes introduced in developing countries are based on the experience of OECD countries and use models that have already been proven: the European label has been used as a model in Brazil, Tunisia, China and Iran, while labels introduced in Thailand and the Korean Republic are based on the Australian model.

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.

Figure 6 Distribution of world CO₂ emissions from energy use (2006)

Source: ENERDATA



Financial incentives rely more and more on tax incentives than on direct subsidies.

Direct subsidies on energy efficiency investments remain popular. As they have often been considered as costly and questionable, they are now better targeted. Subsidies are 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.

Fiscal incentives, such as tax credits, tax reductions and accelerated depreciation, are usually considered cheaper than direct subsidies, especially to households, as they have lower transaction costs. They can work well if the tax collection rate is sufficiently high: such measures usually perform poorly in an economy in recession or in transition. They are more adapted to well-developed countries: so far, mainly OECD countries have implemented such fiscal measures.

Tax reductions on energy efficient equipment or investments have been introduced in many countries and almost equally in all regions: they are used in about 30% of the countries surveyed.

Innovative measures are needed to fully inform consumers.

One of the main barriers to energy efficiency is the lack of information to consumers about what they can do. To address this issue, a large range of tools has been designed: e.g. general information campaign, labelling of appliances and even dwellings rating their energy performance, audits, local information centres, comparative information.

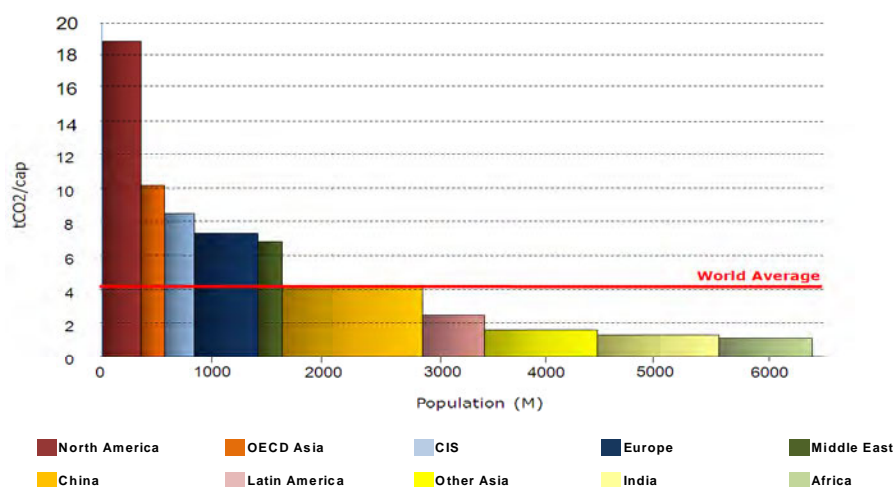
Audits are increasingly made mandatory.

Audit schemes are a practical way of informing 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 usually are 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.

Mandatory audits – like voluntary audits – assume 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.

Figure 7 CO₂ emissions per capita

Source: ENERDATA



The main argument in favour of **mandatory audits** compared to voluntary schemes is that they manage to encompass a significant sample of consumers right from the start. Mandatory energy audits for the building sector, especially in the residential sector, are 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, in Australia, in North African countries and Eastern European countries. Mandatory energy audits in the transport sector are less common and are aimed at fleet owners.

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 a very attractive mechanism to capture cost-effective energy-efficiency potentials 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.

"Greening" of measures to improve energy efficiency of passenger transport.

Several countries are introducing green taxes either on purchase tax or annual tax dependent on the CO₂ emissions or energy efficiency of the cars.

Fuel taxation plays a key role in promoting more efficient vehicles and more sensible driving habits. Tax increases are not always motivated by energy efficiency only. In some countries, specific CO₂/environmental taxes have been set up for motor fuels (e.g. Norway, Sweden, Finland and Germany). Green taxes are better accepted by the population, especially if part of the revenue is used to support energy/CO₂ efficiency measures. The taxation of fuel should follow an escalating approach with periodical growth rates planned to give strong signals to the consumer as to the future price trends (eg Germany and UK).

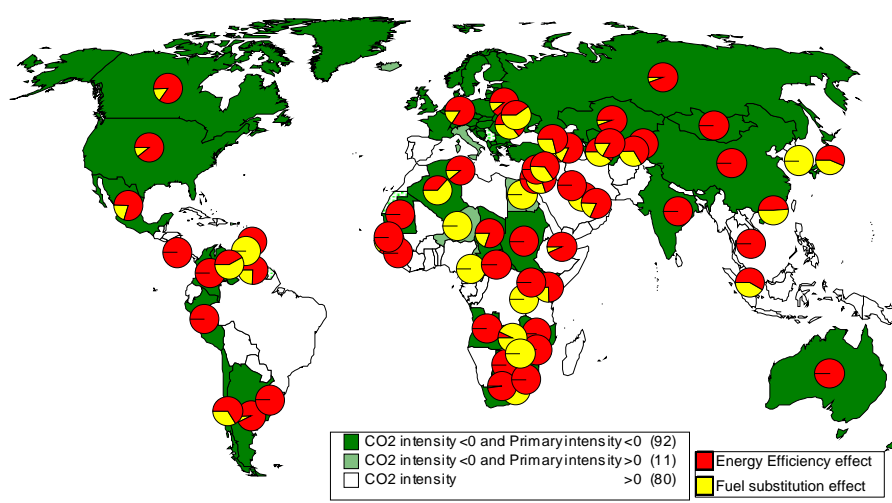
Road pricing indicates an efficient way to enhance the energy efficiency in transport, such as; the congestion charge in London.

CO₂/energy efficiency labelling is a practical method to inform consumers about the fuel economy of new cars. But as the consumer decisions are strongly influenced by other factors (e.g. costs, size, power, brand and safety), the impact on the consumer decision is quite low.

Energy efficiency obligations for utilities: a promising market-based instrument.

Figure 8 Impact of fuel substitutions on the CO₂ intensity variation

Source: ENERDATA



Energy efficiency obligations have been a success in the EU Member States. They have been shown to work in both monopoly and fully liberalised environment, both for supply and distribution companies.

Energy efficiency obligations are attractive also to governments, as they do not have to support the cost of these obligations. 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 modest increase on electricity customers' bills.

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 real continuity.

Improvement of perceived **quality** by customers is necessary to achieve a broad deployment of solar water heating systems. Quality labels and technical standards are effective tools for maintaining or improving quality, provided they are successfully enforced (e.g. the Keymark certification scheme in Europe). The existence

of independent certification centres is a key element to ensure that imported products comply with national standards. The existence of skilled installers and of appropriate network of after sales services is also essential for stimulating further dissemination of solar water heating.

Packages of measures that combine several instruments are very effective: for instance, direct subsidies plus financing, 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, but commercial systems are playing a greater role.

Regulations on domestic appliances and buildings have proved to make energy saving. 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. in the case of cars in Europe). Tax credits have also shown good results to stimulate the market of renewables and efficient appliances that would not have been purchased by consumers without these financial incentives.

General Conclusions and Recommendations: Energy Efficiency Policies: a Win-Win Strategy

The introduction and/or strengthening of energy efficiency policies are becoming increasingly important and a sustained effort will be required over the long term. To be successful energy efficiency programmes need to be based on the development of appropriate strategies, including:

- ▶ **Incentive pricing: a condition for successful energy efficiency policies.**

Fiscal and pricing policies are the most efficient way of internalising long-term costs and benefits in the market. The general unpopularity of taxes should not deter governments from careful design of new taxation schemes, taking into account international competition and the negative impacts 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 for a favourable and stable institutional framework.**

The establishment of energy efficiency institutions is necessary to design, coordinate/implement and evaluate programmes and measures. A proper regulatory framework with an energy efficiency law and official quantitative targets for energy efficiency improvement can provide a long lasting context for energy efficiency policies and avoid the negative effect of “stop and start” actions.

- ▶ **Packages of measures are preferable to single measures.**

Several complementary measures “package of measures” adapted to national circumstances usually have a greater impact. Good information is essential, but it should be complemented by 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 to reinforce the effect of public policies.**

Public-private partnerships are a vital part of public policies to supplement public funds. These partnerships often rely on new and innovative funds that employ tools traditionally used by the private sector (e.g. loans, equity participation, venture capital). Energy efficiency services could provide a new field of activity for companies (ESCO's). However, governments need to bring in some incentives (like soft interest rates, tax credits, etc.) or mandatory targets, (like quotas or commitments). In addition, the involvement of the private sector is only possible if there is a stable regulatory environment.

- ▶ **To be efficient, regulations should be well planned, regularly strengthened and properly enforced.**

Policy makers should give ample notice to both consumers and businesses when future regulations are being planned, so that they can adapt in advance to future regulations, especially with respect to mandatory efficiency standards.

To remain 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 of stimulating technical progress and to ensure a steady improvement in energy efficiency.

Experience shows that technologies and buildings corresponding to future standards (i.e. that are more efficient than what is currently being sold) 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 the “learning curve”.

There is a strong need to develop energy efficiency norms for appliances and equipment to help identify the most efficient ones. These norms should be developed at the international or regional level.

Regulations for buildings or equipment are effective as long as they are really enforced. Enforcing existing regulations can in some cases be as efficient as strengthening these regulations.

► **The public sector should lead by example.**

The positive impacts of the public sector on 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 promotion and consolidation of 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 facilities.**

Policy measures should promote quality by supporting only the equipment and services of the required quality. This requires certification and testing facilities, which may be a constraint in developing countries. Regional centres could be a solution. Accreditation of consultants could guarantee the quality of the services offered.

► **Innovative measures should be promoted in developing countries based on experiences elsewhere.**

Innovative high impact measures should be promoted in developing countries using the experience of the most advanced policies such as efficiency standards for buildings and buildings certificates, energy performance contracting and results guaranty, labelling and standards for cars, reduced or credit tax on energy efficient equipment and energy efficiency obligations

► **Energy efficiency policies should address all areas with energy savings potential.**

Passenger transport and households demonstrate lower energy efficiency achievements, as increased income and lifestyle changes offset part of the technically achieved energy efficiency gains. Policies need to focus also on the maintenance of equipment to avoid efficiency losses over time and to promote technologies that limit the effect of behaviour (e.g. speed limiters, thermal regulation of room temperature, automatic switch off of lights in unoccupied rooms, light sensors).

► **Each country needs to tailor the measures to its own circumstances.**

Although some convergence can be observed in the policy measures across countries, there are still many differences. This confirms that there is not a single model measure.

► **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.

Production of benchmark values could help each country to set up its own target taking into account its national specificities.

► **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 taken should incorporate the expected growth in energy prices and constraints on CO₂ emissions. The mitigation of CO₂ emissions in the transport sector is particularly suited to this approach. An integration of energy efficiency and other public policies will make the mix of market instruments more efficient.

► **Evaluation of implemented measures and their monitoring using indicators should be strengthened.**

Energy efficiency/ CO₂ indicators are increasingly used to monitor targets of energy efficiency gains or CO₂ abatement. Indeed, most governments in Europe and the European Commission are setting quantitative targets and need to monitor the progress achieved on a yearly basis. The benchmarking approach can also be useful to compare the relative performance of different countries.

Nevertheless, data collection still needs to be developed further in many countries to improve 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, in view of international discussions on GHG effects.

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 sharing of experiences on energy efficiency measures among different countries thus paving the fast track to a more efficient global energy economy.

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